2008

Index of the Massachusetts Innovation Economy

MASSACHUSETTS TECHNOLOGY COLLABORATIVE

John Adams Innovation Institute

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Message from the Governor

Dear Friends,

It is my pleasure to introduce the *2008 Index of the Innovation Economy*, the Commonwealth's tool for benchmarking the progress of our state's Innovation Economy against other leading technology states.

The 2008 *Index* underscores the major strengths in R&D and the leading performance of industry domains that make the Commonwealth a national and global hub of innovation. As you review some of the highlights immediately below and the more detailed data for each of the indicators in the *Index*, I think you will conclude that the spirit of innovation remains steadfast in the Commonwealth.

- Massachusetts added jobs faster in 2007 than the average of other leading technology states in Healthcare, Bio/Pharmaceuticals, Medical Devices & Hardware, Financial Services, and Defense.
- Our small businesses continue to rank #1 per capita in winning federal Small Business Innovation Research contracts and we rank #1 per capita in patents, National Institutes of Health funding, and federal R&D funding for universities and hospitals.
- Just as importantly, Massachusetts is #1 in educational attainment, and engineering degrees granted per capita compared with other leading technology states.

As positive as these indicators are, the 2008 *Index* does not capture yet the effect that the global economic downturn is already having in our Innovation Economy. So I would like to take this opportunity to share with you my perspective on why it is important to nurture our Innovation Economy in these difficult times. In doing this, I am pleased to join the distinguished academic and industry leaders who share their own views on this critical subject later in the *Index*.

For us in Massachusetts, innovation is as much a hallmark of our past as it is the promise of the future. Our world-renowned capacity for innovation and discovery has already led to radar, to a cure for childhood leukemia, to mapping the human genome, and to many other technological advances that improve the quality of our individual lives and the human condition as a whole. As we confront the worst economic conditions in more than a generation, let us remember our rich history of innovation in order to look forward and beyond any discouragement in the present.

Times like these inevitably call for sacrifices from all of us. Amidst the current crisis, I believe it is as important as ever to act strategically and make wise use of our limited resources to preserve the dynamism of our Innovation Economy. That is why today, as we face tough fiscal choices, we are making critical investments to harness exciting new opportunities in clean energy, nanotechnology, information technology, biotechnology, and medical devices. These investments will nurture capabilities essential to preserve our Commonwealth's distinguished industrial performance, a pillar of our long-term economic prosperity.

The people of Massachusetts possess a unique set of capabilities that gives us reason to remain hopeful and optimistic as we look ahead. Let us trust that the stubborn entrepreneurial drive of our people, the forward-looking talent concentrated in our higher education and research institutions, and the leadership of individuals across industry, academia, and government will enhance the capacity of our economy to navigate the turbulence. We will be astonished, once again, with Massachusetts' capacity to invent the new and reinvent the old. We will witness the birth of the next generation of life-changing technologies. We will observe the advent of whole new industries that we can not yet imagine.

I am confident and I call on you to be confident. Let us trust that the individual initiative and the collective wisdom we possess as a Commonwealth will afford Massachusetts a unique opportunity to offer to the nation and the world the talent, the tools and the knowledge to embark at last on a journey of sustainable and equitable economic progress.

Sincerely,

Deval L. Patrick

The Massachusetts Technology Collaborative

The Massachusetts Technology Collaborative is an independent, non-partisan 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 and in promoting the development and adoption of renewable energy technologies. It is also working with major healthcare organizations to implement e-health solutions that save lives and reduce costs. Additionally, MTC is helping to promote Governor Deval Patrick's $1 billion life sciences initiative through its founding role in the Massachusetts Life Sciences Collaborative.

MTC operates at the intersection of government, industry, and academia. It brings together leaders and stakeholders to advance technology-based solutions that lead to economic growth, a cleaner environment, and improved healthcare.

MTC energizes emerging markets by filling gaps in the marketplace, connecting key stakeholders, expanding broadband services, conducting critical economic analyses, and providing access to intellectual and financial capital.

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

Contents

2008 Index Overview

The Massachusetts Innovation Economy is built on the capabilities of its people and institutions to advance human understanding and apply new knowledge to create value in the marketplace. In a competitive economy, innovation is the only strategy for long-term economic growth and resiliency.

The *Index of the Massachusetts Innovation Economy*, published annually since 1997, is the premier fact-based benchmark for measuring the performance of the knowledge economy in Massachusetts. Each set of indicators gives us an objective view into a dimension of the dynamic and complex innovation ecosystem. The *Index* shows us where the Commonwealth of Massachusetts stands in relation to other Leading Technology States (LTS), revealing relative strengths and weaknesses. This system feedback is essential to sustain strong performance and focus energy on finding ways to achieve even greater performance.

The nine LTS chosen for comparison throughout the *2008 Index* are: California, Connecticut, Illinois, Minnesota, New Jersey, New York, North Carolina, Pennsylvania, and Virginia. Appendix A describes the methodology for selecting the LTS. Appendix B defines the 11 key clusters selected for their unique links to the innovation process.

MOST RECENT YEAR OVER YEAR CHANGE

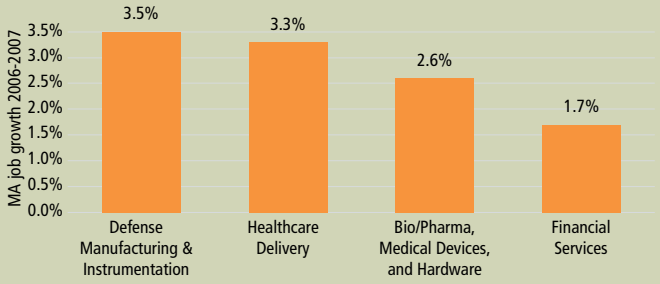
UP *DOWN* *MIXED*

Economic Impact

The industry clusters at the heart of the Innovation Economy outperformed the all-industry average. High inflation has eroded the purchasing power of wages, erasing any real wage gains in many occupations. The median household income in Massachusetts rose faster than inflation in 2007 over 2006, but the longer-term trend has been flat for five years.

Jobs

Massachusetts added 19,800 jobs, year over year, in the 11 key clusters in 2007. Massachusetts added jobs faster than the average of the LTS or the US in four clusters in 2006-2007.



Sales

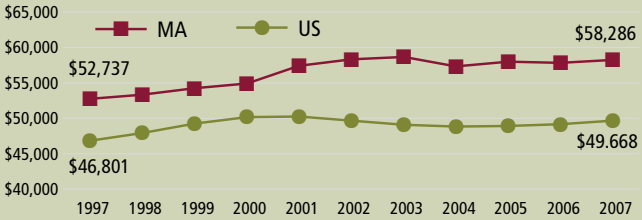
Sales by public companies headquartered in Massachusetts increased 12% in 2007 over 2006, averaging over 7% average annual growth since 2003.

Wages by Occupation

Key occupational groups in the Innovation Economy saw rising real wages, while most occupational groups saw wages rise slower than inflation between 2003 and 2007. Inflation rose significantly in 2007, eroding purchasing power of wages.

Incomes

Median household income is up 0.8% above inflation in 2007 over 2006, but the five year trend is flat.



Exports

Manufacturing exports are up to $67,000 per million dollars of state GDP from $60,000. Massachusetts ranks second among the LTS behind Illinois.

Innovation Activities

Massachusetts' performance in most innovation activities is many times greater than its share of the national economy. There was a slowdown in some early stage innovation activities, including patents and FDA approvals of biotech drugs and medical devices, visible in 2007. IPOs, start ups, and technology licensing all grew in 2007.

↑ Start ups

Business incorporations increased 464 in 2007 over 2006. Massachusetts ranks first per capita in spin-out companies from research institutions.

↑ IPO

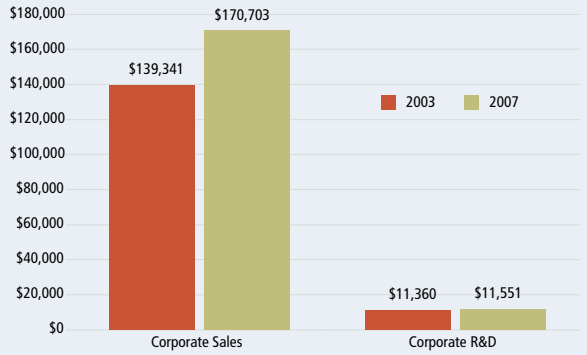
In 2007, the number of IPOs in Massachusetts doubled in 2007 to 22, the largest growth among the LTS.

↓ Small Business Innovation Research

Massachusetts small businesses were awarded $241.4 million in SBIR funds, down from $241.9 in 2005.

↓ Corporate R&D Relative to Sales

Corporate sales grew faster than R&D, resulting in a 17% decline in R&D as a percent of sales.



↓ Patents

All LTS saw a decrease in patents issued in 2007, on both an absolute and per-capita basis.

↓ Medical Device & Biotech Drug Approvals

Massachusetts regularly ranks high among the LTS with regard to medical device approvals and biotechnology drug approvals, but 2007 saw a decline across these measures with the sharpest decline in approvals of medical devices.

↑ Tech Licensing

Between 2002 and 2006 licensing revenue to hospitals and non-profit institutions increased 25% each year.

Innovation Capacity

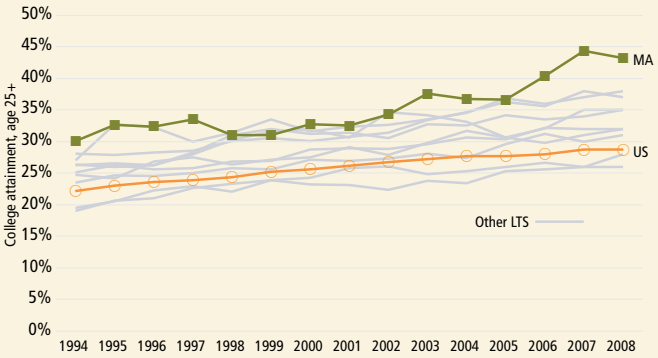
Massachusetts shows strong positive trends in human capital measures which should improve the Commonwealth's capability to adapt to tough economic times. Investment capital was also high in 2007, but declined in the first quarters of 2008.

↑ Investments

Real VC investment in Massachusetts rose 20% in 2007, the largest one-year increase among the LTS. The first three quarters of 2008 show 20% lower real VC investment than the same period a year earlier.

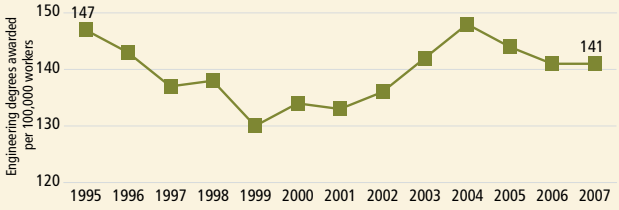
↑ Education

The percent of the adult population with at least a four year degree is up 7% over five years in Massachusetts. The Commonwealth establishes a lead above the next highest LTS.



↔ Engineering Degrees

There is no growth in engineering degrees, resulting in a long-term decline in degrees relative to the size of the Massachusetts labor force.



↔ Population

The working age population with a college degree is up 11% between 2005 and 2008 compared to 2% growth in the age 24–65 population. After four years of accelerating brain drain, the gap between in-migration and out-migration has started to close.

↔ Housing

Percent of Massachusetts households spending more than 30% of income on housing related costs:

- 41% mortgaged homeowners
- 47% percent of renters

Introduction

The *Index of the Massachusetts Innovation Economy* is an annual opportunity to assess the Commonwealth's economic progress and benchmark it against other Leading Technology States (LTS). As we go to press this year, the nation is facing greater economic uncertainty than it has in decades. The New England Economic Partnership* forecasts a recession lasting into 2010. While it is not predicted to exceed the 205,000 jobs lost in Massachusetts during the tech bubble burst of 2001, or the 356,000 jobs lost during the 1989-1991 recession, this recession will surely slow the growth in many, and accelerate the decline in some, of the clusters measured by the *Index*.

In the face of this turbulent economic environment, the twenty sets of indicators in the *Index* give us reason to believe that Massachusetts has entered the current recession on a solid foundation. Compared to other states, Massachusetts is neither leading the decline nor suffering disproportionately. Moreover, our substantial share of jobs in sectors that have been resilient historically, such as Healthcare, Information,** and Postsecondary Education, should help dampen the pace—and hopefully limit the depth—of an economic contraction that has yet to hit bottom.

While innovation does not give Massachusetts immunity from business cycles, it is necessary to generate high wage employment over long cycles of technological change. Twenty-five years ago, mean personal income in Massachusetts was below the US average. Today, Massachusetts has a 24% advantage in personal income per worker.

Even in this period of economic uncertainty, leadership and investments in the Massachusetts innovation enterprise remain critical. They provide not only a bulwark against further decline but also a pathway to recovery and longer-term prosperity. To give a perspective on what is needed to do to adapt to current economic conditions while continuing to nurture innovation capabilities, this edition of the *Index* hosts commentaries by distinguished academic and business leaders in the Commonwealth.

Even in this period of economic uncertainty, investments in the Massachusetts innovation enterprise provide a bulwark against steeper decline, but also a pathway to recovery and longer-term prosperity.

In the feature article, Richard K. Lester, Director of MIT's Industrial Performance Center, reminds us that innovation will continue despite the downturn and will be as important as ever once the recession ends. Citing the advent of the internet and its broad economic impact during the 1990s, Lester warns against assuming that we know what's coming next and suggests we trust in the ingenuity of innovators and entrepreneurs whose creativity never ceases to surprise. This is a time to bridge the "institutional fault-lines" that criss-cross our state to strengthen our innovation ecosystem, Lester says. Innovation is a "team sport," requiring collaboration by individuals across existing boundaries of organizations, regions, and sectors.

Admired across the globe, our research and higher education institutions are indispensable for the vitality of our innovation ecosystem. Two leaders from this arena share their perspectives on this point. Susan Avery, President and Director of the Woods Hole Oceanographic Institution describes how the Ocean Observatories Initiative, is bringing together academic, government, and industry researchers in the ocean, atmosphere, and earth sciences to respond to some of the most important challenges of our time. Jack Wilson, President of the University of Massachusetts, further emphasizes the need to collaborate as he describes

* New England Economic Partnership, November 2008.

** The most up to date employment estimates are only available by major industries. Many components of Information are part of the **Index's** definition of Software and Communications.

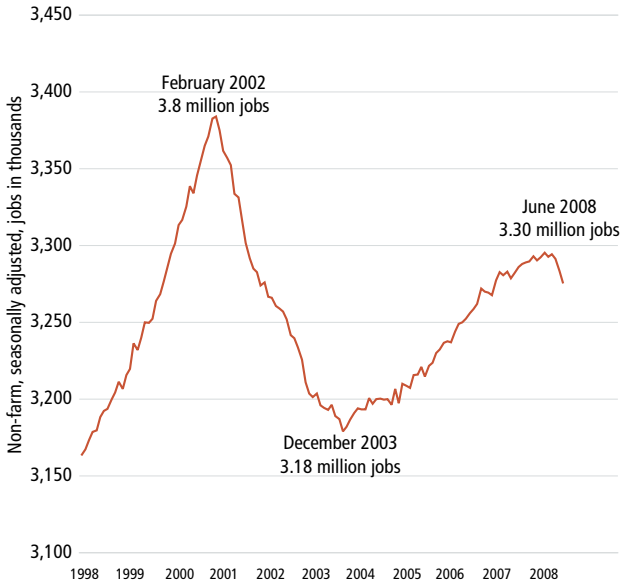
how UMass is building collaborations to strengthen the institutional framework of the Commonwealth's innovation ecosystem. Both Avery and Wilson remind us that preserving the health of the Commonwealth's research enterprise is crucial to sustain the long-term viability of our innovation ecosystem.

In 2008 the Massachusetts Legislature enacted landmark legislation to strengthen the life sciences and clean energy industry clusters in Massachusetts. Henri Termeer, Chairman and CEO of Genzyme Corporation, reflects on upcoming product development challenges in the life sciences industries in the Commonwealth. His commentary also illustrates how our innovation ecosystem is affected by factors well beyond Massachusetts boundaries: federal funding and regulations, global markets, and a healthy flow of new ideas. Still, Termeer says, "one of the key strengths of our region is the proximity we have to one another and a habit and history of working together. We recognized long ago that we are fundamentally dependent on collaborations." Mitch Tyson, CEO of Advanced Electron Beams, describes how collaboration among a wide array of actors in industry, academia, and government is crucial to jell and catalyze the growth of the clean energy industry cluster. With clean energy in mind, Tyson also reminds us that we need to do a better job telling our story: Massachusetts has the research, the companies, and the workforce to excel in innovation and business development.

Paul Bosco, Vice President/General Manager, and Site Executive of Cisco System's New England Development Center discusses how information technology (IT) can enhance our culture of collaboration, from K-12 education to the corporate board room. He suggests that investments to infuse IT across pillars of our economy, such as healthcare, education, and infrastructure will be as important as ever to help us pull out of the downturn. In this, he argues, partnerships between government

The **2008 Index** and the Business Cycle

Massachusetts Employment over a Decade
January 1998 through December 2008



While the economy faces forecasted decline, the **Index** analyses the most recent five years of performance data, which correspond to the recently-ended economic expansion (2003-2007). Monthly employment estimates turned negative in January 2008 for the US and in July 2008 in Massachusetts. As of December 2008, it is still too early to have economic data for most indicators in the **Index** that capture this economic u-turn.

and the private sectors will be vital. With finance at the epicenter of the economic crisis, Bob Higgins, a founding partner at Highland Capital Partners asserts, like Richard Lester, that, "innovation continues in all economic environments." Higgins points out that the rise in venture capital availability over the last 30 years overshadows the current slow down in venture investment. He also points out that "some of the biggest winners over the past few years, were investments made at a similar point to today during the previous economic downturn".

The indicators in the *Index* will inevitably show sinking performance during the downturn. But all commentators in the *Index* share the view that, to sustain innovation and the long-term viability of our economy, we need to strengthen collaboration, continue investing in critical factors of our innovation ecosystem, and maintain our optimism and distinctive focus on the future. "Innovators are typically among the most optimistic of people," Lester says. This optimism inspires the work of people throughout Massachusetts.

An Innovation Strategy for the Downturn

Richard K. Lester, PhD
Founding Director, Industrial Performance Center (IPC)
Professor of Nuclear Science and Engineering
Massachusetts Institute of Technology

Historians of the future will pay special attention to the year 2008. As this precedent-shattering year drew to a close, and a new American president prepared to grapple with possibly the worst financial and economic crisis since the 1930s, the country teetered on the edge of economic calamity.

In Massachusetts, as in so many other parts of the country, uncertainty has enveloped almost every aspect of economic life. Even as familiar economic indicators enter uncharted territory, the crisis underscores the crucial importance of unquantifiable resources like confidence, trust, and optimism. With enough confidence in the future—with enough 'animal spirits,' in Keynes' memorable phrase—economies can literally create miracles. Without them, even the simplest tasks become immensely difficult.

Richard Lester is the founding director of the MIT Industrial Performance Center and a professor of nuclear science and engineering at MIT. His recent books include ***Innovation—the Missing Dimension*** *(with Michael Piore);* ***The Productive Edge; and Making Technology Work*** *(with John M. Deutch). Over the past decade he has led several major research projects on national and regional competitiveness and innovation performance commissioned by governments and industrial groups around the world.*

No economic activity is more deeply affected by a loss of confidence than innovation. At its core, the act of innovation is an expression of confidence in the future. Innovation occurs because innovators believe that their efforts will yield benefits large enough to outweigh the many risks involved in bringing new products and services to market. Innovators are typically among the most optimistic of people.

In modern economies innovation is almost never a solo activity. Whether the outcome is a new technology or a new business model, many people are usually involved in bringing it about. Entrepreneurs and their financial backers are fond of referring to innovation as a 'contact sport.' This is at once a statement of the obvious—to innovate, people need to interact—and a pleasing image of rugged independence and robustness. Yet it is also true that the continuing flow of innovations in dynamic regions depends on the presence of an innovation 'ecosystem'—an interacting community of entrepreneurs, financiers, researchers, educators and others—that is as fragile and vulnerable to disruption as any natural ecological community.

What happens to such communities when their single most important intangible asset—confidence—is suddenly in short supply? This is the situation we now face in Massachusetts, and it demands our urgent attention. Every economy must innovate in order to grow, but the continued prosperity of the Commonwealth depends on innovation to an unusual degree. As the preceding reports in this series have amply documented, for many years Massachusetts has been at or close to the forefront of per-capita performance in many innovation-related activities, including federal and corporate R&D spending, venture capital investment, patenting, entrepreneurial activity, and educational attainment. Other analysts, drawing on similar indicators, recently ranked the Commonwealth first out of all American states—for the fourth consecutive time in the last decade—as a center of innovation and knowledge-based industry.

But today our vaunted innovation engine is operating in low gear. The region's research universities, the source of so much new technology-based business formation, are cutting budgets and halting construction of new facilities as endowments shrink and debt markets dry up. Venture capital firms are hunkering down. The volume of initial public offerings has fallen almost to zero. Many large firms in technology and financial services are reducing head count.

What to do in the face of this difficult outlook depends on the answers to three questions:

First, will innovation continue to be important for the Massachusetts economy? The answer is surely yes. No matter how bad the current downturn, it will eventually come to an end, and innovation will again be a major driver of our economy, as it has been throughout the Commonwealth's nearly four-hundred-year history.

Second, can actions be taken to strengthen our innovation system during the downturn? Once again the answer is surely yes. During periods of prosperity it is easy to ignore weaknesses, but these are more difficult to hide when times are bad. Now would be a good time to take a hard look at our innovation balance sheet—at our liabilities, as well as our assets. At such a time, moreover, the motivation to address problems should be greater.

A good place to start would be the institutional fault-lines that crisscross our state—once famously described as missing a 'collaboration gene.' There is much work to do in bridging the gaps that still divide the area's 'old' and 'new' industries; that divide our large, well-established firms from their younger, entrepreneurial counterparts; that divide our public and private universities; and that divide Greater Boston, with

An innovation strategy designed for the downturn should focus on sustaining the flows of capital, knowledge, and people that are so central to the successful functioning of innovative regions.

its entrepreneurial resources and research universities, and other parts of the state, with more space, lower costs, and a powerful desire to participate in the ongoing reshaping of the Massachusetts economy. And if any more justification is needed to focus our attention on the innovation agenda, consider that other regions, both here in the US and overseas, continue to pursue ambitious, sophisticated and well-funded strategies to build tomorrow's hubs of innovation. The rest of the world will not stand still even during the current downturn, and the competition for the key resources that have fueled our innovation engine in the past—talented people, risk capital, R&D funds—will only intensify.

Third, will there be new opportunities to innovate even during the downturn? Economic activity doesn't come to a complete stop even in periods of deep recession, and neither does innovation. Though opportunities will be scarcer, Massachusetts is well-positioned to exploit at least some of those that are likely to arise. Demand for the health-related product and service innovations developed by our prolific life sciences supercluster should remain fairly strong even in a downturn. And clean energy technology, a strong point of our region and the foundation of what many expect to be the next big innovation-driven industry, will likely receive a boost as part of the incoming administration's economic stimulus program. The new President understands that the nation's difficult economic situation may actually be a very good time to step up the pace of the transition to a low-carbon energy system. He and his administration will be looking for effective models. Massachusetts, with all of the necessary ingredients of a successful energy innovation system, should be ready to step forward.

◆ ◆ ◆

An innovation strategy designed for the downturn should focus on sustaining the flows of capital, knowledge, and people that are so central to the successful functioning of innovative regions. It should concentrate on eliminating obstacles to these flows, both within Massachusetts itself and between our region and other important innovation hubs. It should support

Bentley University's trading room

the development of more public spaces where researchers, entrepreneurs, and financiers can rub shoulders and share ideas about the future direction of technologies and markets (MIT's Deshpande Center is one model of how to do this). It should recognize that the make-up of innovation systems varies by sector, and that a one-size-fits-all approach will not succeed. In life sciences, for example, the proximity of world-leading fundamental research in area universities to state-of-the-art clinical practice at our great teaching hospitals is the keystone of the supercluster. In energy, by contrast, the key ingredient may turn out to be the connections between small, entrepreneurial energy innovators and the large, established energy firms whose access to capital and customers will be necessary to bring the innovations to scale.

Most important, an innovation strategy for the downturn should avoid the mistake of assuming that we know what is coming next. The ingenuity of innovators and entrepreneurs always surprises. When policymakers and pundits were debating how to escape the recession of the early 1990s, no one foresaw the emergence of the internet just a few short years later, and the remarkable spurt of economic activity that followed, with more than 20 million new jobs created in the United States alone during the rest of that decade.

At this writing, the eventual magnitude of the current downturn is uncertain. No one really knows how long the recession will drag on, but conditions will likely get worse before they get better. In this difficult climate there will be many deserving demands for short-term assistance, not least from the most vulnerable and least fortunate members of society. But it is also during such times that the seeds of long-term growth take root. Planting these seeds will require imagination and leadership in equal measure. Fortunately, the innovative history of our Commonwealth gives grounds for optimism that such qualities will come to the forefront once again.

Commentary

With the impacts of the recession still unfolding across the global economy, six distinguished thought leaders from industry, research, and academia share their perspectives on Massachusetts' path forward.

Susan Avery, PhD
President & Director
Woods Hole Oceanographic Institution

Creative Collaborations to Sustain Momentum

It's a cliché that tough times require tough choices. It's more instructive to say that tough times require the fortitude not to abandon good choices made in good times.

With the federal government forced daily to recalibrate optimal economic policy, and state governments dissecting budgets line by line to search for savings, there is a tendency to shelve long-term perspective. Yet sustaining economic growth is an inherently long-term activity.

It's also a team sport. Tightly focused strategic alliances among partners from academia, industry, and government are especially helpful in a shrinking economy, because they serve to share resources and leverage every scarce dollar of investment.

Investment in research is one of those good choices we cannot afford to abandon in the pressure of the moment. Research leads to discoveries that drive innovation that spawns new products and services that encourage partnerships that create jobs that grow the economy. For example, in 2007 the Woods Hole Oceanographic Institution (WHOI) created a special mooring system delicate enough to listen for whales and submarines but strong enough to survive ocean storms. An energy company is now using the system while building an offshore natural gas facility off Boston, and the Department of Homeland Security is assessing its potential use to protect harbors around the country.

Use-inspired research, especially with partners, can more quickly create economic opportunities and support decision-makers. The foundation of my management process is a conviction that casting a wide net to find common interests and identify broadly shared objectives can lead to partnerships that enable all parties to fulfill their separate missions.

And with a growing awareness of the need to reassess our socioeconomic infrastructure in response to a changing climate, partnerships will help us tackle the broader integrated science of climate impacts.

WHOI is particularly grateful for one of our most recent partnerships with the state of Massachusetts; it is one prime example of the power of leveraged investment. Thanks to a cost-share commitment of $10 million from the state, WHOI gained immediate leverage to lead other academic research and industrial partners in winning a $98 million contract to develop, build, deploy, and operate coastal and global ocean observing systems funded by the National Science Foundation under its Ocean Observatories Initiative (OOI).

Susan Avery is an atmospheric physicist with extensive experience as a leader within scientific institutions, and has authored and coauthored more than 80 peer-reviewed articles. As the 9th Director of Woods Hole, a private, independent, not-for-profit corporation, Avery upholds the institution's mission of expanding the frontiers of ocean science through research and higher education.

A Bluefin-12 Autonomous Underwater Vehicle (AUV) captures continuous, real-time information on ocean conditions

Once operational this investment will attract an additional $130 million over ten years in direct operational funds for Massachusetts; these benefits do not begin to consider the additional spin out benefits of OOI from new products and services to be developed in the region.

Ultimately, OOI will speed product development and technology transfer while revolutionizing the way we learn about the ocean, all with long-term social value. The Initiative will generate information to help improve predictions of climate change and weather, mitigate the impacts of natural hazards, bolster the safety and efficiency of maritime operations, enhance homeland security, protect public health, restore coastal ecosystems, and manage resources under the new Massachusetts Oceans Act. OOI also is catalyzing related efforts among wind energy companies off New Jersey seeking moorings that are compliant with OOI standards. In addition, the Initiative is inspiring other countries that want similar coastal observing systems.

There is momentum in such collaboration. Academic, government, and industry researchers in the ocean, atmosphere, and earth sciences are working together more often and more naturally. Our planet is an integrated system in which the oceanic, atmospheric, and terrestrial environments interact in a highly complex fashion that requires integrated intellectual approaches to understand. And with a growing awareness of the need to reassess our socioeconomic infrastructure in response to a changing climate, partnerships will help us tackle the broader integrated science of climate impacts. Given global warming and ocean acidification, this is a critical time to observe and understand these changes. Programs like OOI enable us to collaborate creatively to enhance each partner's ability to add to the global store of knowledge, develop effective ways to manage and mine information, allow efficient delivery of that information to policy forums and decision-makers, and bring innovative products to the marketplace.

This ambitious endeavor promises long-term benefits to the economies of Massachusetts and New England. Plus, the knowledge our partnership gains, the technology and information products we develop and market, and the jobs we create will benefit both our nation and the world.

So, as we each look to sustain the vitality of our individual organizations in these difficult times, we will be well-served to seek commonality with others. Partnerships, carefully chosen and nurtured, can help us all stretch scarce investment dollars. As Governor Deval Patrick recently said, "We ought to seize the opportunity of scarcity."

Jack M. Wilson, PhD
President
University of Massachusetts

Keeping Our Focus on Talent, Innovation, and Collaboration

All institutions today face serious fiscal challenges due to the current global economic and financial crisis. At the University of Massachusetts, we are making difficult decisions to reduce expenditures across the system. Yet even as we do so, we recognize the critical roles that we and others play in developing talent and generating innovation for the Commonwealth. We are making these decisions in ways that ensure that we continue to provide an affordable, first-class education for our students and grow our world-class research enterprise.

All of our campuses are continuing with their strategic plans and growth strategies, and strengthening collaborations with each other and with industry and private institutions. While some adjustments may be necessary in light of new economic realities, we are moving forward.

Indeed, if we are to grow out of the present economic turmoil, our major research universities—particularly the public institutions—will need to be more assertive in providing leadership that leverages our research and education to advance the Innovation Economy in Massachusetts.

Similarly, the Commonwealth will need to navigate the current period of uncertainty in ways that keep the state moving forward and well-prepared for the future. Fortunately, we have seen far-sighted economic leadership from the Governor and legislative leaders in recent years, who have actively supported key innovation clusters and encouraged partnerships between universities and industry that have produced impressive returns.

Massachusetts policymakers began experimenting earlier in this decade with new approaches to the Innovation Economy that led to creative new programs such as the John Adams Innovation Institute and the Massachusetts Technology Transfer Center (MTTC). Since 2004, the Innovation Institute has made matching investments for university research programs that have leveraged more than $155 million in new R&D support for Massachusetts, and encouraged collaborative new ventures such as a National Science Foundation-sponsored nanotech manufacturing initiative involving Northeastern University, UMass Lowell and the University of New Hampshire. The MTTC, a state-wide program housed at UMass, has partnered with over 30 public and private universities, teaching hospitals and research institutes and assisted start-up companies, many that emerged from these institutions, in raising more than $120 million of new investment funds. Proven efforts such as these merit ongoing judicious state support.

Fortunately, we have seen far-sighted economic leadership from the Governor and legislative leaders in recent years, who have actively supported key innovation clusters and encouraged partnerships between universities and industry that have produced impressive returns.

Jack M. Wilson is the 25th President of the University of Massachusetts, which has 60,000-students enrolled on its five campuses. A physicist, Wilson has served in various academic leadership roles and as a private sector entrepreneur. President Wilson is nationally and internationally known for his leadership in the reform of higher education programs.

UMass President Wilson and Senator Kennedy at a gathering of industry and academic leaders

More recently, the establishment of the Life Sciences Center and the Clean Energy Center takes the state's commitment to a new level and scale. Each has taken a budget cut, like the rest of us. Nevertheless, they still control substantial resources and can provide intelligent incentives for talent development and fill critical gaps between basic research and commercialization that will make Massachusetts more competitive. The Life Sciences Center, for example, has promoted institutional collaboration in stem cell research through the establishment of the Stem Cell Bank and Registry at UMass Medical School, and it has encouraged opportunities for industry/university partnerships in talent development and R&D.

In a related effort through the Life Sciences Collaborative, Presidents Drew Faust of Harvard and Susan Hockfield of MIT are joining Genzyme CEO Henri Termeer and me in a joint appeal to our Congressional delegation to advocate for increased National Institutes of Health (NIH) funding in the economic stimulus package now before the Congress. I'm confident that university and industry leaders will be equally supportive of the proposals on clean energy being developed by the new Obama Administration.

Collaborative advocacy among industry, academia, and our state and federal elected officials represents another area of opportunity for the Commonwealth.

In sum, although we face stark challenges in the near future, we cannot at this critical time abandon or seriously slow our long-term efforts at building the Commonwealth's Innovation Economy. Each of us acting as individual institutions and working collaboratively in partnership must do all we can at to ensure our long-term economic prosperity.

Henri A. Termeer
Chairman, President & Chief Executive Officer
Genzyme Corporation

Sustaining Innovation in the Life Sciences

Biotechnology has enormous potential to transform human health over the next fifty years. The field's potential to benefit the environment and agriculture is equally massive. This promise is why it is critical that we sustain the innovation that has made the United States—and Massachusetts in particular—the life-sciences research capital of the world.

Our capacity to develop innovative medicines will become increasingly constrained by the accelerating transition to generic drugs, which are expected to represent 85 percent of all prescriptions within five years. This means that the cost of developing breakthrough new medicines will be funded by branded product sales representing only 15 percent of all drug spending. To sustain this investment, the prices for innovative medicines will be significantly higher, and the drugs themselves will be expected to provide substantial therapeutic and economic benefits. This will lead to more personalized medicines—drugs that are specifically targeted to patients based on their genetic makeup and that work more effectively and safely because they are prescribed only to those most likely to benefit.

We should embrace this reallocation of resources. The transition from trial-and-error medicine will increase the value of truly innovative drugs that society will demand and will reduce the overall cost of care. Biotechnology is poised to lead this transformation, with its focus on high-impact medicines for diseases affecting smaller numbers of patients and its capacity to link diagnostics and therapeutics. To fulfill its promise, the industry will have to increase the engagement, collaboration and outward-looking perspective that have historically enabled it to sustain the development of ideas, technologies, and products. Specifically:

- We will need to become more active in shaping a policy environment that supports innovation. In Massachusetts, the conditions for the growth of biotechnology improved with the enactment of the Life Sciences law. Passage of the Gift Ban law, however, revealed a need to explain more effectively how we operate and what we contribute in order to earn the trust of politicians and the public. In Washington, a new presidential administration and new leadership of a key Congressional committee will bring potentially dramatic changes for health care. This will require us to actively and convincingly communicate the value that innovative life-sciences companies create, the impact we have on patients' lives, and the capacity we hold to cure devastating diseases such as Parkinson's disease, Alzheimer's disease and cancer.

Biotechnology companies especially must continue to take risks and to innovate to earn their right to exist and to fulfill their promise to feed, fuel and heal the world.

Henri A. Termeer has helped lead the development of the biotechnology industry from its infancy over the past 25 years. Under his leadership, Genzyme Corporation has grown into one of the world's leading biotechnology companies; developing, manufacturing, and marketing innovative healthcare products and services in 100 countries. Termeer is a member of Massachusetts Governor Deval Patrick's Council of Economic Advisors, is deputy chairman of the Federal Reserve Bank of Boston's board of directors, and is cochair of the Leadership Council of the Massachusetts Life Sciences Collaborative.

Genzyme's new Science Center in Framingham opened in 2008.

Photo credit:
John Horner Photography

In Washington we will need to work with our Congressional delegation and others to increase the budget for the National Institutes of Health (NIH). The NIH budget has not grown over the past five years and has actually eroded in real terms by 13 percent. Stagnant NIH funding constrains the flow of innovation by limiting resources and discouraging higher risk ideas. We also need to continue to strengthen the FDA by ensuring that it is adequately staffed and capable of retaining its best and most experienced people, and that it has strong leadership. A healthy FDA can facilitate the development of innovative medicines through simpler, more predictable and less costly requirements. A healthy FDA can have an enormous impact in navigating the transition to more personalized medicine.

- Globally, we must increase our engagement with international markets, an orientation that has driven innovation in Massachusetts for two centuries. India and China hold enormous growth potential and will surpass the United States as the key markets for pharmaceuticals over the next 25 years. The development of India and China will double or triple the number of people with access to modern medicine, a multiple never seen before. Because these countries are just starting to organize their health care sectors, they are not constrained by the restrictive attitudes and practices that have taken hold in the developed markets. The desire for innovation and the receptiveness to new ideas in these countries exceeds what we have today in Europe, Canada, the United States and other established markets.
- Finally, we must maintain the culture of transparency that has sustained us. We need to be open to research and ideas emerging outside of our companies and institutions and be willing to bring those ideas in. One of the key strengths of our region is the proximity we have to one another and a habit and history of working together. We recognized long ago that we are fundamentally dependent on collaborations. Only now have the large pharmaceutical companies begun to look to biotechnology for the real innovation missing in their own laboratories.

What will make Massachusetts relevant for the future are its technology companies, in particular its life sciences companies. Innovation is an attitude that sustains our commonwealth. We must maintain this culture as we grow. Biotechnology companies especially must continue to take risks and to innovate to earn their right to exist and to fulfill their promise to feed, fuel and heal the world.

Paul D. Bosco
Vice President/General Manager and Site Executive, New England Development Center
Cisco Systems, Inc.

The Innovation Economy and Information Technology Industry

Massachusetts as a Location for Investment and Growth

The economic crisis we face in the United States presents an enormous challenge for our country's new President and the nation's citizens. Science, technology, and innovation must be policy priorities to improve American competitiveness, achieve sustainable economic growth, and solve our nation's most pressing issues. The Commonwealth of Massachusetts offers excellent examples of success in this arena.

Economic and social measures of success include jobs and investment. The funding of new ventures, organic growth of existing businesses, and relocation activity are examples of business decisions which result in job creation and investment growth. Decisions on locations for investment and growth are based on many factors—regional talent in specific areas of expertise, overall business environment, employee quality of life, and more. These decisions are heavily based on the comparative strengths of particular regions. State and regional strengths and policies are thus of vital importance.

Cisco is proud to be part of the vibrant Massachusetts innovation economy. Our New England Development Center (NEDC) based in Boxborough is home to many of our 2,000 workers in the region—one of the largest Cisco locations in the world. Our teams here are engaged in key programs and activities including communications, collaboration, broadband, security, internet routing, video/content, and service provider development. Cisco has invested over $11 billion this past decade on startups and acquisitions in the region.

Our presence here is easily explained. Massachusetts is one of very few regions in the world that offers a critical combination of research, talent, and venture activity in areas of strategic importance to Cisco. Sixty of the world's top public and private universities are within commuting distance of our campus. On all metrics of innovation, Massachusetts competes favorably with areas many times our size. Our quality of life is enhanced by the choice of cosmopolitan cities, suburban lifestyles, the New England countryside, and shorelines to our north and south. Our employees and their families also benefit from strong public schools, diverse cultural options, and nearby vacation opportunities.

As we address the serious economic challenges which confront us today, Massachusetts is building on strong pro-innovation policies and regional collaboration to position for recovery and success.

We also benefit from a supportive state government that has played a vital role shaping the comparative strengths of this region in the innovation economy. Massachusetts is fortunate to have a Governor and Legislature focused on excellence in public education, health care access and innovation, and a supportive business environment. Our public schools are ranked best in the nation. Massachusetts has launched an exciting initiative to ensure consumer broadband access across the Commonwealth for critical

Paul D. Bosco is a high tech business executive and evangelist for the Massachusetts IT cluster, working with partners across government, industry, and academia to promote and strengthen regional innovation, investment, and economic growth. Bosco has led Cisco broadband, wireless and video business units. He has also been involved in 13 Cisco startup acquisitions and investments. Bosco currently serves as Cisco Vice President and Site Executive for the Cisco New England Development Center.

service delivery and statewide participation in the innovation economy. The University of Massachusetts is increasingly recognized for research and education excellence, with a world-class computer science department at its flagship campus in Amherst. The state is actively facilitating growth beyond metro Boston into more cost effective areas of the region. Our rivers which powered the industrial revolution are being harnessed as sources of cost-effective renewable energy. The state is also increasingly active in promoting the unique strengths of our region to grow local businesses and attract new jobs and investment.

Innovation has fueled the economic success of our region for generations. The future success of the information technology industry will build on innovation in areas such as enterprise collaboration, cloud computing, software as a service, web technologies, multi-core computing, mobility/wireless, media/entertainment, storage/content, virtualization, next generation internet, and more. Significant innovative activity at the intersection of computer science and areas such as the life sciences, robotics and the creative economy are also important. Massachusetts is a dynamic hub of innovative activity in each of these key technology areas and many others. We are home to MIT and Harvard, the world's top computer science laboratory, the most renowned media research program, and global web standards efforts. We are a global center of venture activity.

Information technology advances can also help address our education, healthcare, and energy challenges—critical issues in this economic downturn. In the classroom, IT can enhance the learning experience while affording students the opportunity to develop important skills such as collaboration, communication, and global awareness. In hospitals and doctors' offices, secure electronic health records can enhance care and create records available wherever and whenever a patient needs medical attention. In energy, IT promises intelligent infrastructure systems which dramatically improve energy efficiency. These include smart power grids and smart buildings that use sensors and systems to adjust heating, lighting, and air conditioning systems in real time. Massachusetts is a leader in the application of IT innovation to address education, healthcare, and energy challenges.

Massachusetts is an exceptional location for business success in the innovation economy. We have begun building upon the uniquely successful Massachusetts life sciences model of government-industry-academia collaboration to develop a regional vision and strategy for our industry. To start we have recruited the University of Massachusetts Donahue Institute to analyze the regional IT sector. With the Massachusetts Technology Collaborative's John Adams Innovation Institute, we are convening a broader collaborative effort to advocate for basic science and research funding, improve industry-academia linkages, cultivate regional innovation and entrepreneurship, enhance regional infrastructure to enable growth statewide, strengthen the business environment, and promote our region. As we address the serious economic challenges which confront us today, Massachusetts is building on strong pro-innovation policies and regional collaboration to position for recovery and success.

Mitch Tyson
CEO, Advanced Electron Beams
Co-Founder, New England Clean Energy Council

Building Massachusetts' Clean Energy Future

While Massachusetts is not blessed with significant natural energy resources, it does have world class research universities, a large venture capital community, a talented and technical workforce, a culture of entrepreneurship, forward-thinking policy leaders, and a significant base of innovative and growing energy efficiency and renewable energy companies. Combined, these resources create a clean energy cluster that is developing innovative energy technologies and businesses, addressing the global energy challenge and building a vital economic sector in Massachusetts.

Private and public sector activities have been driving the growth of the clean energy cluster. Two and a half years ago, representatives from clean energy companies, venture investors, universities, industry associations, utilities, labor, environmental organizations, major financial institutions, and large commercial end-users came together to form the New England Clean Energy Council. The Council's mission is to make New England's clean energy economy a global leader by building an active community of stakeholders and a world-class cluster of clean energy companies.

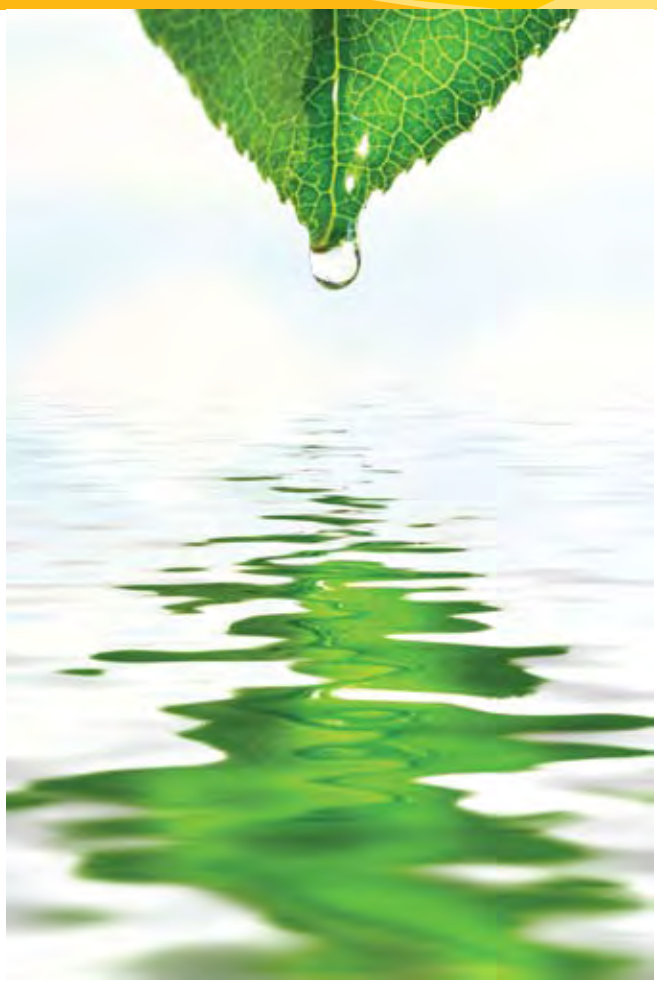
The leadership of Governor Patrick, the strategy and policy efforts of Secretary Ian Bowles and his team at the Executive Office of Energy and Environmental Affairs, and the initiative and commitment of House and Senate leaders, has resulted in Massachusetts adopting the most forward thinking clean energy policy in the nation. The Green Communities Act of 2008 requires utilities to invest in efficiency and renewables before investing in new conventional energy supplies; the Massachusetts Oceans Act of 2008 promotes the development of wind, wave, and tidal power generation; the Clean Energy Biofuels Act of 2008 provides the first-in-the-nation state gas tax exemption for cellulosic biofuels; the Green Jobs Act of 2008 establishes a Clean Energy Technology Center to stimulate clean energy research and venture and job creation; and the Global Warming Solutions Act of 2007 mandates an 80% reduction in greenhouse gas emissions from 1990 levels by 2050. The Governor has also rejoined the Regional Greenhouse Gas Initiative, decoupled electricity rates, and launched the Commonwealth Solar Rebate Program. Combined, these policies and activities give the cluster a strong foundation and momentum for future growth while enhancing our global reputation.

The Commonwealth's clean energy cluster, however, is not immune from the current global economic recession. The credit crisis is making it difficult to obtain financing. The lack of IPO exits and other pressures are forcing venture firms to limit what is available for new start-ups. Potential buyers of clean energy systems are deferring spending while state spending cuts are limiting incentive programs. Universities are limited in new research and academic programs. And perhaps most perversely, the recession has caused a drop in energy demand, dramatically lowering the price of energy and making some clean energy technologies temporarily uneconomic or less compelling.

If we can stay energized, continue to collaborate, and remain focused on the future, the clean energy cluster's outlook is bright.

The economic crisis is temporary. Economic growth will resume, energy demand will increase, energy prices will rise, and the demand for clean energy technologies will be stronger than ever. We need to concentrate our efforts on the following

As CEO of an innovative technology company, co-founder of the New England Clean Energy Council, and member of numerous agencies' executive and governing boards, Mitch Tyson is an energetic leader in building the Massachusetts clean energy economy. AEB's compact electron beam emitters replace thermal and chemical processes for cleaner, more efficient, lower-cost manufacturing.



major activities to make sure that the clean energy cluster does not lose momentum:

Implement: Draft regulations needed to properly implement the legislation that has passed. Gather input from the cluster to assure that the goals of these bills are achieved efficiently.

Advocate: Push for strong federal energy policies focused on increased innovation through increased R&D, programs to commercialize university and government R&D, and loan guarantees for demonstration projects.

Train: Develop the leaders, scientists, engineers, and employees needed to perform the research, build the companies, and utilize the technology. Training must focus on real needs identified by companies. Universities need new academic programs to help students apply their disciplines in the clean energy field. Massachusetts needs to provide ways for executives and employees in other fields to transition to clean energy.

Convene: Continue to build the clean energy ecosystem by increasing the collaboration between universities, venture firms, and entrepreneurs in order to spawn new clean energy companies; between utilities, environmental and community groups, and developers in order to site clean energy projects; between clean energy companies, financial institutions, and the state to ensure that clean energy companies will stay and grow in Massachusetts; and between energy consumers and clean energy companies in order to encourage adoption of locally produced solutions.

Brand: Communicate the message that Massachusetts is the best place to access clean energy research, to grow clean energy companies, and to find the strongest clean energy workforce. The Commonwealth needs to attract companies, entrepreneurs, researchers, employees, and students. Through these efforts Massachusetts will also assist companies with local roots to reach global markets.

Current economic conditions are quite challenging. But those of us in the clean energy field are energized. We know that the energy challenge will not be solved in the next few years or even decades; that it is of enormous scale and involves retooling a massive global infrastructure; and that it is highly complex, involving national security, environmental, economic, social, and moral issues.

But we have seen what can be achieved in a short time by working together in Massachusetts and we are not discouraged. We have a very passionate clean energy community and have received extraordinary support from our political leaders. If we can stay energized, continue to collaborate, and remain focused on the future, the clean energy cluster's outlook is bright.

Robert F. Higgins, MBA
General Partner, Highland Capital Partners
Senior Lecturer of Business Administration, Harvard Business School

Preserving and Promoting Innovation in the Downturn

Venture capitalists play an important part in the innovation economy. They make their contribution in three ways. First, they identify opportunities for new businesses. Second, they provide the critical early capital to launch these enterprises. And, third, they provide guidance and direction to entrepreneurs as they go through the early difficult years of a new business. In today's economy, the third component is the most important.

2008 was a difficult year for all constituents of the innovation economy, and the venture community has not been spared by the current economic crisis. The recent tribulations of the venture industry have reached the mainstream media. Some journalists have portrayed a bleak future with Forbes declaring "venture capital's coming collapse."

This is not surprising. The sources of a successful venture capital model have nearly come to a halt across the nation, and particularly in the Commonwealth. For example, venture capitalists often look to initial public offerings (IPOs) as a major source of financing for young companies and as a step toward liquidity. Unfortunately, according to Dow Jones VentureSource, the number of IPOs of venture capital funded companies based in the Commonwealth plummeted from 20 in 2007 to zero in 2008. Nationally, the story has not been any better, with the number of IPOs falling from 86 in 2007 to 11 this past year. In addition, the increased economic uncertainty has led to fewer new investments by venture capitalists. The venture firms have spent their time looking to ensure the health of their existing young companies. In Massachusetts, 191 companies raised capital totaling $2.2 billion in 2008, a significant decline from the 303 companies raising $3.3 billion in the previous year. The decline is even more precipitous in comparing the fourth quarter of 2008 with the fourth quarter of 2007.

The venture community is an important component of the innovation economy. Its health is all the more essential in a state like Massachusetts, which is disproportionally dependent upon the development of new technology companies. In today's economy, venture capitalists are working closely with entrepreneurs to ensure that companies backed in previous years survive the downturn.

In today's economy, venture capitalists are working closely with entrepreneurs to ensure that companies backed in previous years survive the downturn.

Economic uncertainty can be particularly tough on the entrepreneurial ventures that were started in times of prosperity. These companies grew in an environment where capital was abundant. Now, they face a situation where access to capital has largely disappeared and their ability to obtain more money is no longer assured. As this need becomes apparent, entrepreneurs and venture capitalists must force each other to make difficult decisions regarding corporate strategy, short-term growth, and personnel. These decisions bring costs down by improving the efficiency of the company's operations. In times of economic turmoil, better operational efficiency can mean the difference between a company forced to shut down and its survival. Such discipline will

As General Partner and co-founder of Highland Capital Partners, Robert Higgins has more than twenty-five years of experience in venture capital and has served as a director of many private and public companies. Higgins is a former director of the National Venture Capital Association and President of the New England Venture Capital Association. In addition to his role at Highland, Higgins has served as a faculty member at the Harvard Business School since 2001.

allow valuable contributors to keep their vital places in the innovation economy of the Commonwealth.

However, preserving existing innovation should not come at the expense of promoting new innovation through investment. Inherent to the human spirit, innovation continues in all economic environments. Legislative leaders in the Commonwealth recognize this important fact and continue to actively support innovation and foster collaboration through numerous initiatives such as the Massachusetts Technology Collaborative and the John Adams Innovation Institute. Venture investors should also recognize that difficult economic times can often provide the best opportunities for investment. Arguably the most important resource for a venture, qualified and capable entrepreneurs are often more easily accessible now than in times of prosperity. Combined with a steady stream of innovative ideas, big winners will certainly emerge. Some of the largest winners of the past few years, such as Conor Medsystems and VistaPrint, were investments made at a similar point to today during the previous economic downturn.

The innovation economy has much reason to be optimistic. Entrepreneurship has only recently been recognized as a key driver of long-term economic prosperity. Over time, the visibility of the role of entrepreneurship in driving economic growth has increased. The venture capital industry has grown around this idea in the last thirty years. US venture capital firms have raised over $29 billion dollars this past year compared to $354 million in 1978. Despite the recent slowdown in venture investment, the capital available to fund innovation dramatically exceeds what was available thirty years ago.

Universities have played a major role in the development of new companies. Both the Massachusetts Institute of Technology and Stanford University have a long list of successful firms that were founded on university research. Also, entrepreneurship is a big part of the curriculum at business schools today. In the early 1980s, only two members of the faculty of Harvard Business School (HBS) were focused on the study of entrepreneurship. Today, thirty-five faculty members at HBS are part of a department of entrepreneurship.

Venture capital, like entrepreneurship, is long-term in nature. It is designed to provide resources for growth that help to bring an economy out of a downturn. Despite facing a challenging economy in the near future, the venture industry can help the community by working closely with entrepreneurs to preserve the progress made in the past. In addition, it should foster an environment that promotes new innovation and supports the bold entrepreneurs that drive the prosperity of this great Commonwealth.

The Massachusetts Innovation Ecosystem

Each of the 20 sets of indicators in the *2008 Index* examines a dimension critical for the performance of the Commonwealth's innovation ecosystem. These indicators cover economic impact, innovation activities, and innovation capacity.

Economic Impact

The *Index* studies the economic impact of innovation at the cluster and state level. Impact is measured by changes in employment and wages, and by various measures of business output. Household income is also an important measure of innovation's effect on the economy at the state level.

Innovation Activities

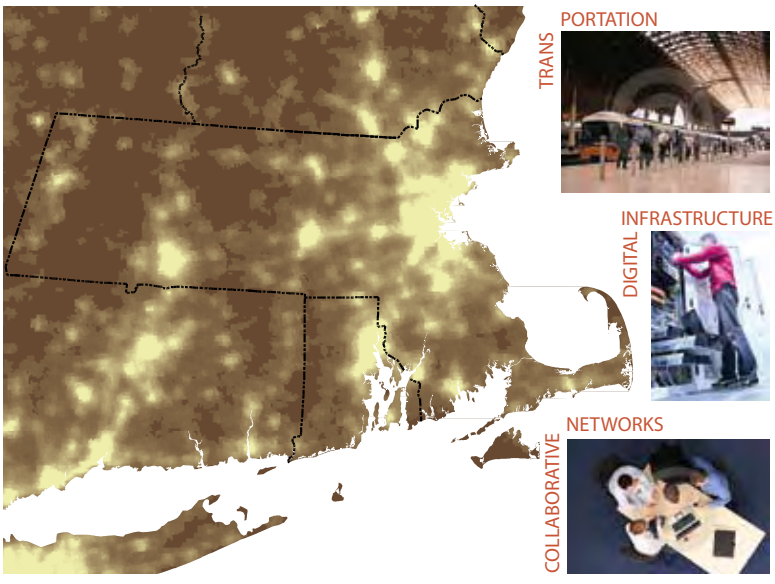
In the *Index*, innovation is defined as the capacity to continuously translate knowledge into new products, processes, and services that create, improve, or expand business opportunities. The *Index* assesses innovation by examining three categories of activities that underlie this complex and interactive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

- **Research:** The massive and diversified research enterprise concentrated in Massachusetts universities, teaching hospitals, and government and industry laboratories is the source of the frontier scientific and technological knowledge that fuels 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.
- **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.
- **Business Development:** Technical, business, and financial expertise each plays a role in the process of analyzing and realizing business opportunities which result after R&D are translated into processes, products, or services. Business development involves commercialization, new business formation, and business expansion. Business model innovation is also an important source of business growth by finding new ways to create value. Breakthrough innovations can not only introduce new or improved products to existing markets, but can create entirely new markets and product categories.

Innovation Capacity

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

- **People:** Innovation may be about technology and business outcomes, but it is a social process. As such, innovation is driven by the people of Massachusetts who are actively involved in the innovation process. One of the Commonwealth's key competitive advantages in the global economy is a notable concentration of highly talented men and women of all origins and ages who choose to live, study, and work within its boundaries.
- **Capital:** Massachusetts attracts billions of dollars of funding every year for research, development, new business formation, and business expansion. Public funds support the most cutting-edge and forward-looking R&D efforts in both universities and research-oriented companies and organizations. Such funds also enable the



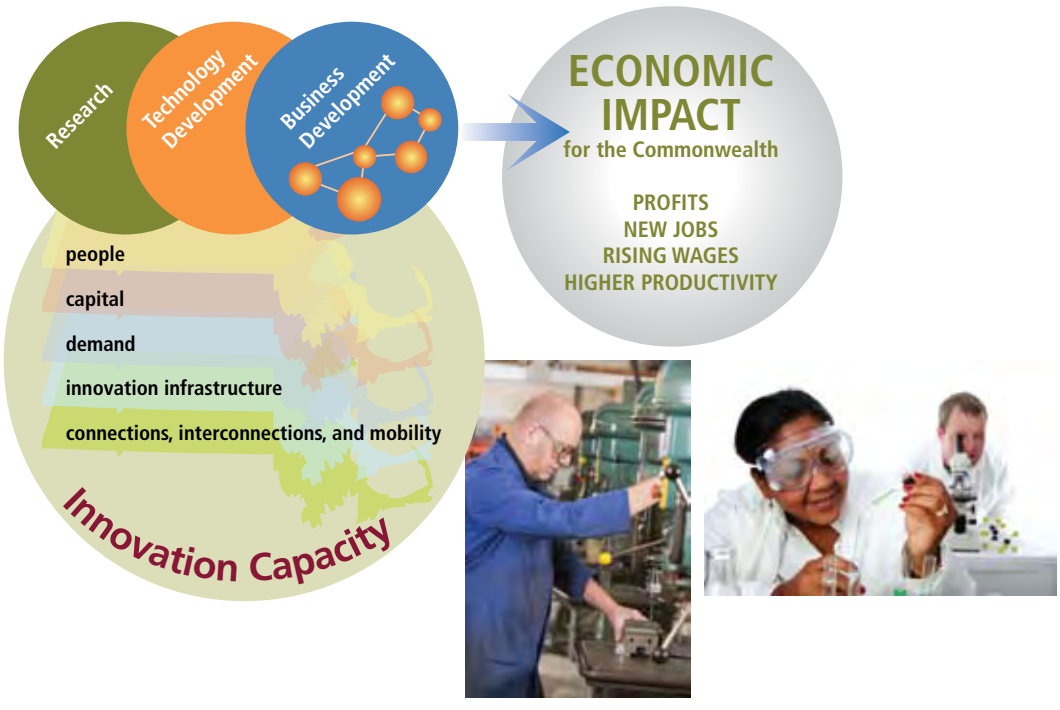
The institutional and human resources that Massachusetts can network through transportation, digital infrastructure, and collaborative networks create a cluster of innovation capability that gives the Commonwealth its competitive advantage.

Map data sources: NOAA Defense Meteorological Satellite Program, Radiance Calibrated Lights: 1996-1997; The coastline is masked using MASSGIS and RIGIS data.

development of proof-of-concept projects in businesses. Corporate funding for research is critical for applied research in corporate laboratories. For new business formation and expansion, Massachusetts' concentration of venture capitalists and angel investors is critical. Experts in these areas, capable of assessing the risk of new technologies and entrepreneurial ventures, are key partners in the innovation process and vital to its success.

- **Demand:** Demand for innovative products and services is an important driver of innovation. Not only does it provide a stream of revenue; it motivates entrepreneurs and businesses to keep creating new or improved products. In Massachusetts, demand for innovative products 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. Secondly, the federal government, through its mission-oriented agencies such as the Department of Defense and the Department of Energy among others, is a crucial "purchaser" of R&D services that sustains viability and pushes the technological frontier of many Massachusetts businesses.
- **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 necessary contributions throughout the innovation process.
- **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.
- **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 research 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.

The Massachusetts Innovation Ecosystem



2008 Indicators of the Massachusetts Innovation Economy

Highlights

This year's *Index* documents Massachusetts' strengths in its educated workforce, research and business development enterprise, and innovative industry clusters. Here are some of the top stories in the *Index* this year.

The Quest for Talent

Human capital measures are the most surprising movers this year. After four years of increasing brain drain in Massachusetts, the gap between out-migration and in-migration turned around in 2006 and continued to improve in 2007, a reflection of the improving economy. In the innovation ecosystem, a positive balance of trade in talent is important, but so is having a high rate of exchange connecting Massachusetts to other parts of the globe. This edition of the *Index* adds a new chart (in Indicator 19) illustrating that in 2007, Massachusetts ranks second among the Leading Technology States (LTS) for its ability to attract college educated adults from other states and abroad.

Massachusetts continued to solidify its position as having one of the best talent pools in the nation. Educational attainment figures (Indicator 18) show a decisive uptick for the working-age population and for the youngest cohort of adults. While Massachusetts has been at or near the top in educational attainment for years, Massachusetts saw a significant rise in college attainment in 2007 and 2008 establishing a lead over the other LTS. Massachusetts saw 11 percent growth in the working-age population with a college degree between 2005 and 2008 compared to 2 percent growth in the whole population age 25–65. Increasing educational attainment is one way Massachusetts, a state with slow population growth, can meet the workforce needs of a growing Innovation Economy.

While an increasing population of college educated adults bodes well for Massachusetts, the lack of income of people with two-year college and postsecondary technical education limits the Commonwealth's ability to grow the Innovation Economy and broaden its impact on the overall workforce. This is a segment of the workforce that fills many technical and middle management jobs and plays a particularly important role in advanced manufacturing in most states.

The progress achieved by the K-12 education system shows up in data for the youngest cohort of Massachusetts workers from 2005–2008. The percent of the population age 19–24 that has not yet completed high school declined from 12–8 percent. There has been an even larger percent change positive in this case from 60–71 percent of this age cohort that has at least started college.*

The State of the Research & Business Development Enterprise

Massachusetts continues to have one of the most R&D intensive economies in the world and an extraordinary capacity to move ideas from the laboratory to the marketplace. However, there are areas for concern. Some early stage innovation activity slowed in 2007. Recent data raise concerns about declining performance across several measures of early stage innovation activity: patents, invention disclosures, pre-market regulatory approvals of medical devices, and biopharmaceuticals. Although Massachusetts small businesses continued to rank first per capita in winning federal Small Business Innovation Research (SBIR) contracts, in FY 2006 Massachusetts experienced a decline in absolute dollars of awards and in market share .

The trends were not all negative, however. Several other measures of innovation activity remained strong in 2007, including business incorporations and initial public offerings. Despite a decline in patent awards (experienced by all of the LTS), Massachusetts is now tied with California for first place in rank in patents per capita.

*Current Population Survey, three-year rolling averages.

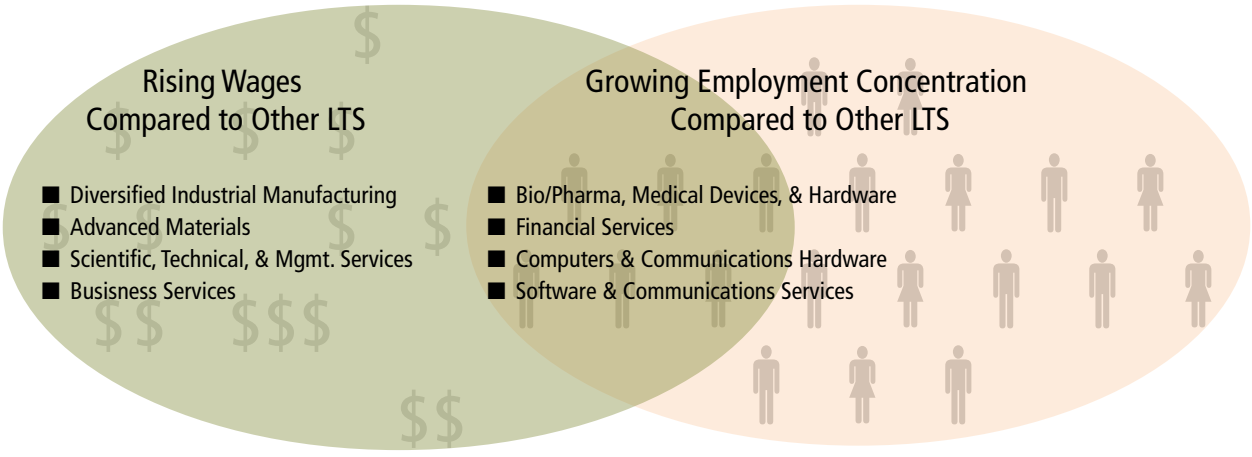
Economic Outcomes - Job Growth by Industry Cluster

The eleven key clusters added 37,000 jobs over the four years, 2003–2007. Software & Communication Services is arguably the strongest performing cluster in the 2003–– 2007 period adding jobs and growing wages faster than elsewhere in the United States. Relative to 2003, Massachusetts had a rising concentration of jobs in four of the eleven key clusters compared to the performance of each cluster nationally: Financial Services; Computer & Communications Hardware; Software & Communications Services; and Bio/Pharmaceuticals, Medical Devices, & Hardware. Massachusetts improved its job mix in eight of the eleven clusters with annual earnings rising faster in Massachusetts than the nation. The three clusters with wage growth slipping against the national average are Postsecondary Education, Healthcare, and Diversified Industrial Manufacturing.

Economic Outcomes - Income

Real median household income in Massachusetts is up in 2007 over 2006, but not over the period of 2003–2007. While not unique to Massachusetts, the erosion in real wages, especially for the bottom 40% of households, is pronounced. Combined with slow job growth in some sectors and 34% percent of working-age adults having no education beyond high school, there is room for progress in expanding the benefits of the Innovation Economy to a greater fraction of the population. Research by The University of Massachusetts' Donahue Institute (in Indicator 4) puts rising income inequality in bold relief.

Massachusetts Clusters with Strong Performance Relative to the LTS, 2003–2007



Construction of the *Index*

Indicator Selection

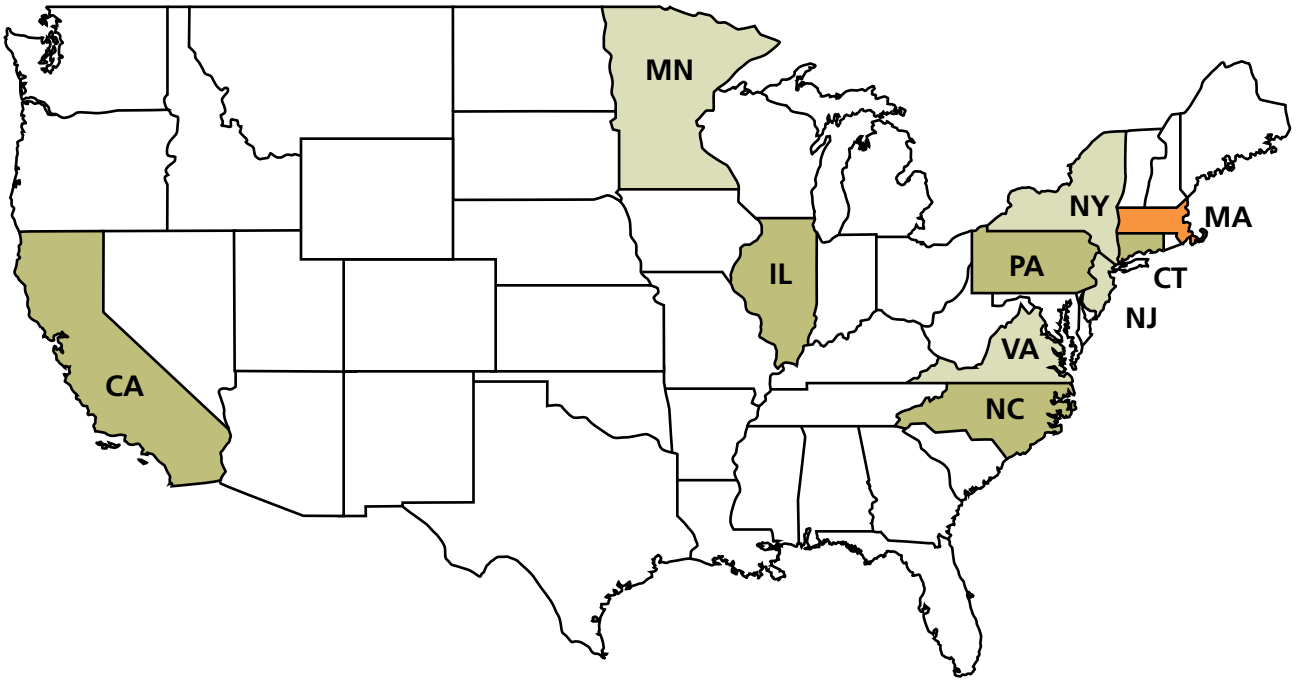
The indicators are quantitative measures that give an objective view into many dimensions of the dynamic and complex Innovation Economy and allow performance comparisons with other LTS. The indicators were selected to be statistically measurable on an ongoing basis and derived from objective and reliable data sources. It is the aim of the *Index* to publish indicators that are easily understood and accepted by business leaders, state policymakers, and community leaders

About the Data

The purpose of the *Index* is to look at changes in regional economic fundamentals rather than to track the state's position in the business cycle. The 20 Indicators in the *Index* are constructed with the most reliable data available to give us an objective look at where Massachusetts stands relative to other LTS. When necessary, we have used three-year averages with sample-based data such as the American Community Survey and Current Population Survey. Monthly estimates, 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 it advisors have worked hard to construct Indicators that will not be subject to any significant revisions.

In light of rapid increases in the cost of living, the *2008 Index* uses inflation-adjusted figures for most indicators. While firms are paying nominal wages that are higher in 2007 than in 2003, adjusted for inflation, many workers have seen the purchasing power of their wages decline. Consumer prices started to increase rapidly in 2007 and accelerated into 2008.

Leading Technology States (LTS)



Benchmark Comparisons: Leading Technology States (LTS)

Benchmark comparisons provide an important context for understanding how Massachusetts is performing in a relative sense. For this reason, performance indicators for Massachusetts are compared with other LTS, the national average, and/or with a composite measure of the other LTS. The nine LTS chosen for comparison in the *2008 Index* are the same as in those used in the *2007 Index*: California, Connecticut, Illinois, Minnesota, New Jersey, New York, North Carolina, Pennsylvania, and Virginia. Appendix A describes the methodology for selecting the LTS.

Eleven Key Industry Clusters

The *2008 Index* monitors the impact of innovation through eleven industry clusters (listed below) that are critical to the Commonwealth's economy and linked uniquely to the innovation process.

Together, these 11 core Innovation Economy clusters account for 39% of non-government employment in Massachusetts, including most of the highest paying jobs in the Commonwealth. Counting direct and indirect jobs, these innovation clusters support more than half of all state employment. For purposes of the *Index* analysis, however, indirect employment effects are not considered.

* See studies on employment multipliers published by the Economic Policy Institute and others.




Eleven Key Industry Clusters

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







Industry Cluster Employment and Wages

Why Is It Significant?

Increasing employment in technology- and knowledge-intensive industry clusters points to competitive advantages for the Massachusetts Innovation Economy and potential for future economic growth. Changes in mean wages are evidence of the shifting mix of higher and lower value-added jobs within the cluster.

How Does Massachusetts Perform?

The Massachusetts economy added 19,800 jobs among the 11 key industry clusters in 2007. Driving innovation job growth are the Scientific, Technical, & Management, and Healthcare Delivery clusters, both experiencing steady employment growth since 2003. Job losses in the Massachusetts Innovation Economy are concentrated in the Advanced Materials and Diversified Industrial Manufacturing sectors—with employment shrinking on average -3.8% and -3.6%, respectively, since 2003. Total employment among the Commonwealth's key clusters is projected to slow to 9,200 jobs added in 2008, with losses concentrated in the Computer & Communications Hardware; Diversified Industrial Manufacturing; and Financial Services clusters.

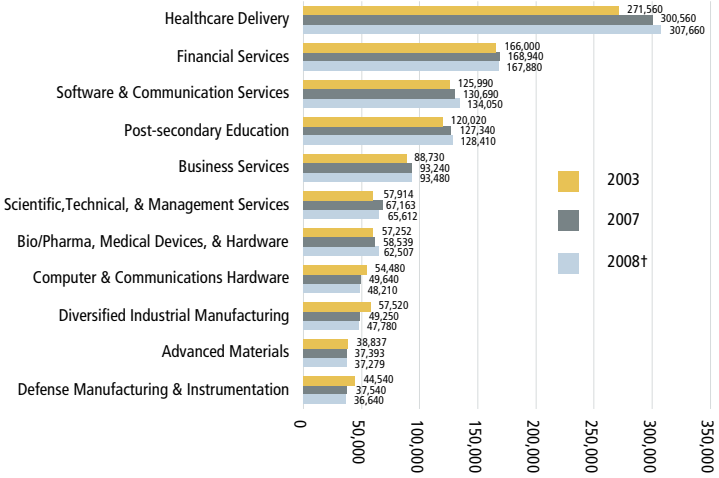
Adjusting for inflation, average annual pay in all of Massachusetts key industry clusters—with the exception of Postsecondary Education and Healthcare Delivery—increased last year over their 2003 level. The largest and most noticeable four-year average annual pay increase was in Financial Services. The strong growth of average pay in the Financial Services cluster is concentrated largely in the Other Investment Pools and Funds industry group, which saw average pay grow 185% since 2003.*

Indicator #1 Key Takeaways:

- Massachusetts added jobs faster than the average of the LTS and the US in four clusters in 2006–2007: Bio/Pharma, Medical Devices, & Hardware (2.6%); Defense Manufacturing & Instrumentation (3.5%); Financial Services (1.7%); and Healthcare Delivery (3.3%).
- Year-over-year job growth in the 11 key industry clusters is projected to slow considerably in 2008.
- Real average annual pay increased year-over-year in 2007 for 9 of the 11 key clusters in Massachusetts, with Healthcare Delivery and Postsecondary Education the only two to experience real annual pay decline.

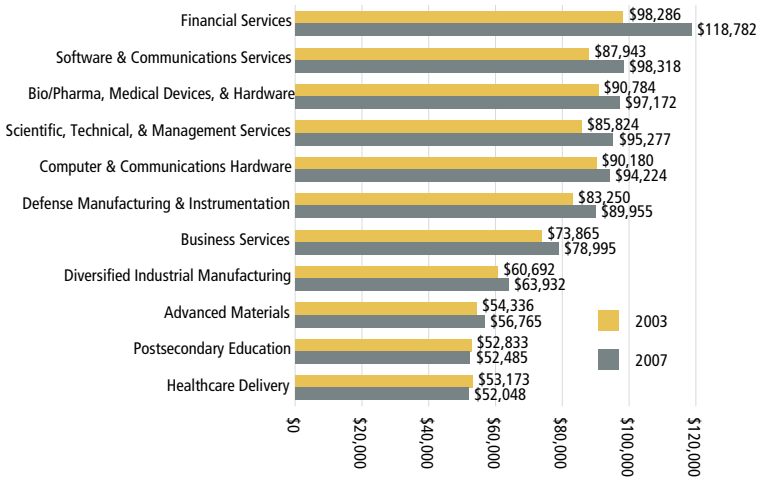
*NAICs code 5259. This industry group comprises legal entities (i.e., investment pools and/or funds) organized to pool securities or other assets (except insurance and employee-benefit funds) on behalf of shareholders, unit holders, or beneficiaries.

Total employment by industry cluster, Massachusetts, 2003, 2007, and 2008



Source: Moody's Economy.com (†2008 estimated in October 2007)

Average annual wage by cluster, in 2007 dollars, Massachusetts, 2003 and 2007



Source: Bureau of Labor Statistics

Percent change in cluster employment, 2006-2007

	CA	CT	IL	MA	MN	NJ	NC	NY	PA	VA	US
Advanced Materials	-3.3%	-2.1%	-2.8%	-3.0%	-1.5%	-6.0%	-3.1%	-7.4%	-2.2%	-5.2%	-2.9%
Bio/Pharma, Med Dev, & Hdwe	1.0%	-1.1%	-2.1%	2.6%	1.3%	0.7%	0.2%	0.5%	-1.4%	3.1%	1.7%
Business Services	1.5%	-0.1%	1.5%	1.4%	1.0%	0.2%	5.0%	2.9%	1.5%	1.0%	2.0%
Computer & Comm Hdwe	0.0%	2.0%	-4.2%	-1.4%	-5.7%	-3.9%	0.1%	-3.6%	-3.9%	1.0%	-3.4%
Def Mfg & Instrumentation	-1.1%	1.1%	3.3%	3.5%	0.6%	-2.1%	4.8%	1.6%	2.2%	-10.1%	1.5%
Diversified Ind Mfg	-0.8%	-1.4%	-0.9%	-2.7%	1.6%	-4.2%	1.6%	-0.8%	-1.3%	2.5%	-1.0%
Financial Services	-0.4%	0.8%	0.8%	1.7%	0.7%	0.7%	3.1%	1.1%	0.0%	0.5%	1.1%
Healthcare Delivery	2.5%	2.1%	2.1%	3.3%	4.9%	2.1%	3.7%	2.4%	2.3%	2.6%	2.9%
Postsecondary Education	3.5%	3.4%	1.8%	1.8%	7.0%	5.5%	5.4%	2.9%	1.6%	4.0%	2.8%
Scientific, Tech, & Mgmt Svcs	4.4%	0.2%	0.0%	2.1%	6.8%	2.6%	9.0%	3.3%	2.2%	4.0%	5.6%
Software & Comm Svcs	5.8%	-0.7%	6.0%	2.2%	-1.9%	3.4%	3.8%	-0.5%	-0.3%	1.1%	1.8%
Total State Employment	0.5%	0.7%	0.5%	0.9%	1.1%	0.2%	1.5%	1.5%	0.7%	0.4%	0.7%

Source: Moody's Economy.com (Shaded cells show positive employment growth)

Corporate Sales, Publicly Traded Companies

Why Is It Significant?

The volume and growth of corporate sales by publicly traded companies underpin the fundamental soundness and future prospects of an industry cluster. Examining corporate sales data across the LTS and the US provides insight into the patterns of a particular cluster's market demand as well as the competitiveness of industry players within a cluster. While highly affected by productivity changes, corporate sales are nonetheless an early and significant indicator of potential employment change and the potential of a cluster to create new jobs.

How Does Massachusetts Perform?

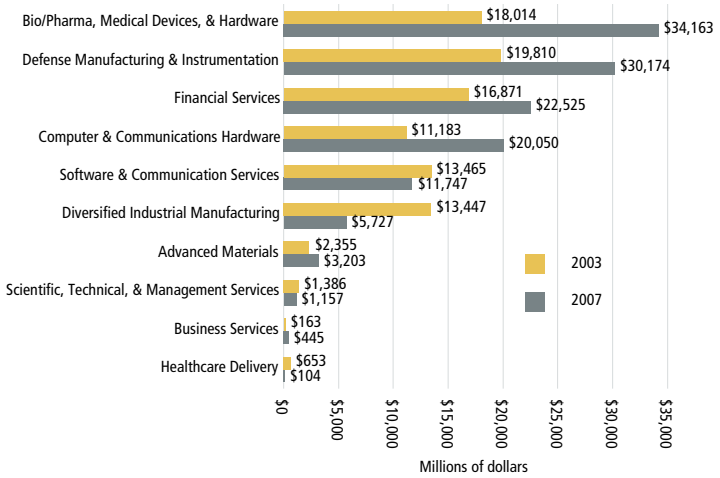
In 2007, Massachusetts ranked ninth among the LTS in terms of corporate sales, with an average of $428 million in sales for each publicly traded company headquartered in Massachusetts. The largest four-year average annual growth rates (AAGR) of corporate sales in Massachusetts have occurred among the Bio/Pharma, Medical Devices, & Hardware (17%) and Computer & Communications Hardware (16%) clusters. Corporate sales in the Scientific, Technical, & Management Services cluster show a declining AAGR of -4% since 2003. The sharp decline in corporate sales in the Diversified Industrial Manufacturing sector can be attributed largely to the 2005 acquisition of Boston-based Gillette Company by Cincinnati-based Procter & Gamble. When adjusting for the 11 billion dollars lost with the acquisition of Gillette, the cluster has grown 15% annually, on average, since 2005.

From 2003 to 2007, however, the AAGR of total cluster-based corporate sales in Massachusetts was 7%, slightly above the LTS average.

Indicator #2 Key Takeaways:

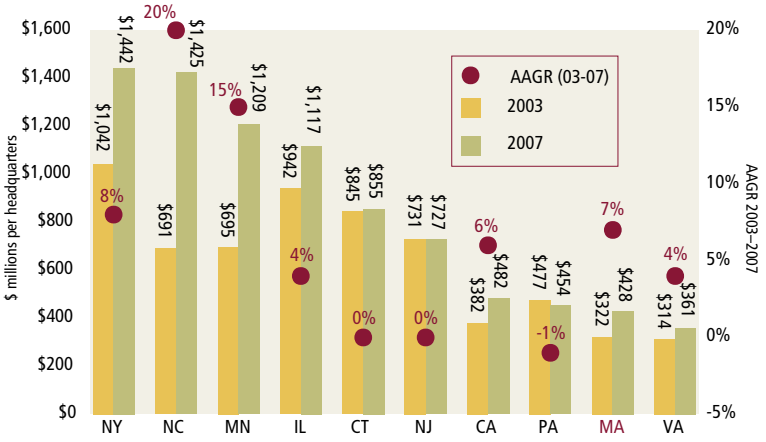
- Massachusetts ranked relatively low in terms of corporate sales per number of headquarters in 2007.
- Six of the 10 key industry clusters in Massachusetts showed growth in corporate sales of publicly-traded companies between 2003 and 2007.
- Massachusetts demonstrates impressive AAGRs in the following industry clusters: Business Services (28%); Bio/Pharma, Medical Devices, & Hardware (17%); and Computer & Communications Hardware (16%).

Corporate sales by cluster, companies with headquarters in Massachusetts, 2003 and 2007



Source: Standard & Poor's COMPUSTAT

Corporate sales per headquarters (all clusters), LTS, 2003 and 2007



Source: Standard & Poor's COMPUSTAT and ReferenceUSA

Occupations and Wages

Why Is It Significant?

Massachusetts embraces the Innovation Economy as a means to grow its base of middle- and high-wage jobs and provide a rising standard of living to people throughout the Commonwealth. Changes in occupational employment and wages provide clues about shifts in job quality as well as the skill mix of the workforce cutting across all industries.

How Does Massachusetts Perform?

Among the LTS, Massachusetts has the greatest share of its total state employment in the Professional & Technical (17.8%); Life, Physical, & Social Sciences (1.5%); and Healthcare (9.5%) occupational categories. These categories are among the highest-paying and fastest-growing in both Massachusetts and the nation. Among all occupational categories in Massachusetts, Life, Physical, & Social Sciences—which includes market research analysts, biological technicians, and medical scientists, among other occupations—has the second highest average annual pay and the highest employment concentration relative to the US. Life, Physical, & Social Sciences is among the fastest-growing categories in Massachusetts and has the highest growth rate in the country at 3.8%.

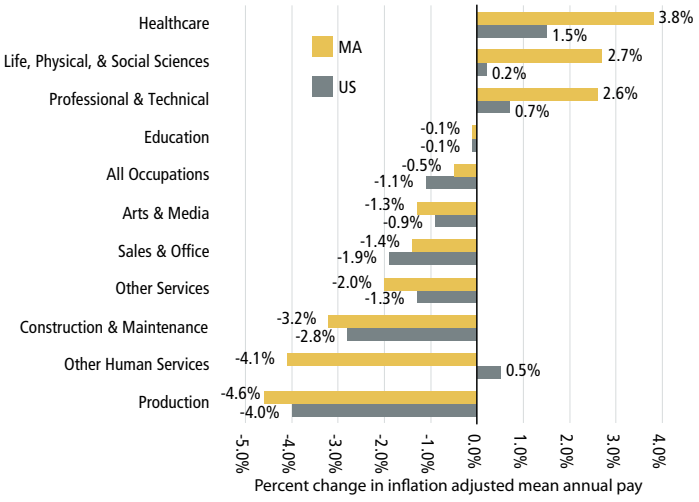
Arts & Media, representing arts, design, entertainment, sports, and media occupations, shows the strongest job growth rate in Massachusetts for the past four years at 4.6% annually. These occupations are the core of the creative economy.

The only occupations making real gains in annual pay between 2003 and 2007 are Healthcare; Life, Physical, & Social Sciences; and Professional & Technical. Wage growth in Massachusetts was stronger than the US average in each of these three occupational groups. The other seven occupational groups experienced declining real annual pay between 2003 and 2007.

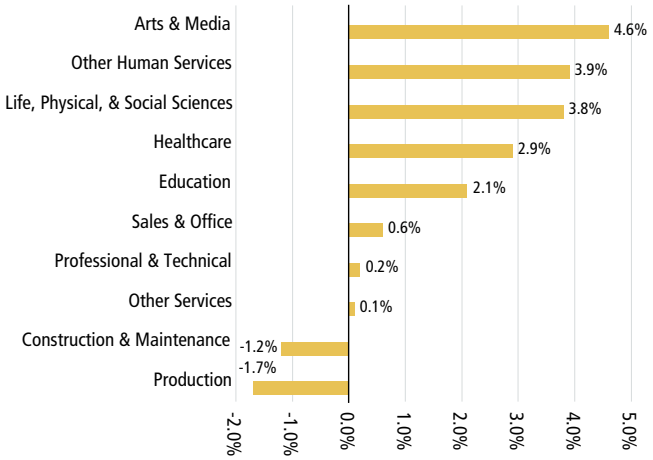
Indicator #3 Key Takeaways:

- Massachusetts has the highest concentration of employment in the Professional & Technical; Life, Physical & Social Sciences; and Healthcare occupations among the LTS. These are also the only three occupations making real gains in annual pay from 2003 and 2007.
- Arts & Media shows the strongest job growth rate signifying growth in Massachusetts creative economy.

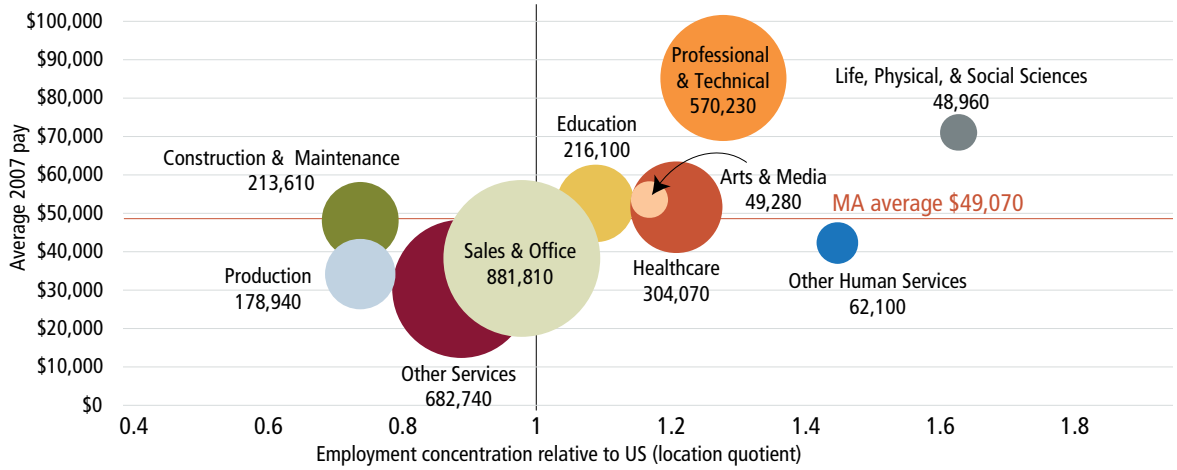
Change in real annual pay by occupation, Massachusetts and US, 2003 to 2007



Average annual employment growth by occupation, Massachusetts, 2002-2006



Occupations by employment concentration and annual pay, Massachusetts, 2007



Circle size represents employment total by occupation

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

Household Income

Why Is It Significant?

Rising household incomes relative to inflation enable overall increases in a region's standard of living. Median household income tracks changes in the general economic condition of the middle income households in Massachusetts and other LTS. Measures of income disparity are important in assessing the extent to which the benefits of the Innovation Economy are broadly shared.

How Does Massachusetts Perform?

In 2007, Massachusetts median household income outpaced inflation by about 0.8% over 2006. The Commonwealth is one of five LTS in which median income growth did not outpace inflation over the past five years, from 2003-2007. During this period, the median Massachusetts household experienced declining real income while median income in the US rose slightly. In comparison, the respective winners and losers were New Jersey with median household income up 6% in real terms and Minnesota with a 6% decline since 2003.

Analysis by the University of Massachusetts Donahue Institute provides a comprehensive picture of median income shifts for families in Massachusetts over the last three decades.* Median family incomes grew significantly faster than inflation in the 1980s and 1990s, but lost ground from 1999 through 2006 with income disparities widening consistently over all three decades.

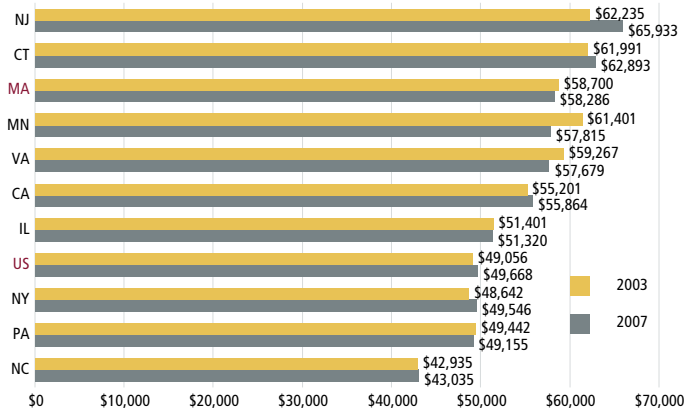
The American Community Survey allows us to compare the income distribution in Massachusetts to the US using the mean income of households by income quintile. For Massachusetts households, each of the upper four income quintiles have mean incomes approximately one fifth more than the US average. In contrast, the mean income of the lowest income quintile of households is only 10% above the US average. Massachusetts compares well for strong earnings among middle income households. The mean income of the top 20% of households is $208,000, 16 times the mean income of the lowest earning 20% of households, $13,000.

Indicator #4 Key Takeaways:

- In 2007, median household income in Massachusetts outpaced inflation by 0.8%.
- Family incomes in Massachusetts outpaced inflation in the 1980s and 1990s, but declined in real dollars from 1999 through 2006.

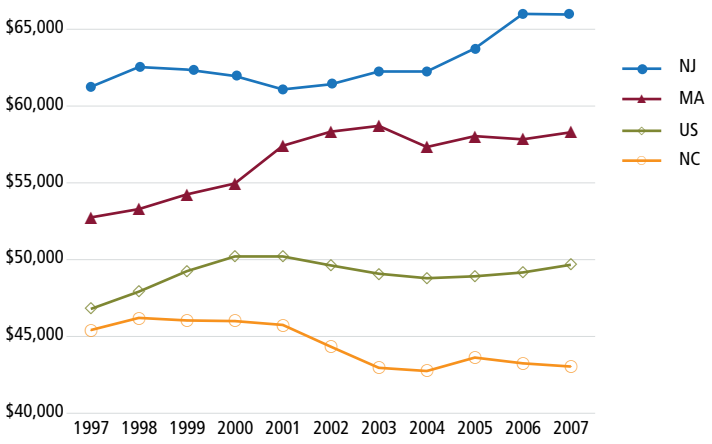
*UMass Donahue Institute. 2008. Rebecca Loveland, Robert Nakosteen, Raija Vaisanen, and Roy Williams. "Income Inequality in Massachusetts, 1980 – 2006." *Mass*Benchmarks. Volume 10, Issue 2.

Three-year average median household income, in 2007 dollars, LTS and US, 2003 and 2007



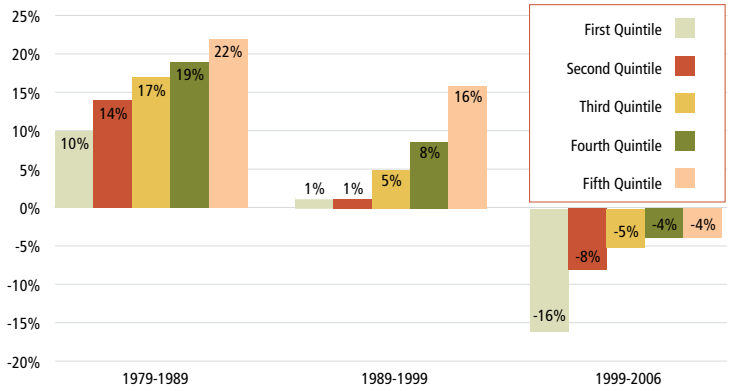
Source: US Census Bureau

Three-year average median household income, in 2007 dollars, LTS and US, 1997-2007



Source: US Census Bureau

Change in median family income by quintile over three decades, in 2006 dollars, Massachusetts



Source: UMass Donahue Institute analysis, based on US Census Bureau Decennial Census and American Community Survey PUMS, *MassBenchmarks* 10:2

Manufacturing Exports

Why Is It Significant?

Manufacturing exports are an indicator of the Commonwealth's global competitiveness. Supplying emerging global markets can help bolster growth in employment and sales, and increase the market share for innovation-intensive companies in Massachusetts. Moreover, 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?

In 2007, Massachusetts increased the total value of manufacturing exports as a share of state Gross Domestic Product (GDP), and now exports relatively more than California by this metric. Massachusetts manufacturing export value increased 5% in 2007, and grew 7% per year on average between 2003 and 2007. Data for the first half of 2008 shows a 14.7% increase in manufactured exports over the same period in 2007.

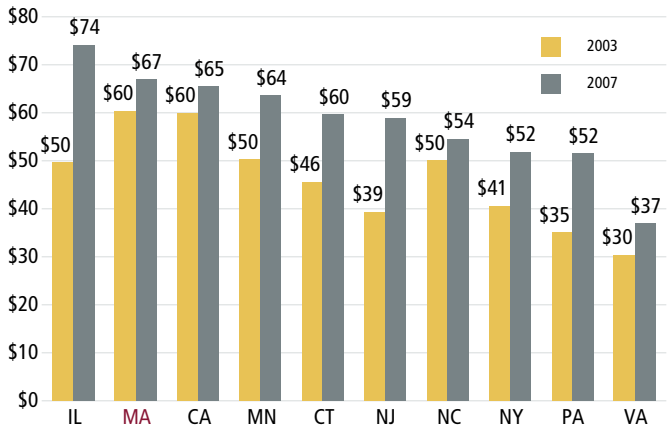
The distribution of Massachusetts top export categories—Computer & Electronic Products, Chemicals, Machinery, and Miscellaneous Manufactured Commodities—have held steady over the last three years. The share of Computer & Electronic Products exports has decreased more than 10% since 2003; still, this sector, which includes information technology products, analytical instruments, and electronic medical devices, maintains the largest share of total state exports.

The top foreign importers of commodities produced by Massachusetts-based companies in 2007 were Canada, Germany, and Great Britain. Massachusetts exports to emerging markets in China, Taiwan, India, Russia, and Egypt have all increased rapidly in the past five years. In the first half of 2008, the weakening position of the dollar against the euro, British pound, and Canadian dollar has given Massachusetts exporters a boost.

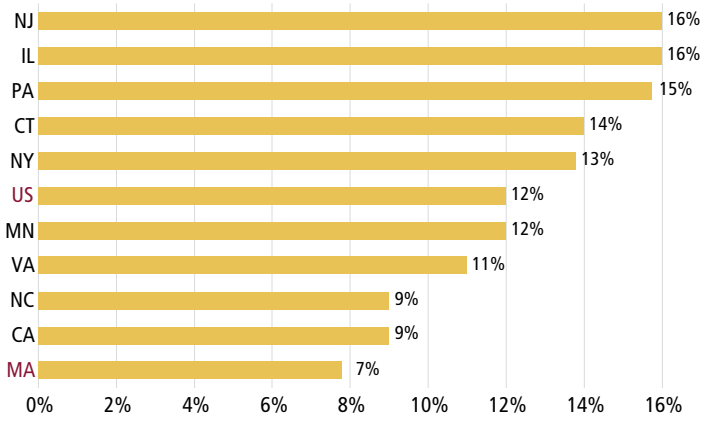
Indicator #5 Key Takeaways:

- Among the LTS, Massachusetts ranks second in manufacturing exports as a share of state GDP. However the average annual growth between 2003 and 2007 is the lowest of the LTS.
- The distribution of Massachusetts top export categories—Computer & Electronic Products, Chemicals, Machinery, and Miscellaneous Manufactured Commodities—have held steady over the last three years.
- Over the past five years, Massachusetts exports to China and Taiwan increased at an average annual rate of more than 20%.

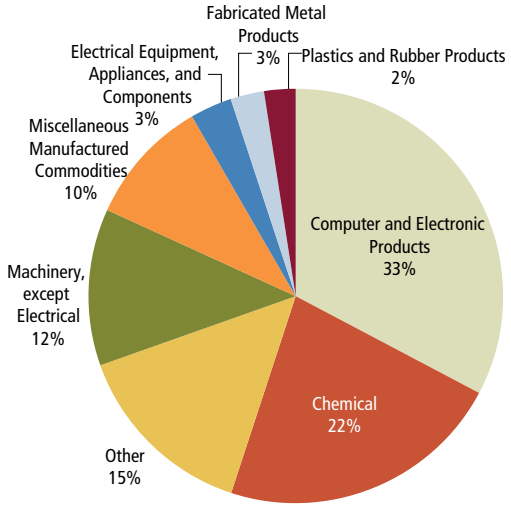
Manufacturing exports per $1,000 state GDP, LTS, 2003 and 2007



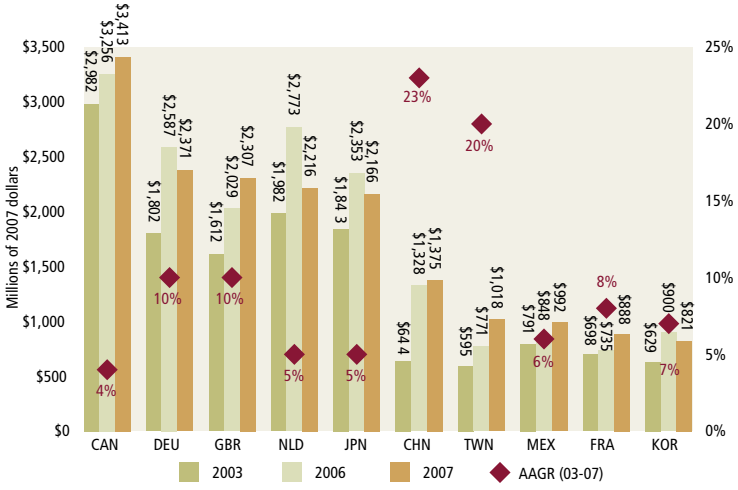
Average annual growth rate (AAGR) of manufacturing exports, LTS and US, 2003–2007



Distribution of manufacturing exports, Massachusetts, 2007



Export value by top foreign trade destination, all commodities, Massachusetts, 2003, 2006, and 2007



Source of all data for this indicator: WiserTrade

New Business Incorporations

Why Is It Significant?

The number of new business incorporations per year is an indicator of economic dynamism. A relatively high number of business starts typically indicates an economic environment with the capacity to support new entrepreneurial ventures and pursue new business ideas. Successful new companies not only produce their own jobs, goods, and services, but also create an increased demand for new ideas, products, and services.

How Does Massachusetts Perform?

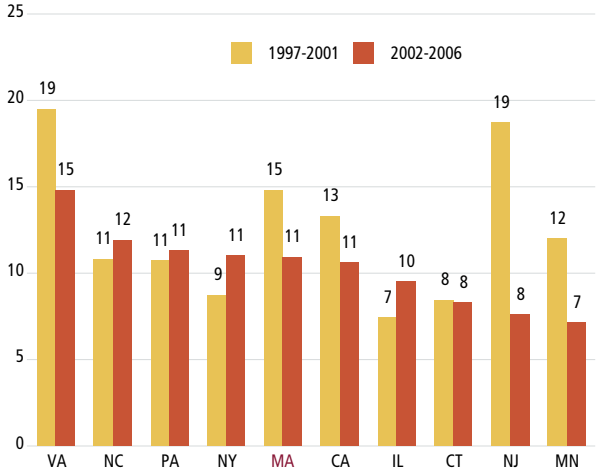
New business incorporations in Massachusetts continue to grow steadily, with 31,919 new incorporations in 2007—464 more than the prior year. Over the last five years domestic for-profit incorporations have slowed slightly, while new foreign incorporations in Massachusetts have grown 6% per year, on average. Massachusetts offers a range of business incubators to support new business formation. In 2007, Massachusetts ranked first among the LTS in the number of business incubators per 10,000 business establishments.

Particularly important to the Innovation Economy are new businesses spinning out of research institutions. Massachusetts' strength in research is leveraged into a strong second place next to California in the number of start-up companies originating from the research at universities, hospitals, and not-for-profit research institutions. However, when the number of spin-outs is scaled based on the volume of research expenditures the states are less differentiated. Massachusetts drops to fifth place among the LTS in start-ups per dollar of research. Over the last decade, 32 research institutions in Massachusetts report at least one start-up company as a consequence of their research. Massachusetts Institute of Technology stands out for the number of spin-out ventures, followed by Boston Children's Hospital, Harvard University, and Massachusetts General Hospital.

Indicator #6 Key Takeaways:

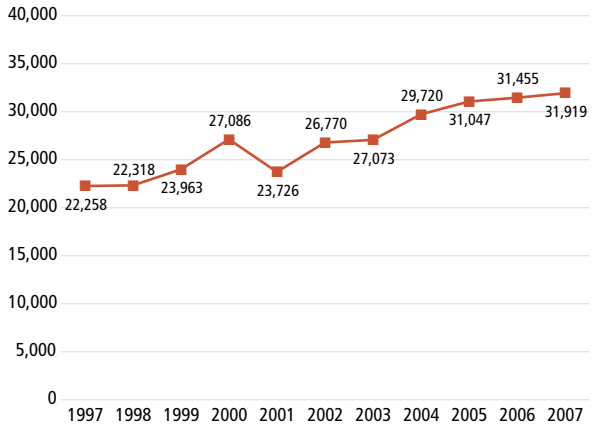
- New business incorporations in Massachusetts continue to grow steadily, with 31,919 new incorporations in 2007.
- The fastest growing segment of new business incorporations in Massachusetts is foreign incorporations.
- Massachusetts has a strong second place position in the number of start-up companies originating from research at universities, hospitals, and not-for-profit research institutions.

Spin-out companies from research institutions per billion 2007 dollars of research expenditures, LTS, 1997–2001 and 2002–2006



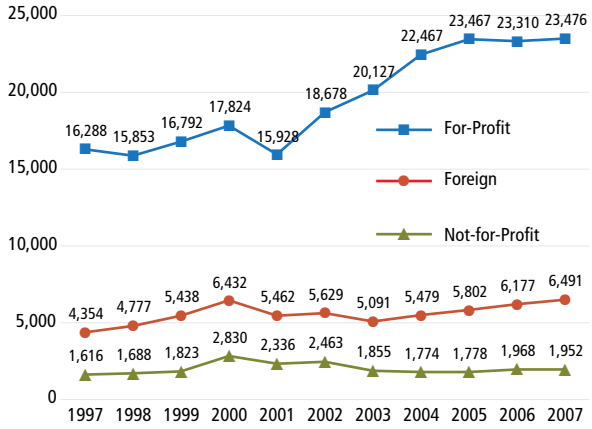
Source: Association of University Technology Managers (AUTM)

Total new business incorporations, Massachusetts, 1997–2007



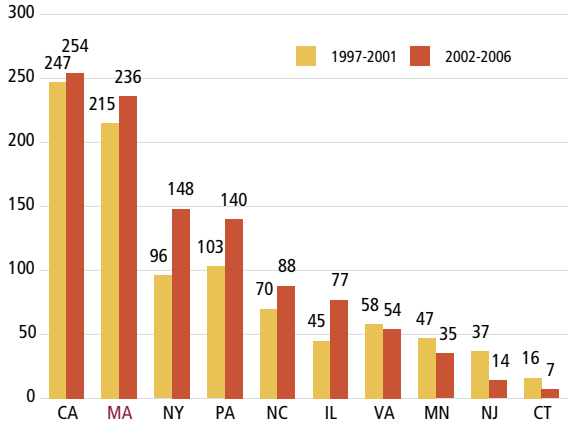
Source: Commonwealth of Massachusetts

New business incorporations by category, Massachusetts, 1997–2007



Source: Commonwealth of Massachusetts

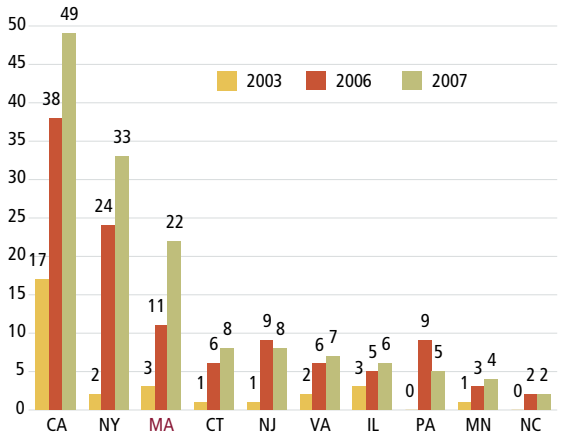
Spin-out companies from research institutions, LTS, 1997–2001 and 2002–2006



Source: Association of University Technology Managers (AUTM)

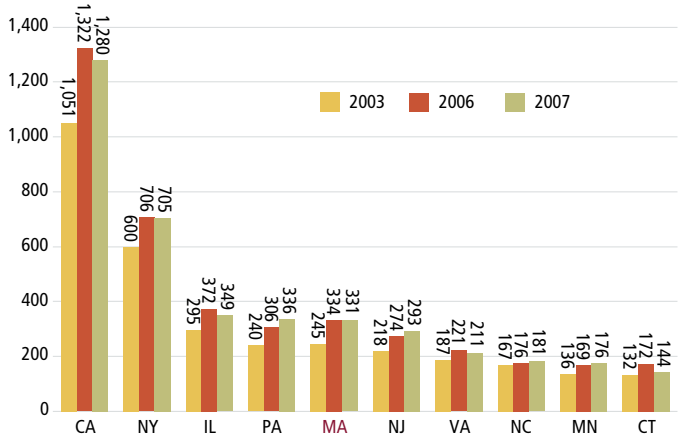
Initial Public Offerings and Mergers & Acquisitions

Initial public offerings, LTS, 2003, 2006, 2007



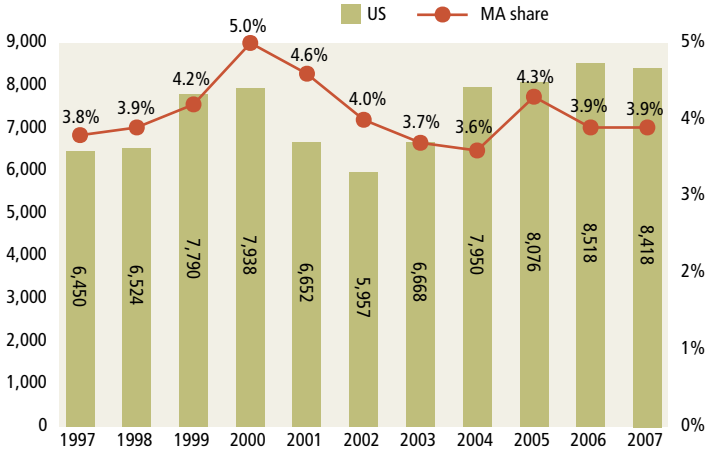
Source: Renaissance Capital, IPO Home

Mergers and acquisition by location of acquired company, LTS, 2003, 2006, 2007



Source: FactSet MergerStat, LLC

Mergers and acquisitions and Massachusetts' share of total US, 1997-2007



Source: FactSet MergerStat, LLC

Why Is It Significant?

The number of initial public offerings (IPOs) indicates the number of companies with potential for rapid growth in the Innovation Economy. IPOs are issued when privately owned companies opt to offer common stock to the public. "Going public" via an IPO is intended to raise significant capital to stimulate next-stage growth, typically in the form of investments in R&D, new employee hiring, or business development. A successful IPO reflects investor confidence that a company can increase in value, sustain growth, and produce satisfactory returns on investment.

Mergers and acquisitions (M&As) are another critical avenue for achieving liquidity for entrepreneurs and investors in rapidly growing firms seeking to diversify, accelerate new product development, or expand market share. However, in an environment of numerous M&A transactions, there exists the risk of significant job losses as the result of the elimination and/or consolidation of redundant functions and the relocation of offices or operations, especially if the acquiring company is an out-of-state firm.

How Does Massachusetts Perform?

Massachusetts ranked third among the LTS in IPOs issued in 2006 and 2007, trailing California and New York. In 2007, the number of IPOs in Massachusetts doubled from a year earlier to 22, with $1.9 billion in proceeds. The historical high for IPOs occurred in 2000, when 34 Massachusetts-based companies went public, totaling $7.1 billion in proceeds. At the time of publication, there are 10 IPOs in the pipeline but no IPOs issued for Massachusetts-based companies in 2008.*

Although total US M&A activity reached near-record levels, fewer Massachusetts companies were acquired in 2007 than in 2006. M&A transactions in Massachusetts account for 3.9% of the US total, down from an historical high of 5% in 2000. The Commonwealth ranks fifth among LTS in M&A deals, down one place since the **2007 Index**.

Indicator #7 Key Takeaways:

- The number of IPOs issued in Massachusetts doubled in 2007 to 22, the largest one-year growth rate among the LTS. As of publication, there are no IPOs issued for Massachusetts-based companies in 2008.
- Mergers and acquisitions of Massachusetts companies remained steady in 2007.

*Renaissance Capital's IPOhome.com

Technology Fast 500 Firms and Inc. 500 Firms

Why Is It Significant?

The Technology Fast 500 list compiled by Deloitte and Touche, LLP and the Inc. 500 firm list compiled by **Inc. Magazine** provide insight into the number of rapidly growing gazelle* firms in a region. The Technology Fast 500 ranks the fastest growing technology, media, telecommunications, and life sciences companies in North America based on percentage revenue growth over five years (2002–2006). The Inc. 500 ranks independent, privately held companies with rapid revenue growth from 2004 through 2007.

How Does Massachusetts Perform?

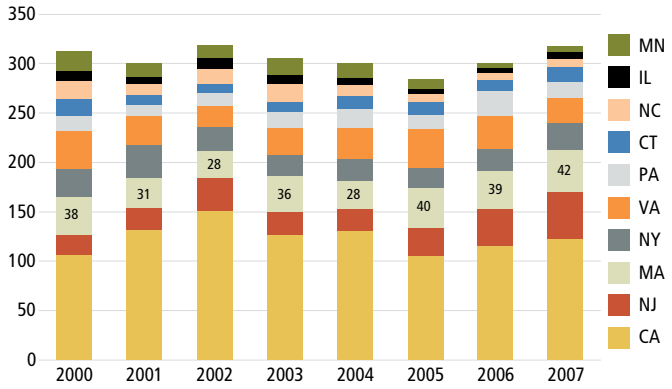
The number of Massachusetts-based firms named in the 2007 Technology Fast 500 list increased significantly from 2004, from 28 to 42. The number of Massachusetts-based Inc. 500 firms remained virtually unchanged. The shares of Technology Fast 500 and Inc. 500 companies based in the LTS have remained largely unchanged since 2000. Massachusetts consistently has more companies on the Technology Fast 500 than on the Inc. 500.

Indicator #8 Key Takeaways:

- Marking a historic high, 42 firms based in Massachusetts were named in the Technology Fast 500 in 2007.
- Twenty-seven Massachusetts-based firms were named in the Inc. 500 in 2007, approaching Massachusetts' peak level of 29.
- Massachusetts consistently has more companies on the Technology Fast 500 than on the Inc. 500.

* A "gazelle" firm is one that has grown at 20% per year or greater for at least a five year period.

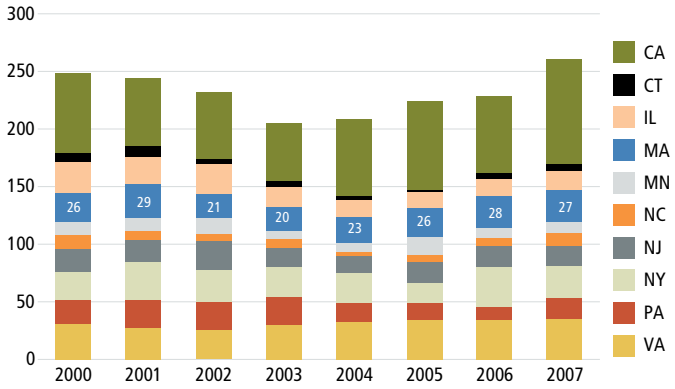
Technology Fast 500 firms, LTS, 2000–2007



	2000	2001	2002	2003	2004	2005	2006	2007
MN	20	13	13	17	15	10	5	5
IL	11	7	11	10	7	4	5	7
NC	18	11	15	18	11	9	7	8
CT	16	11	10	9	13	12	12	15
PA	16	11	13	17	19	15	24	17
VA	38	29	21	27	31	39	34	24
NY	29	33	24	22	23	21	22	28
MA	38	31	28	36	28	40	39	42
NJ	21	22	33	23	22	29	37	48
CA	106	132	151	127	131	105	116	123

Source: Deloitte & Touche LLP

Inc. 500 firms, LTS, 2000–2007

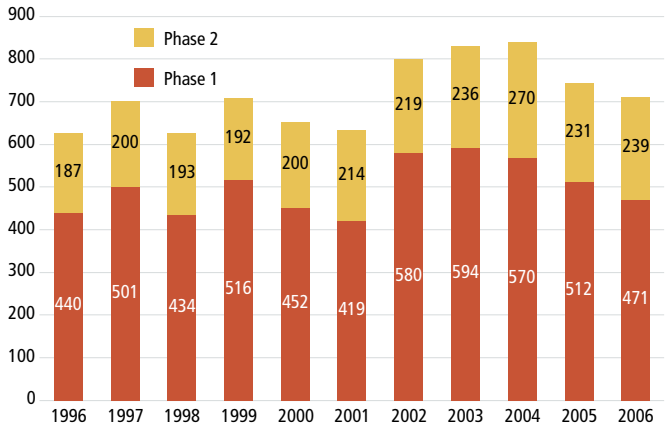


	2000	2001	2002	2003	2004	2005	2006	2007
CA	69	59	58	50	66	77	66	91
CT	7	9	4	5	3	1	5	6
IL	27	24	26	18	15	14	15	17
MA	26	29	21	20	23	26	28	27
MN	11	11	14	7	7	15	8	10
NC	12	8	6	8	4	6	7	11
NJ	20	19	25	17	15	19	19	18
NY	24	33	28	26	26	17	34	27
PA	21	25	24	24	16	14	12	19
VA	31	27	26	30	33	35	34	35

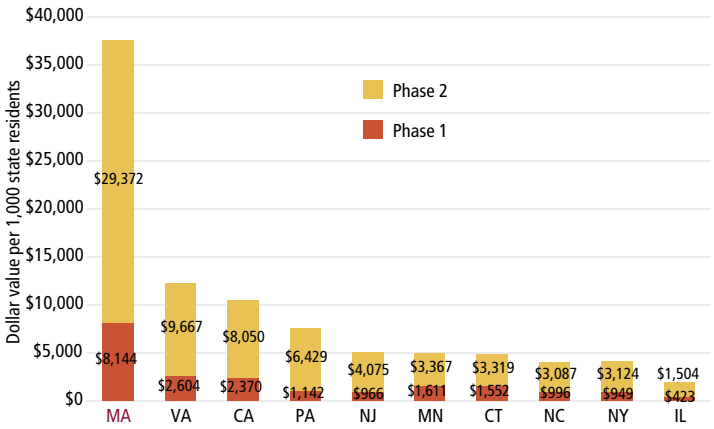
Source: *Inc. Magazine*

Small Business Innovation Research Awards

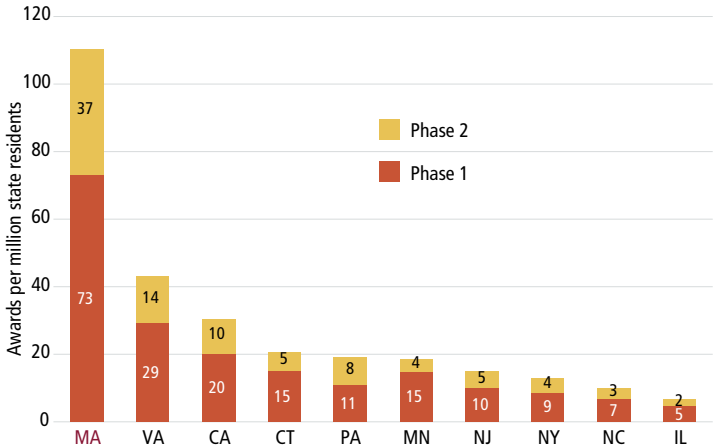
SBIR awards to companies by phase, Massachusetts, 1996–2006



Dollar value of SBIR awards, per capita, LTS, 2006



SBIR awards to companies, per capita, LTS, 2006



Why Is It Significant?

The federal Small Business Innovation Research (SBIR) Program is a highly competitive federal grant program that enables small companies to conduct proof-of-concept (Phase 1) research on technical merit and idea feasibility and prototype development building (Phase II) on Phase I findings.

Unlike other federal research grants that support basic research, SBIR grants are reserved for applicant teams led by companies with fewer than 500 employees. The program is intended to address the technology needs of the federal government 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?

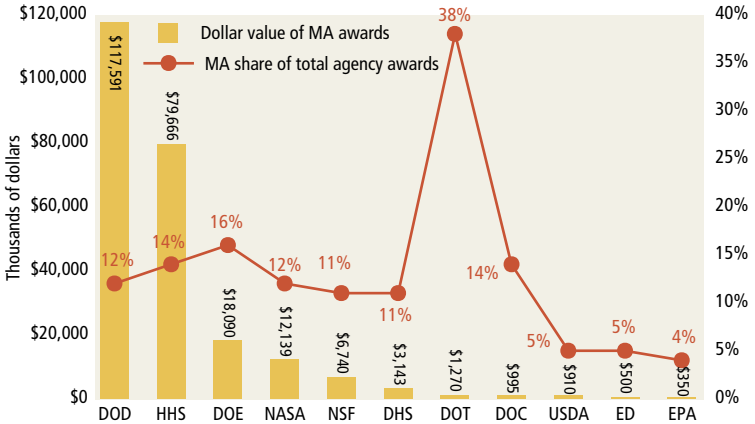
Massachusetts small businesses are very successful in winning a major share of the R&D funding available from the SBIR program. While second to California in absolute terms (dollar value and number of awards), Massachusetts is by far the greatest recipient of SBIR funding on a per-capita basis. There was a decline for the second straight year in the number of SBIR awards granted in Massachusetts, dropping 16% from its ten-year peak in 2004. In 2006, Massachusetts received more than three times the SBIR dollars per capita of its closest competitors, Virginia and California.

In 2006, 17 of the 18 SBIR awards greater than one million dollars to Massachusetts companies were for medical research. Department of Defense (DOD) and Health and Human Services (HHS) are by far the largest sources of SBIR awards in Massachusetts.

Indicator #9 Key Takeaways:

- Massachusetts small businesses were awarded 12% of the $2 billion in federal 2006 SBIR dollars, putting $241 million to work to support innovation research and prototype development in the Commonwealth.
- The number of SBIR awards to Massachusetts firms in 2006 declined 16%.
- On a per-capita basis, Massachusetts maintains a strong lead in obtaining SBIR funding.

SBIR awards by agency, Massachusetts, 2006



Source of all data for this indicator: US Small Business Administration (SBA)
More recent data unavailable for this indicator at time of publication

Regulatory Approval of Medical Devices and Biotechnology Drugs

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) 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 (CDER). Biotechnology drugs now in development utilize state-of-the-art technologies to treat cancer, infectious diseases, autoimmune disorders, and other medical conditions. This measure reflects innovation in health research and pharmaceutical manufacturing.

How Does Massachusetts Perform?

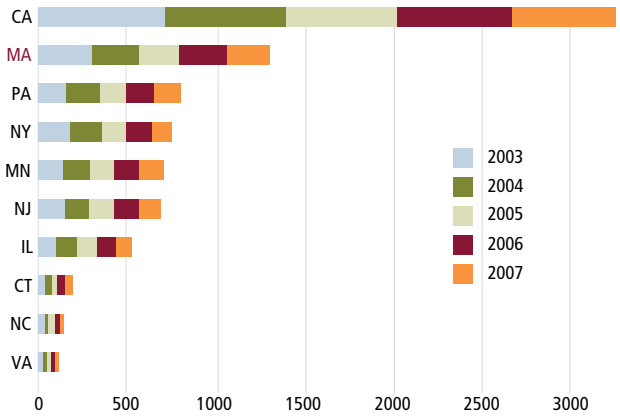
Massachusetts regularly ranks high among the LTS with regard to medical device approvals and biotechnology drug approvals. This reflects the Commonwealth's strong life sciences and healthcare technology sectors. In 2007, however, Massachusetts experienced a decrease in both PMA and 510(k) approvals. 510(k)s are at their second lowest number in the last decade with 241 approvals. There was an overall increase in biotechnology drugs in development among the LTS in 2008, while the number in Massachusetts decreased.

Indicator #10 Key Takeaways

- In 2007, the number of 510(k) submissions in Massachusetts was at its second lowest level since 1996, with 241 approvals.
- Following a national decline in releasable PMAs in 2007, there were no PMAs granted to Massachusetts companies last year.
- As of July 2008, Massachusetts-based biopharmaceutical companies had 76 biotechnology drugs in development, representing 12% of all drugs in development.

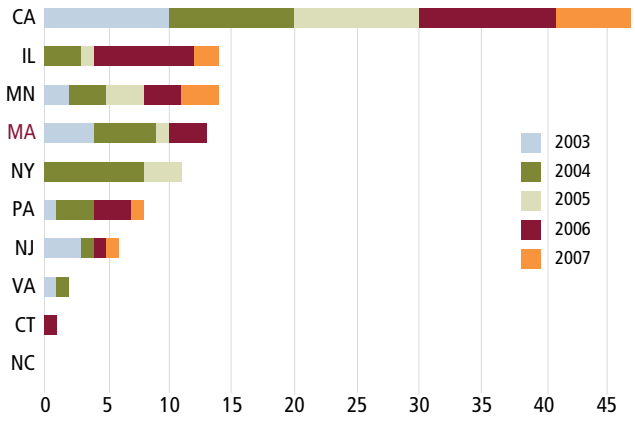
*The data include only medicines that involve recombinant DNA, monoclonal antibody/hybridoma, continuous cell lines, cellular therapy, gene therapy and vaccines technology are included.

Medical device pre-market notifications (releasable 510(k)s), LTS, 2003–2007



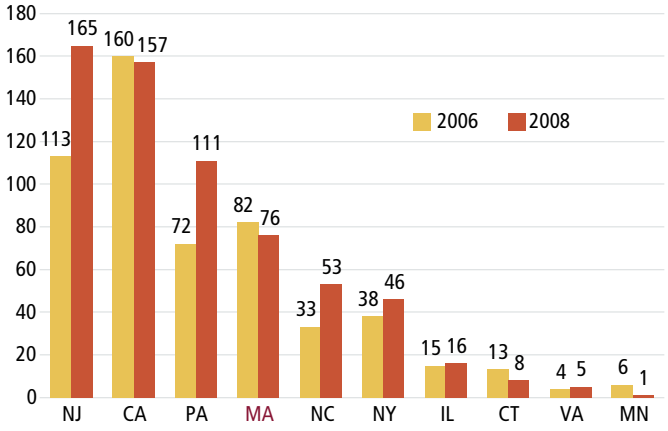
Source: US Food and Drug Administration

Medical device pre-market approvals (PMAs), LTS 2003–2007



Source: US Food and Drug Administration

Biotechnology drugs in development, LTS, 2006 and 2008



Note: 2006 data collected through June 1, 2006; 2008 data collected through July 31, 2008.
Source: Pharmaceutical Research and Manufacturers of America (PhRMA)

Corporate R&D Expenditures, Publicly Traded Companies

Why Is It Significant?

Corporate research and development (R&D) is an essential ingredient in the formula for producing innovative new products and services that keep Massachusetts companies competitive in the global marketplace. It is evidence of company commitment to long-term investment and the company's assessment of market demand for new products. This indicator reports corporate R&D expenditures at publicly traded companies by the location of the corporate headquarters.

How Does Massachusetts Perform?

Massachusetts' share of total US corporate R&D expenditure increased slightly in 2007 to 4.4%.

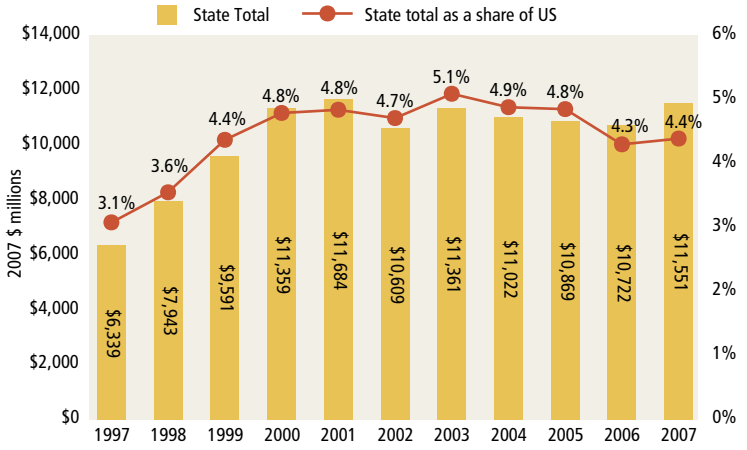
R&D expenditures per number of headquarters for Massachusetts-based corporations in 2007 are down 10% from their 2003 level, to over $38 million per headquarters. Still, publicly-traded companies in the Commonwealth spend significantly more on R&D per headquarter (and per sales) than the LTS median.

Two clusters—Bio/Pharmaceuticals, Medical Devices, & Hardware; and Computer & Communications Hardware—have committed the highest ratios of corporate R&D expenditures to sales. They also show robust sales growth, demonstrating that the Massachusetts Innovation Economy excels at translating initial R&D expenditures into downstream revenue for firms in select clusters. R&D in the Biopharmaceuticals, Medical Devices, & Hardware cluster represents more than half of the total across all clusters making it the most R&D intensive cluster in Massachusetts.

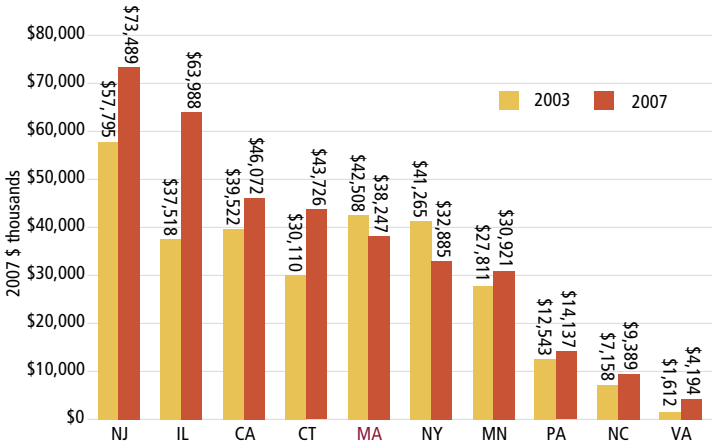
Indicator #11 Key Takeaways:

- Although corporate R&D expenditures in Massachusetts reached record levels in 2007, R&D as a share of the US total remains below its 2005 peak.
- The five-year average annual growth rate of corporate R&D in Massachusetts has slowed to 4%—about half the corresponding national rate.
- Two key clusters—Computer & Communications Hardware; and Bio/Pharmaceuticals, Medical Devices, & Hardware—lead in corporate sales growth and investing the greatest proportion of revenues in R&D.

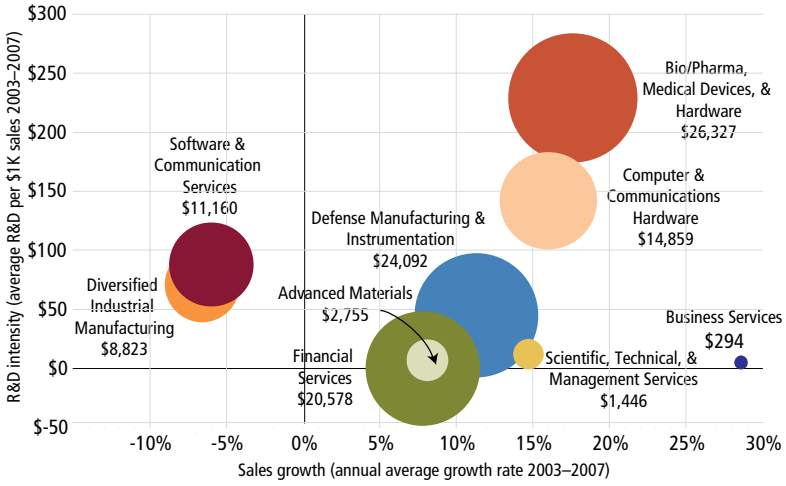
Corporate R&D expenditures and as a percent of US corporate R&D expenditures, publicly traded companies, Massachusetts, 1997-2007



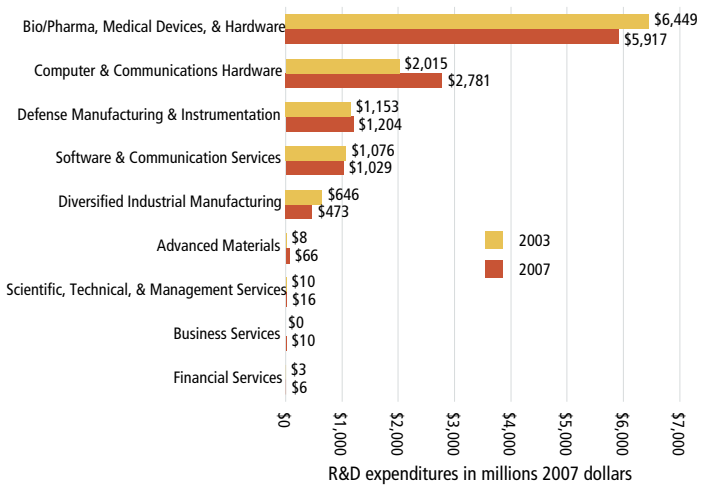
Corporate R&D expenditures, per headquarters, LTS, 2003 and 2007



Corporate R&D intensity and sales growth by industry cluster, Massachusetts, 2003 and 2007



Corporate R&D expenditures by industry cluster, Massachusetts firms, 2003 and 2007



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

Patent Applications, Patent Awards, and Invention Disclosures Applications

Why Is It Significant?

Patents reflect business activity related to the initial discovery and legal protection of innovative ideas. Massachusetts universities, hospitals, and research institutions are important breeding grounds for innovation. Individual inventors formally disclose their discoveries to sponsoring institutions in order to initiate the complex process of patent registration. Following disclosure, the next step in the registration process is the formal patent application to the US Patent and Trademark Office (USPTO). The number of invention disclosures and formal patent applications reflects the progression of innovative ideas with commercial potential. Typically, strong patent activity reflects a high level of effective institutional R&D coupled with potential commercial relevance.

How Does Massachusetts Perform?

Massachusetts remains one of the most inventive and innovative states in the nation by this measure. In 2007, Massachusetts was virtually tied with California in the number of patents issued per capita. All LTS, however, saw a decrease in patents issued on both an absolute and per-capita basis in 2007.

Patents awarded to Massachusetts-based companies are distributed across a diverse range of sectors. Semiconductor Devices, representing 3% of total patents awarded in the Commonwealth, shows the strongest growth in patents issued, with a four-year AAGR at 18%. Healthcare and Industrial Equipment/Machinery, with a 24% and 3% share of total patents awarded, respectively, are both declining at an average annual rate of about 8%.

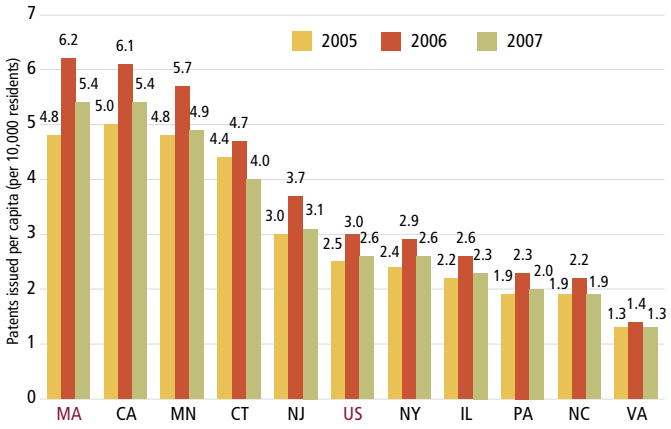
Patent applications and invention disclosures by Massachusetts universities, hospitals, and not-for-profit institutions reached an historic high in 2006.* Invention disclosures by universities increased 18% in 2006. Total patent applications and patent disclosures in Massachusetts increased 10% in 2006 and 8% annually, on average, since 2000.

Indicator #12 Key Takeaways:

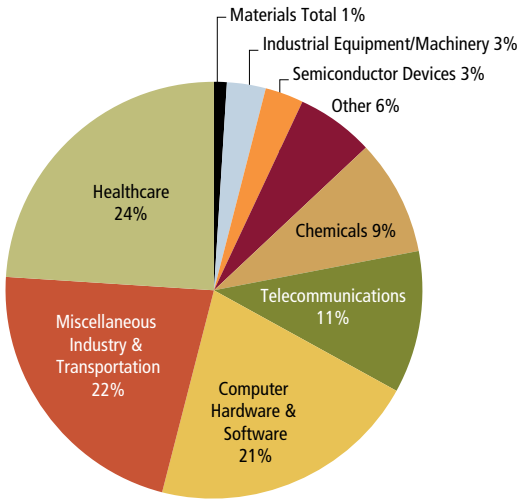
- Massachusetts remains one of the most inventive states in the nation.
- In 2007, Massachusetts was virtually tied with California in the number of patents issued per capita.
- Patent applications and invention disclosures in Massachusetts reached an historic high in 2006. Invention disclosures by universities in the state saw the largest one-year increase, at 18%, in 2006.

*2006 is the latest year for new patent applications and invention disclosures data.

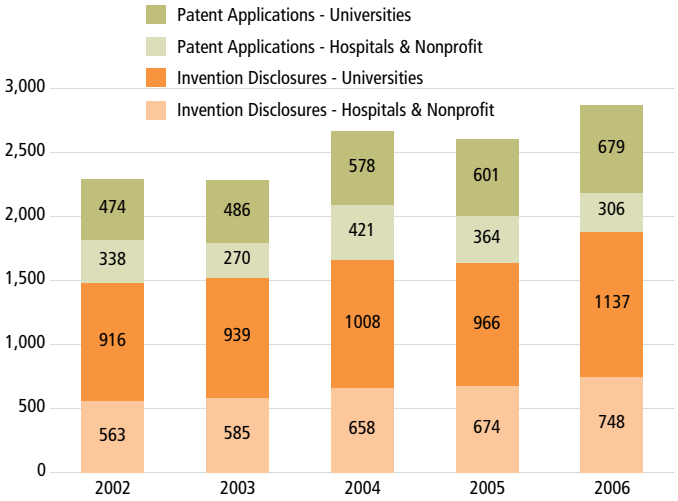
Patents issued per capita, LTS and US, 2005–2007



Distribution of patents awarded in Massachusetts, 2003–2007



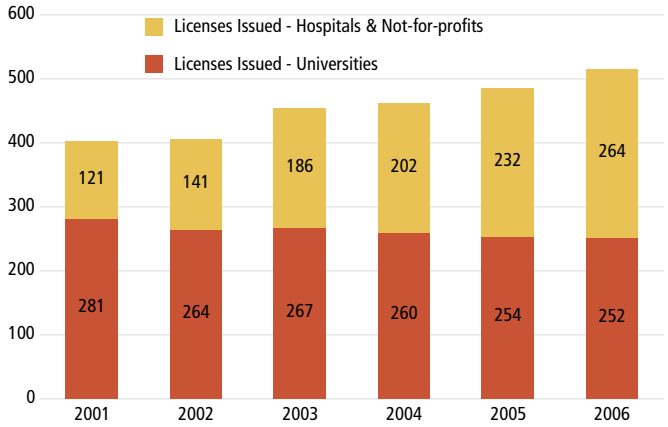
New patent applications and invention disclosures filed by Massachusetts universities, hospitals, and not-for-profit research institutions, 2002–2006



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

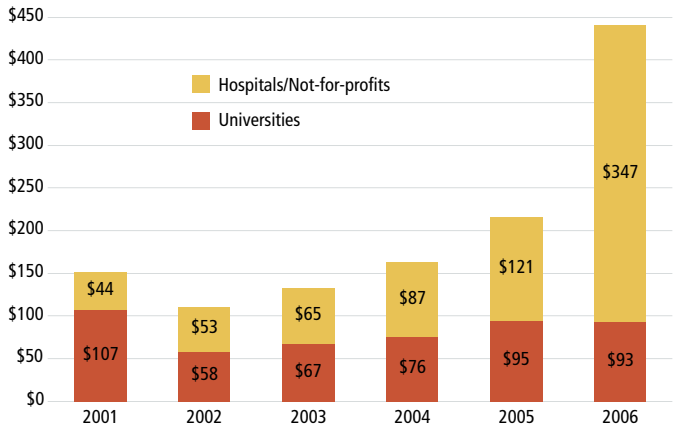
Technology Licenses, Royalties, and Industry-Sponsored Academic Research

Technology licenses issued by major universities, hospitals, and other not-for-profit research institutions, Massachusetts, 2001–2006



Source: Association of University Technology Managers

Technology licensing revenue for major universities, hospitals, and other not-for-profit research institutions, Massachusetts, 2001–2006



Source: Association of University Technology Managers

Industry funding of academic research, LTS, 1998–2007

Source: National Science Foundation

Why Is It Significant?

Technology licenses provide a vehicle for the transfer of intellectual property (IP), patents, and copyrights from universities, hospitals, and other research organizations to companies that may 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 intellectual capital. The increase in royalties collected is important, because a significant portion of this revenue is recycled back into R&D, feeding a cyclic process of innovation at universities, teaching hospitals, and other institutions. Industry funding of academic research is a third measure of industry-university relationships and the relevance of university research to industry.

How Does Massachusetts Perform?

Massachusetts academic, medical, and research institutions continue to increase technology licensing with 516 total technology licenses issued and nearly $400M in royalties in 2006. Total licensing revenue increased 25% annually, on average, since 2002. Leading the robust growth in revenue is licensing activity by Massachusetts hospitals and medical centers: licenses issued increased 87% in four years and revenue nearly tripled in 2006—largely due to major drug royalties received by Massachusetts General Hospital.

The growth in licensing revenue can be attributed to the strength of the medical and life sciences sector in the Massachusetts economy. In addition, it serves as an acknowledgement of a return on investment made in the technology transfer function by the Commonwealth's institutions of higher education and medicine.

Industry funding for university research in Massachusetts was up 12% in 2007 over 2006, but still below its 2001 peak. In 2007, California, North Carolina, and Massachusetts had the fastest rates of growth in industry funding of academic research.

Indicator #13 Key Takeaways:

- Growth in the number of licenses and royalties in Massachusetts is especially strong in hospital and not-for-profit research institutions.
- Between 2002 and 2006, licensing revenue to hospitals and not-for-profit institutions in Massachusetts increased 25% on average each year.
- Industry funding for university research in Massachusetts was up 12% in 2007 over 2006, exceeding the US average of 8%, but not growing as fast as California or North Carolina.

Investment Capital

Why Is It Significant?

Venture capital (VC) firms are one of the primary sources of funds for the creation and development of innovative new companies. The amount and direction of VC investment can be predictive of employment change, revenue growth, and new products and services in the Innovation Economy. In addition, VC firms often provide valuable business strategy guidance. Private investment capital derived from sources such as the funds of individual entrepreneurs and "angel investors" can offset shortfalls that might exist in VC pools. The funding offered by "angel investors" is growing in significance, but is not reflected in the data for this indicator.

How Does Massachusetts Perform?

Massachusetts firms continue to attract a significant proportion of total US VC investment at 10%. Real VC investment in Massachusetts rose 20% percent between 2006 and 2007, the largest one-year increase among the LTS. The four-year AAGR of VC investment in Massachusetts is 4% above inflation—a lower rate than the state's top competitors. 2008 data show early signs of scaling back in VC financing: the first three quarters of 2008 shows 20% lower VC investment than the same period a year earlier. Recent volatility in financial markets will likely interfere with short-term VC investments.

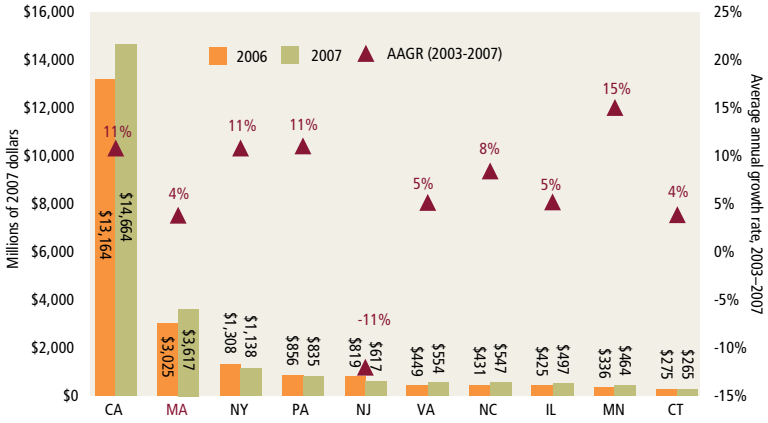
The Biotechnology sector is Massachusetts' top recipient of VC funds, attracting a quarter of all the Commonwealth's VC investment. In 2007, VC investment in the Biotechnology sector was up $155 million (20%) over 2006. Massachusetts has proved to be a viable environment for biotechnology start-ups contributing to the large and successful Life Sciences cluster. Other big movers in year-over-year growth in 2007 are Software which increased $177 million (27%) and IT Services which increased $145 million (149%).

The shift toward later-stage investment that has taken place among VC firms in Massachusetts since 2003 continued in 2007. Consistent with trends in the other LTS, later-stage investments in Massachusetts now account for almost half of all investments, revealing a more cautious outlook by VC firms.

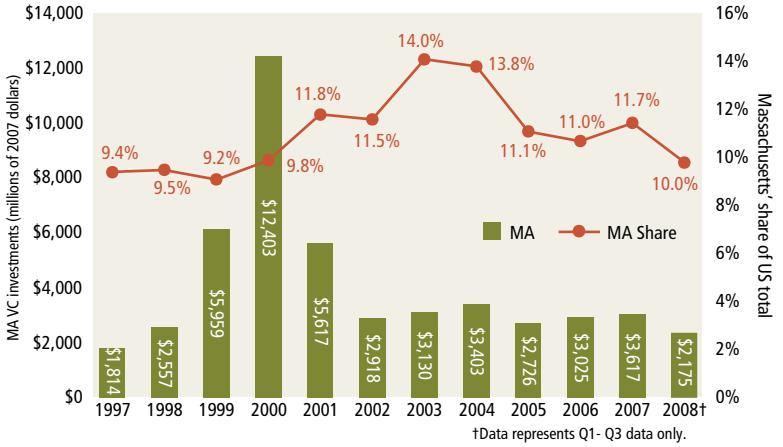
Indicator #14 Key Takeaways:

- VC investment in Massachusetts as a share of the US total continues to shrink from its 2003 peak.
- Investments in Biotechnology and Software continue to dominate the Massachusetts venture portfolio. The Commonwealth's share of VC invested in the biotechnology sectors has more than doubled since 2001.
- Later-stage investments in Massachusetts now account for almost half of all VC investments revealing more cautious behavior among VC firms in recent years. A fifth of VC investments continue to be in start-up and early stage companies.

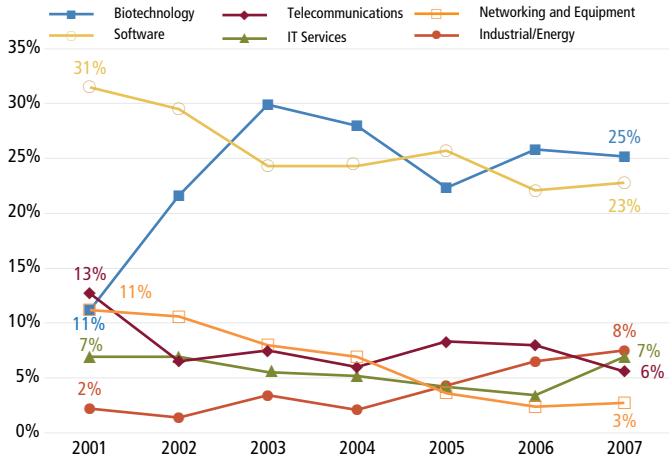
Venture capital investment in 2007 dollars, LTS, 2003–2007



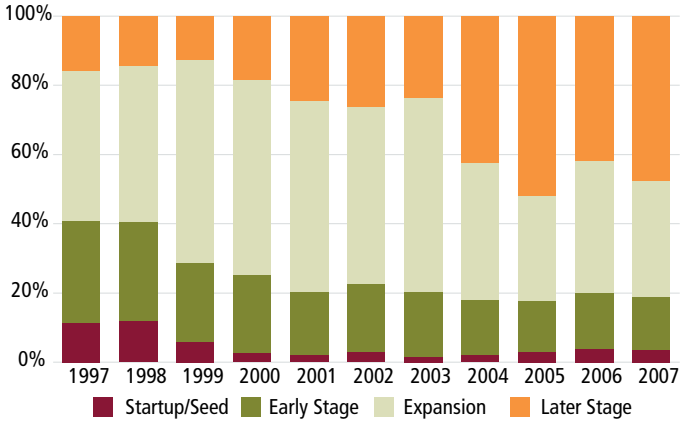
Venture capital investments in Massachusetts and as a share of total venture capital investment in the US, 1997–Q3 2008



Venture capital investment percentage by sector, Massachusetts, 2001–2007



Venture capital investments by stage of financing, Massachusetts, 1997–2007



Source of all data for this indicator: PricewaterhouseCoopers MoneyTree Report

Federal Academic and Health R&D Expenditures

Why Is It Significant?

The primary source of funds for academic research in the US is the federal government. 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 educate technical experts. R&D conducted by academic institutions also has a pronounced effect in stimulating private sector R&D investments.

The National Institutes of Health (NIH), a part of the US Department of Health and Human Services and composed of 27 separate Institutes and Centers, is the primary federal agency for conducting and supporting medical research. NIH funds approximately half of all biomedical research in the US. NIH-funded research is a critical driver of the Commonwealth's biotechnology, medical device, and health services industries, which together comprise the Life Sciences cluster.

How Does Massachusetts Perform?

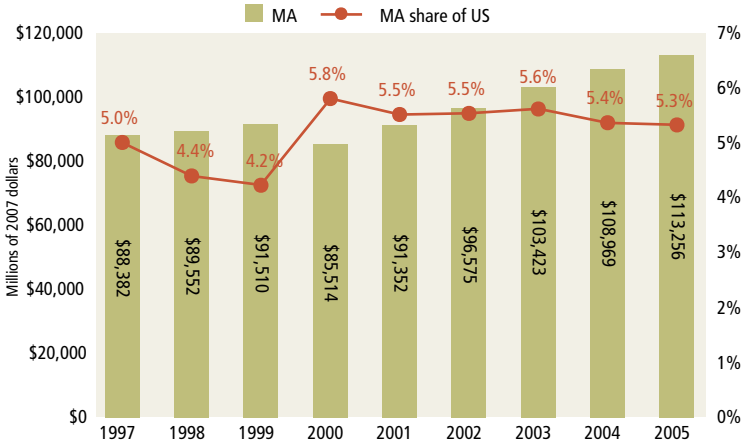
Massachusetts has consistently captured a relatively large proportion of federal funding for R&D. Massachusetts' share represents 5.3% of total federal R&D expenditures in 2005.* Moreover, federal funding for R&D in the Commonwealth on a per-capita basis continues its upward trend, reaching an historic high in 2005 at $940 per capita—a figure outmatched only by Virginia among the LTS. Still, this represents a second year of declining share for Massachusetts of total US federal R&D per-capita funding. The Commonwealth also continues its leadership position among all LTS in both academic and health research funding. Since 2002, the average growth rate of per-capita federal R&D funding for academic and not-for-profit institutions in Massachusetts is 8% annually, a growth rate rivaled only by New Jersey and North Carolina among the LTS. Massachusetts leads all LTS in per-capita NIH funding, with $656 awarded per capita in 2007. Following a national trend, real per-capita NIH funding in the Commonwealth has decreased since 2003, declining at an average annual rate of 2.6%

Indicator #15 Key Takeaways:

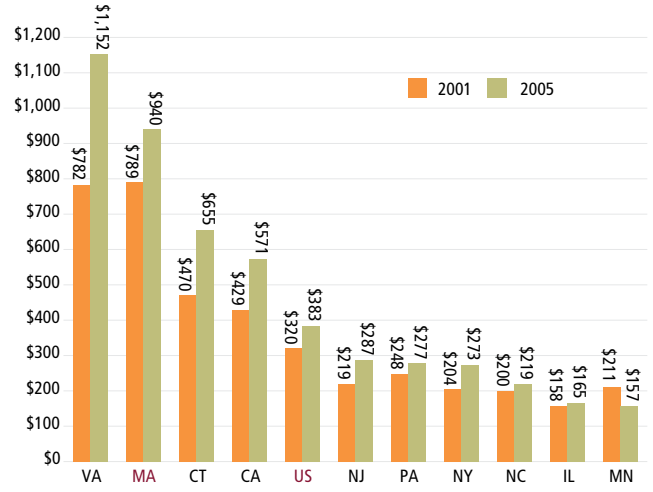
- Massachusetts leads all LTS in per-capita federal R&D expenditures by academic and nonprofit research institutions, as well as NIH funding.
- Federal R&D funding in Massachusetts reached an historical high in 2005 at $940 per capita—surpassed only by Virginia among LTS.
- Massachusetts continues its leadership position among all LTS in both academic and health research funding per capita.

*2005 is the latest year that federal R&D expenditures data are available at time of printing.

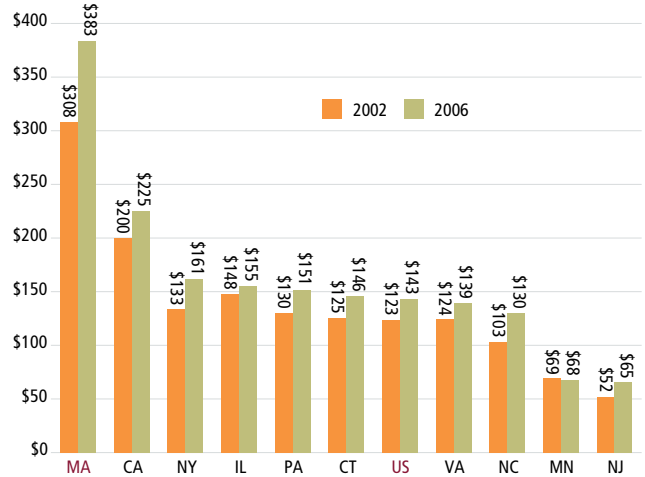
Federal R&D expenditures and Massachusetts' share of total expenditure, 1997–2005



Per-capita federal R&D expenditures, in 2007 dollars, LTS and US, 2001 and 2005



Per-capita federal R&D expenditures at academic and nonprofit research institutions, in 2007 dollars, LTS and US, 2002 and 2006



NIH funding per capita and average annual growth rate (AAGR), LTS and US, 2003, 2006, and 2007

Source of all data for the indicator National Science Foundation

Intended College Major of High School Seniors and High School Dropout Rates

Why Is It Significant?

Most colleges and universities require submission of the SAT Reasoning Test as part of their admissions process. The profile of the intended majors of college-bound seniors who take the SAT indicates the interest of high school students in disciplines that are critical to the Innovation Economy.

The high school dropout rate is a risk indicator that warns of lost potential and future societal costs. The need to develop local talent and ensure that residents have the opportunity to further their education, skills training, and career development is especially critical given the Commonwealth's low population growth rate in recent years.

How Does Massachusetts Perform?

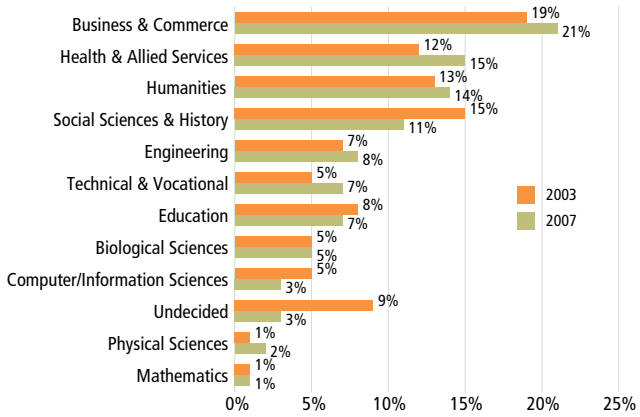
Interest on behalf of Massachusetts high school seniors continues to grow in the business and management disciplines, health and allied services, and humanities. There are consistent shifts among high school seniors in all LTS with increased interest in Health and Allied services and Biological Sciences, and declining interest in Engineering and Computer/Information Sciences.

The pipeline for talent in the life sciences continues to be of concern with interest levels by Massachusetts seniors being lower than in any of the LTS. Only eleven percent of seniors report interest in Engineering and Computer/Information Sciences, placing Massachusetts behind many of its competing states. High school seniors' interest in Computer/Information Sciences and Engineering has declined more sharply nationally than in Massachusetts from 2003–2007. The Massachusetts high school dropout rate is up to 3.8%, from 3.5% in the 2005–2006 academic year. In recent years, the Commonwealth's dropout rates have been similar to US rates. Another way to compare effective drop out rates is to look at the percentage of high school drop outs among the young adult population. In Massachusetts, 8% of 19-24 year olds are high school non-completers, which places Massachusetts tied with Connecticut and Minnesota for the lowest rate among the LTS .

Indicator #16 Key Takeaways:

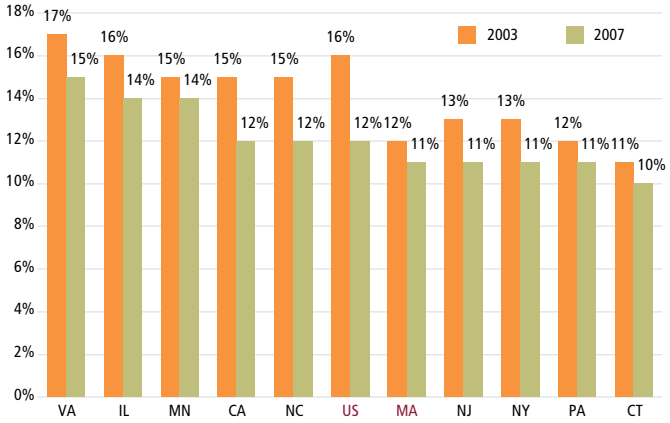
- With 20% of high school seniors intent on majoring in Health and Allied services and Biological Sciences, Massachusetts ranks last among the LTS, which is seemingly contraindicated given the Commonwealth's historic leadership position in life sciences. The life science cluster has and will likely need to be supported by significant non-native talent.
- The high school drop-out rate in Massachusetts increased slightly in the 2006–2007 academic year over the previous year.

Distribution of intended college majors of high school seniors, Massachusetts, 2003 and 2007



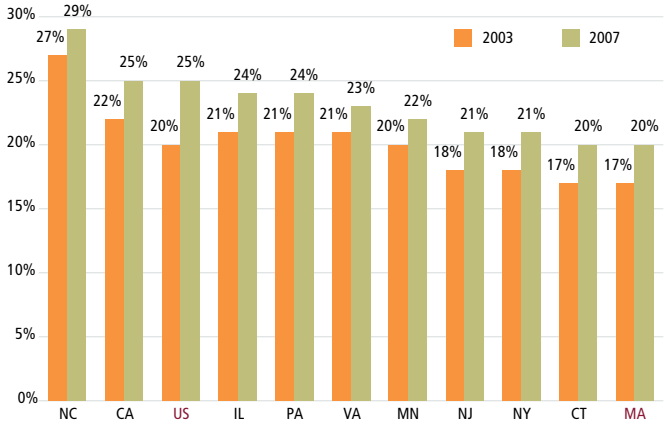
Source: The College Board

Percentage of high school seniors planning to major in Computer, Engineering, or Information Science, LTS and US, 2003 and 2007



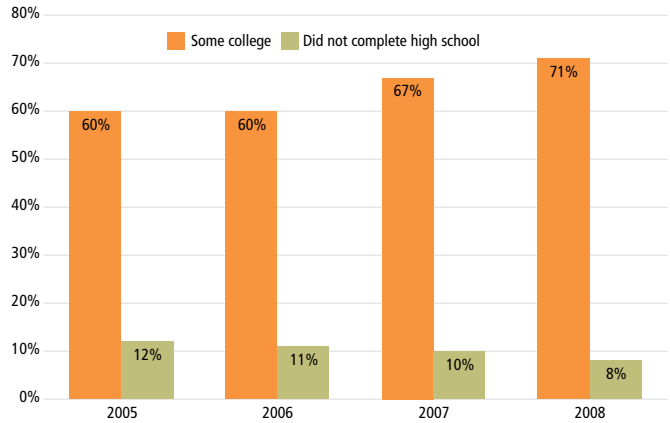
Source: The College Board

Percentage of high school seniors planning to major in Health and Allied Services or Biological Sciences, LTS and US, 2003 and 2007



Source: The College Board

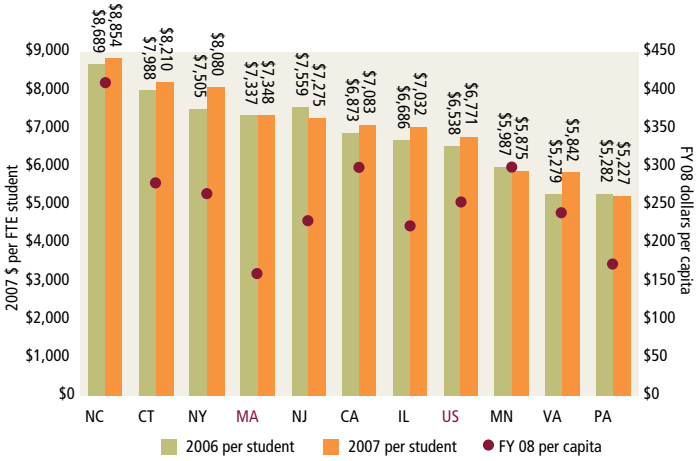
Educational attainment of population age 19–24, Massachusetts (three year rolling averages for intervals ending 2005–2008)



Source: US Census Bureau

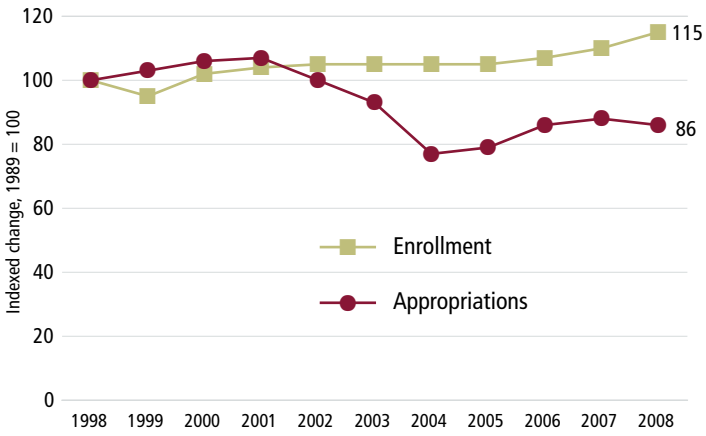
Public Secondary and Higher Education Expenditures

Public higher education appropriations per full-time equivalent (FTE) student and per capita, LTS and US, 2007



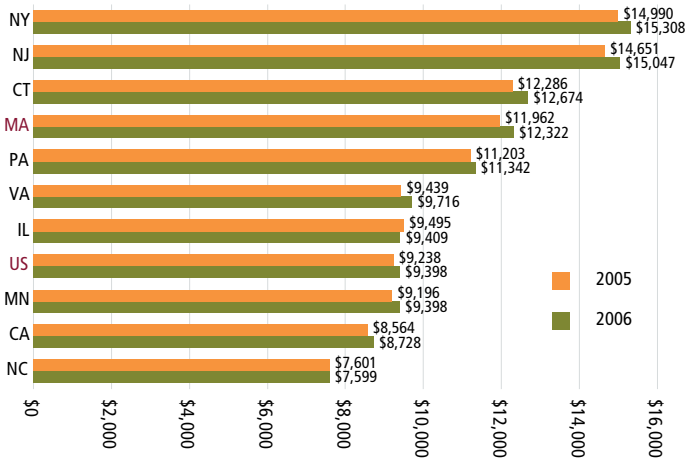
Source: State Higher Education Executive Officers (SHEEO)

Change in public higher education enrollment and appropriations, Massachusetts 1998–2008



Source: National Center for Education Statistics (NCES) and State Higher Education Executive Officers (SHEEO)

Per pupil spending of public elementary/secondary school systems, in 2007 dollars, LTS and US, 2005–2006



Source: US Census Bureau

Why Is It Significant?

Quality K-12 and higher education programs impart broad skills demanded of people in their roles as workers, citizens, and parents, including creative problem solving and the ability to be a life-long learner. Investments in elementary, middle, and high schools are important in generating a broadly educated and flexible workforce. Investments in public postsecondary education are critical for increasing the accessibility and capability of academic institutions so they can attract and prepare students for skilled and well-paying employment in Massachusetts. In addition, strong higher education programs play a significant role attracting motivated students from around the globe, some of whom choose to work in Massachusetts after graduation.

How Does Massachusetts Perform?

Massachusetts recently increased inflation-adjusted per pupil spending for K-12 education, but real higher education spending in 2007 remained unchanged over the previous year. Per pupil spending for Massachusetts elementary- and secondary-school levels exceeded most of the LTS and the US average with over $12,000 spent per pupil in 2006, an increase in real terms of 3% from the previous year.

Massachusetts spent approximately $7,300 per full-time equivalent (FTE) student in public higher education educational appropriations* in 2007, resulting in a fourth place rank among the LTS on a per pupil basis, but a last place ranking per capita.** Adjusted for inflation, the 2007 appropriation in Massachusetts is virtually unchanged compared to the previous year, whereas aggregate state and local appropriations in the US increased nearly 4% in 2007. Appropriations per student in both the US and Massachusetts are down 8% from their 2002 level.

Public higher education funding per FTE is likely to decline in Massachusetts as the current economic recession creates upward pressure in enrollment at public colleges and universities while state investments remain flat or even decline. Historically, tight job markets and employment declines are followed by increased enrollment in higher education particularly in lower-cost institutions. Following the 2001 recession, the growth in total enrollments in public higher education institutions in Massachusetts began to outpace growth in state higher education appropriations. Given current economic conditions, this gap in growth between public higher education enrollments and appropriations appears likely to persist.

Indicator #17 Key Takeaways:

- When adjusting for inflation, Massachusetts is increasing spending per pupil in K-12, but not in higher education.
- Massachusetts public higher education institutions have been squeezed by rising enrollments and declining appropriations compared to funding levels prior to 2002.
- Massachusetts public higher education appropriations in 2007 rank 4th among the LTS on a per pupil basis, but last place ranking per capita.

*The data on higher education appropriations used in this indicator include educational operating expenses and exclude appropriations for research, agricultural, and medical purposes.

**Massachusetts ranks 46th place rank among the 50 states for state support to public higher education per capita.

Educational Attainment and Engineering Degrees Awarded

Why Is It Significant?

The educational attainment of the workforce contributes directly to the region's ability to generate and support innovation-driven economic growth. Regions that are well served by postsecondary engineering programs have a comparative workforce advantage in the creation of new products and ideas. The potential pool of new engineers and scientists for technology and health-related industries offers an indication of future workforce resources for these critical clusters.

How Does Massachusetts Perform?

In terms of the college attainment of residents, Massachusetts is strong and growing stronger. In 2006, 2007, and 2008, the percent of Massachusetts adults with a bachelor's degree or higher increased markedly, giving Massachusetts a significant lead over the next highest states. Massachusetts has been among the top states for over a decade in college attainment among people age 25 or over, rivaled most closely by Connecticut.

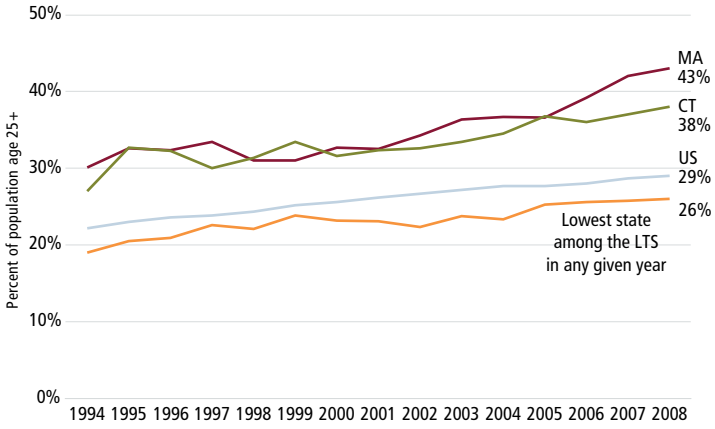
Massachusetts is the most highly educated of the LTS with 46% of its population age 25-65 holding a bachelor's degree or higher. By this measure, Massachusetts exceeds the next highest LTS, Connecticut and New Jersey, by 6%. Massachusetts has a smaller percentage of working-age population with some college education, but no four-year degree. Minnesota in particular stands out with 70% of its working age population having some education beyond high school.

On a per-capita basis, Massachusetts ranks first in the number of bachelor's, master's, and doctoral degrees awarded in engineering. The number of engineering degrees awarded in Massachusetts, however, has declined since 2004, especially when compared to the growing workforce. The majority of Massachusetts engineers are trained in the electrical, computer, and mechanical disciplines. Barely 3% of Massachusetts engineers are trained in the emerging field of biomedical engineering. Six of the LTS grant more degrees in biomedical engineering than Massachusetts.

Indicator #18 Key Takeaways:

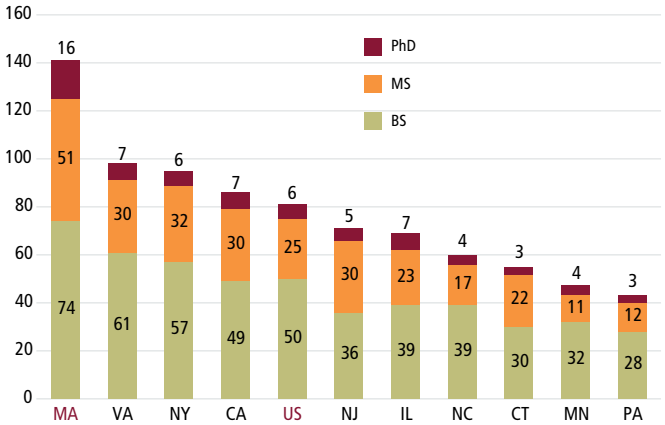
- The rise in four-year college degree attainment in Massachusetts is one of the most surprising movers in this year's **Index**. Massachusetts' performance on this measure has pulled ahead of all other states.
- Massachusetts leads the LTS in attainment of a four-year degree, with 46% of the population aged 25-65 with a bachelor's degree or higher.
- Massachusetts shows a weakening of its competitive position in engineering degree-granting.

Persons 25 years old and over with a bachelor's degree or higher, Massachusetts and range of LTS, 1994–2008



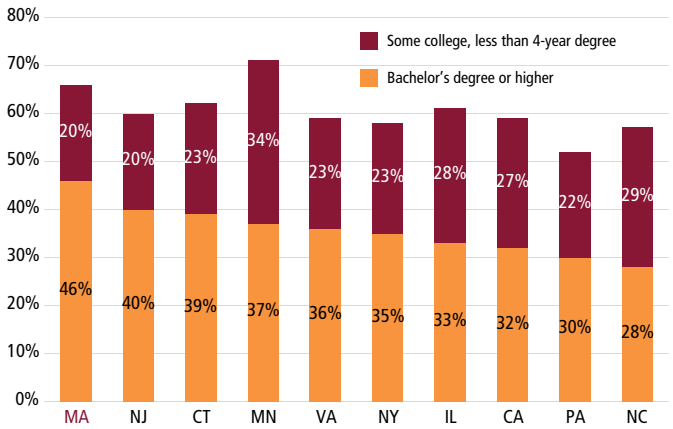
Source: US Census Bureau, Current Population Survey
Note: The orange line illustrates the lowest state attainment level among the LTS in any given year. Together, Massachusetts and Connecticut comprise the highest attainment among the LTS.

Engineering degrees awarded, per 100,000 in workforce, LTS and US, 2007



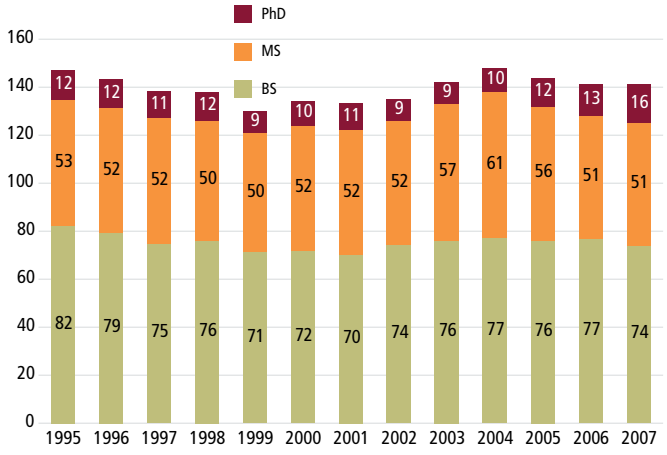
Source: American Association of Engineering Societies

Educational attainment of working age population, LTS, three-year average, 2006, 2007, 2008



Source: US Census Bureau, American Community Survey

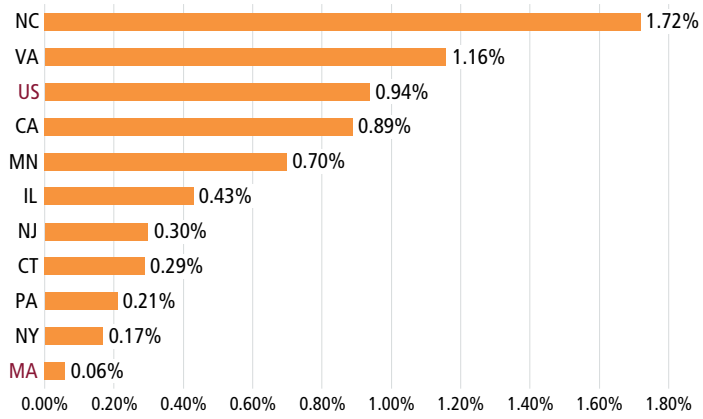
Engineering degrees awarded in Massachusetts, per 100,000 in workforce 1995–2007



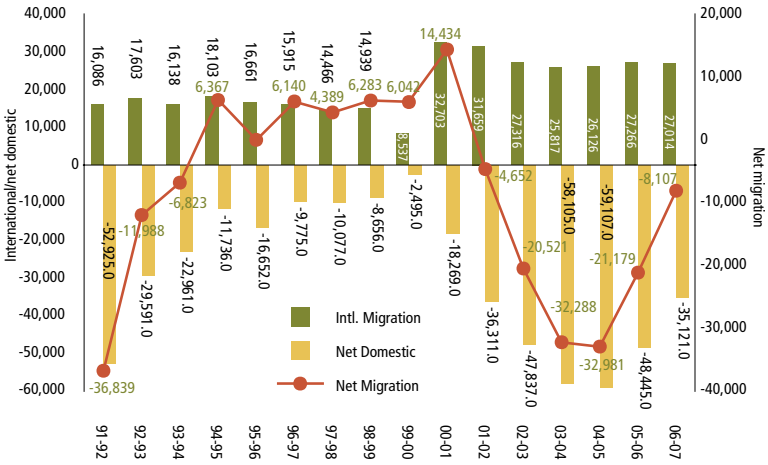
Source: American Association of Engineering Societies

Population Growth Rate and Migration

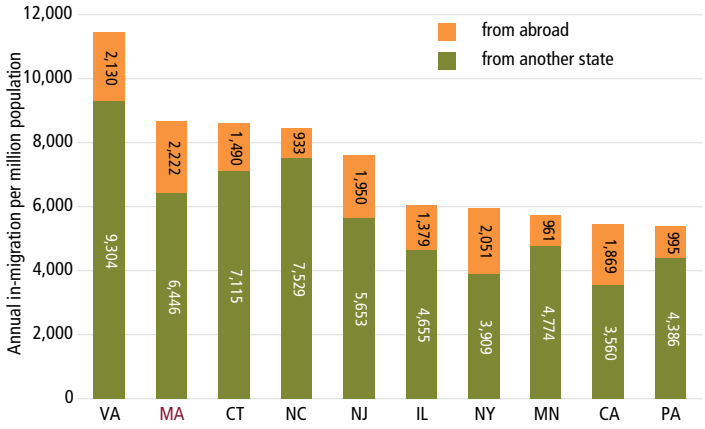
Average annual growth rate (AAGR) of population, LTS and US, 2002–2007



International and net domestic migration, Massachusetts, 1992–2007



Relocations to LTS by college educated adults, 2005–2007 average



Source of all data for this indicator: US Census Bureau, American Community Survey

Why Is It Significant?

Migration is both an input to the innovation workforce and a bottom line measure of a region's combination of quality of life, affordability, and economic opportunity. Regions that are hubs of innovation have both high concentrations of educated, high-skilled workers and dynamic labor markets refreshed by a global exchange of talent. In-migration fuels innovative industries by bringing in skill-sets and educational backgrounds that are in demand. While a positive net-talent exchange is important, Massachusetts benefits from the brain exchange connecting Massachusetts institutions and businesses to other regions through in- and out-migration.

How Does Massachusetts Perform?

The overall Massachusetts population grew at a slow average annual rate of 0.06% between 2002 and 2007. Massachusetts population growth is concentrated in the working-age population with a four-year college degree or more, augmented significantly by in-migration of educated people from out of state. The working age population with a college degree grew at an average annual rate of 3.5% between 2005 and 2008, while the overall population in this age range shrunk 0.7% per year in the same period. The Commonwealth is a hub of talent exchange with high numbers of working-age people moving into and out of the state. The American Community Survey (ACS) provides estimates of the number of people moving into each state from other states and from abroad, allowing a comparison between Massachusetts and the LTS in ability to attract college-educated adults. In 2007, Massachusetts ranked second in total relocations (i.e., individuals moving into the Commonwealth from another state or country), demonstrating that despite slow total population growth, the labor market remains dynamic and the rate of exchange with other regions is high.

In 2006 and 2007 the distressing net out-migration from Massachusetts that began in 2002 moderated, although the balance of migration remains negative. In contrast to a net outflowing of over 58,000 people in 2003–2004 and 2004–2005, Massachusetts lost just over 35,000 in 2006–2007. Moreover, this population loss was largely offset by net international immigration of 27,000 resulting in a 0.1% population loss. The Commonwealth continued to sustain relatively high rates of international migration.

Indicator #19 Key Takeaways:

- Massachusetts has had the slowest population growth of the LTS.
- Massachusetts ranks second among the LTS for its ability to attract college-educated adults from other states and abroad. Migration contributes to the 3.5% average annual growth in the working age population with a college degree between 2005 and 2007.
- In 2007, Massachusetts continued to improve its balance of migration with domestic in-migration coming closer to matching out-migration.

Housing Affordability

Why Is It Significant?

Housing affordability has a direct impact on quality of life as residents are driven to trade off proximity to jobs and amenities in order to meet basic housing needs. The combination of quality of place and housing affordability influences Massachusetts' ability to attract and retain talented people. A lack of affordable housing options for essential service providers and entry-level workers can slow business expansion in the region.

How Does Massachusetts Perform?

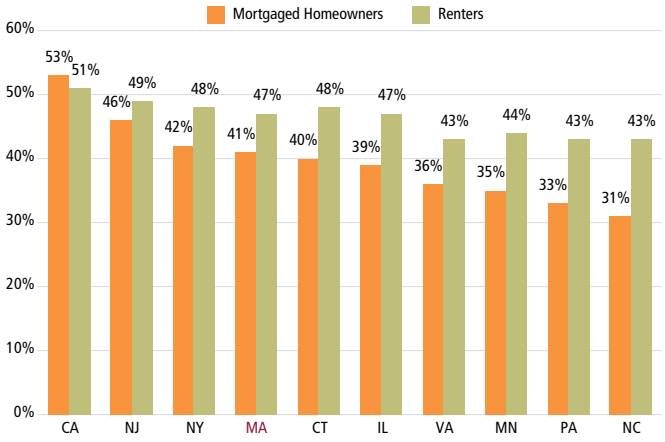
Massachusetts ranks seventh among the LTS in housing affordability for home owners with a mortgage and sixth for renters. While California, New York, and New Jersey have less affordable housing markets, many Massachusetts households are under financial strain. Forty-one percent of homeowners with a mortgage and 47% of renters are spending more than 30% of household income on housing related costs including taxes and utilities. The lack of affordability is reflected in the relatively lower homeownership rates in Massachusetts compared to the more affordable LTS. Only New York and California have lower rates of home ownership than Massachusetts.

According to the Office of Federal Housing Enterprise Oversight's Housing Price Index (HPI), 2006 marked the end of nearly a decade of rapid housing appreciation in Massachusetts. Single-family homes in Massachusetts, on average, have depreciated in value since the second-quarter of 2006, falling faster than both the national and LTS averages. The four-quarter house price appreciation chart shows the housing bubble in Massachusetts compared to California, the LTS that experienced the largest bubble and crash, and compared to North Carolina, the most steady of the LTS. While houses are becoming more affordable, housing price depreciation can place a considerable financial strain on existing homeowners. By inhibiting relocations, current housing market conditions could put a drag on labor force dynamism. In 2007 housing starts were at a historic low, with 2.4 new housing units under construction per 1,000 residents.

Indicator #20 Key Takeaways:

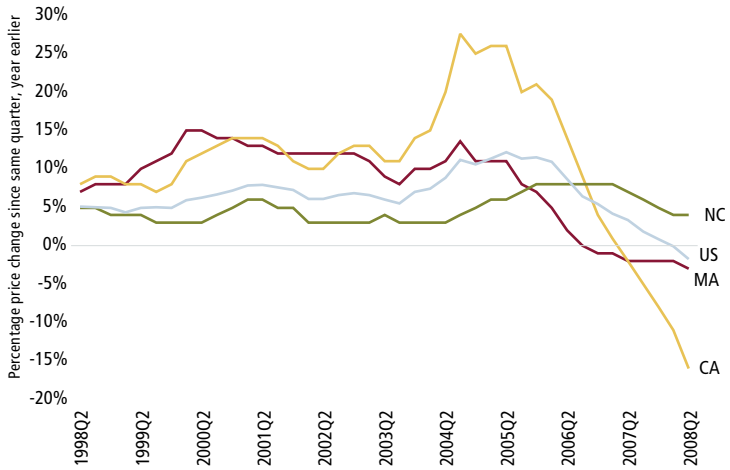
- Forty-one percent of homeowners with mortgages and 47% of renters in Massachusetts are spending more than 30% of household income on housing related costs.
- The average value of a single-family home in Massachusetts fell more than 2% in 2007 and nearly 3% in the second-quarter of 2008.
- Per-capita housing starts were at a historic low in Massachusetts in 2007 and are among the lowest of the LTS.

Households spending 30 percent more of income on housing costs, LTS, 2007



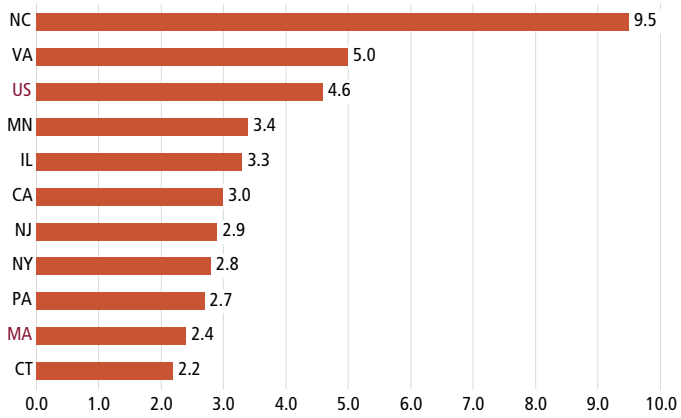
Source: US Census Bureau, American Community Survey

Year-over-year house price appreciation by quarter, Massachusetts, US, and range of LTS, 1998 Q2–2008 Q2



Source: Office of Federal Housing Enterprise Oversight

Housing starts, per 1,000 residents, LTS and US, 2007



Source: US Census Bureau

APPENDIX A

DATA SOURCES FOR INDICATORS AND SELECTION OF LTS

Data Availability

For the 2008 **Index**, data indicators were assembled using proprietary and other existing secondary sources. In most cases, data from these sources required the reconfiguration, reorganization, and recalculation of existing datasets. Since these data groupings were derived from a wide range of sources, there are variations in the time frames used and in the specific variables that define the indicators. This appendix provides notes and additional information on data sources for each indicator.

Price Adjustment

Dollar figures represented in this report, when indicated, are in chained 2007 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

A primary goal of the **Index** is to measure Massachusetts' performance in the context of various indicators and appropriate benchmarks. The main focus of the **Index** is Massachusetts and other Leading Technology States (LTS) that were selected for the purposes of comparison. In addition to Massachusetts, the LTS includes: California, Connecticut, Illinois, Minnesota, New Jersey, New York, North Carolina, Pennsylvania, and Virginia.

The LTS are selected based on the total number of 11 key industry clusters having an employment concentration above the national level. States with employment concentration exceeding the national level in three or more clusters are included among the LTS. This methodology yields a roster of LTS that is comparable to Massachusetts and has a similar composition of industry clusters.

II. Notes on Data Sources for Individual Indicators

ECONOMIC IMPACT

1. Industry Cluster Employment and Wages

Moody's Economy.com tracks industry employment at the state level using a methodology based upon individual corporations filings with State Employment Securities Agencies (SESA) 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 included in Appendix B.

http://www.economy.com

Data on cluster wages are from the US Bureau of Labor Statistics' (BLS) Quarterly Census of Employment and Wages (CEW). 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 calendar quarter, 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 2007 dollars.

http://www.bls.gov/cew/

2. Corporate Sales, Publicly-Traded Companies

Corporate sales figures are provided by Standard & Poor's COMPUSTAT database. These data are derived from publicly traded corporations' annual 10k report filings with the US Securities & Exchange Commission (SEC). All sales data are aggregated to the location of the corporate headquarters.

http://www.compustat.com/www/

Data on the number of headquarters of publicly-traded companies by state are from ReferenceUSA, an internet-based reference service from the Library Division of infoUSA.

http://www.referenceusa.com

2007 Cluster Employment Concentrations

This is a comparison of cluster employment as a percent of all non-government employment in the state compared to the United States as a whole. Values above one indicate that the state has more jobs in this cluster relative to overall employment than the US does.

	CA	CT	IL	MA	MN	NJ	NC	NY	PA	VA
Advanced Materials	0.60	0.84	1.28	0.86	0.86	1.04	1.49	0.64	1.31	0.86
Bio/Pharma, Medical Devices, & Hardware	1.43	1.55	0.96	1.81	1.57	2.30	1.97	0.61	1.40	0.51
Business Services	0.98	0.81	0.95	0.97	0.83	1.05	0.71	1.25	0.97	1.20
Computer & Communications Hardware	1.88	1.08	0.86	1.95	1.46	0.69	1.49	0.88	0.99	0.53
Defense Manufacturing & Instrumentation	1.24	2.92	0.88	1.23	0.89	0.55	0.72	0.54	0.70	0.27
Diversified Industrial Manufacturing	0.82	1.71	1.63	1.17	1.41	0.69	0.87	0.80	1.20	0.62
Financial Services	0.85	1.62	1.20	1.34	1.21	1.26	0.87	1.46	1.09	0.72
Healthcare Delivery	0.80	1.05	0.98	1.24	1.09	1.12	0.90	1.14	1.22	0.85
Postsecondary Education	0.81	1.46	1.01	2.42	0.93	0.84	0.97	2.20	1.84	1.02
Scientific, Technical, & Mgmt. Services	1.24	0.82	1.29	1.43	0.79	1.25	0.88	1.03	0.93	1.92
Software & Communication Services	1.11	1.08	0.97	1.41	1.03	1.34	0.82	1.01	0.85	2.11
Total cluster concentrations >1.10	**5**	**5**	**4**	**9**	**4**	**5**	**3**	**4**	**5**	**3**

Source: Moody's / economy.com and BLS CEW.

3. Occupations and Wages

Data on occupations and wages are from the US Bureau of Labor Statistics' Occupational Employment Statistics (OES) program. The OES produces employment and wage estimates for over 700 occupations. These are estimates of the number of people employed in certain occupations, and estimates of the wages paid to them. Self-employed persons are not included in the estimates. The OES data include all full-time and part-time wage and salary workers in non-farm industries. Wages data are presented in 2007 dollars.

The OES uses the Standard Occupational Classification (SOC) system, which is used by all federal statistical agencies to classify workers into occupational categories for the purpose of collecting, calculating, or disseminating data. The 22 major occupational categories of the OES were aggregated by MTC into 10 major occupational categories for analysis. MTC grouped occupational categories according to related industry sectors, comparable pay scales, and other associated data. For this indicator, MTC consulted with the Massachusetts Department of Unemployment Assistance (DUA); Collaborative Economics in Mountain View, California; and The Donahue Institute at the University of Massachusetts.

The 10 occupational categories included in this indicator 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
- Healthcare: Healthcare practitioner and technical occupations; Healthcare support occupations
- Human Services: Community and social services occupations
- Life, Physical, & Social Sciences: Life, physical, and social science occupations
- Professional & Technical: Management occupations; Business and financial operations occupations; Computer and mathematical occupations; Architecture and engineering occupations; Legal occupations
- 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

http://www.bls.gov/oes/home.htm

4. Median Household Income

Data on median household income 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 2007 dollars.

http://www.census.gov

Data on the income gap and mean household income by quintile are from the American Community Survey, 2007, Table B19081 ("Mean Income of Quintiles"). http://factfinder.census.gov

Data on changes in median family income in Massachusetts are provided by the University of Massachusetts Donahue Institute from the 2008 publication by Rebecca Loveland, Robert Nakosteen, Raija Vaisanen, and Roy Williams, "Income Inequality in Massachusetts, 1980 – 2006." MassBenchmarks. Volume 10, Issue 2. This analysis is based on US Census Bureau Decennial Census and American Community Survey Public Use Microdata Series (PUMS).

http://www.massbenchmarks.org/

5. Manufacturing Exports

Manufacturing exports data are from the US Census Bureau's Foreign Trade Division. These export data are derived on a transaction basis from the Shipper's Export Declaration (SED) or its electronic equivalent as filed by qualified exporters, forwarders, or carriers. This dataset measures the movement of physical merchandise out of the US.

http://www.census.gov/foreign-trade/www/

Exports by foreign trade destination 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/

Associated Industries of Massachusetts. "State exports strong in first half; weaker dollar makes a difference." **MassBusiness Magazine**, August/ September ,2008.

INNOVATION ACTIVITIES

Business Development

6. 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

Data on business incubators are from the National Business Incubation Association (NBIA).

http://www.nbia.org/

Data on spin-out companies from universities, hospitals and non-profit research institutions are from the Association of University Technology Managers. Research dollars are converted to 2007 dollars using the CPI-U from the BLS.

http://www.autm.net

7. Initial Public Offerings (IPOs) and Mergers & Acquisitions (M&As)

The total number and distribution by industry sector of filed initial public offerings (IPOs) by state and for the US are provided by Renaissance Capital's IPOHome.com. Industry classifications for IPOs are based upon the **Index's** definition of the ten key industry clusters, excluding postsecondary education.

http://www.ipohome.com

Data on total number of mergers and acquisitions (M&As) by state and the US are provided by FactSet Mergerstat, LLC. M&A data represent all entities that have been acquired by another for all years presented in the indicator.

http://www.mergerstat.com

8. Technology Fast 500 Firms, and Inc. 500 Firms

Data for location of Technology Fast 500 companies located in Massachusetts and the LTS are provided by Deloitte and Touche, LLP. The ranking includes both public and private companies. To be eligible for the Fast 500, a company must meet the following criteria: 1. Must own proprietary intellectual property or proprietary technology that contributes to a significant portion of the company's operating revenues or devotes a significant proportion of revenues to R&D of technology. Using other companies' technology in a unique way does not qualify; 2. Base-year operating revenues must be at least $50,000 USD or $75,000 CD and current-year operating revenues must be at least $5 million USD and CD. Companies are required to submit tax returns or audited financial statements with their submitted nomination to complete their eligibility; 3. Be in business a minimum of five years; 4. Be headquartered within North America. Subsidiaries or divisions are not eligible (unless they have some public ownership and are separately traded).

http://www.public.deloitte.com/fast500

Data on location of **Inc.** 500 companies located in Massachusetts and the LTS are from **Inc. Magazine**. The 2007 **Inc.** 500 list measures revenue growth from 2003 through 2006. To qualify, companies had to be US-based, privately held independent—not subsidiaries or divisions of other companies—as of December 31, 2006, and have at least $600,000 in net sales in the base year.

http://www.inc.com/inc500/

Technology Development

9. Small Business Innovation Research (SBIR) Awards

Data on SBIR awards are provided by the US Small Business Administration (SBA) and exclude STTR. Data are accessed through the SBA's Tech-Net database.

http://tech-net.sba.gov/

10. FDA Approval of Medical Devices and Biotech Drugs

Data regarding medical device approvals in the US are provided by the US Food and Drug Administration (FDA). 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. 510(k)'s have a higher approval rate than PMAs and thus, are in larger numbers compared to PMAs.

http://www.fda.gov

Data on the number of biotechnology drugs in development are provided by Pharmaceutical Research and Manufacturers of America (PHRMA)'s biannual Medicines in Development- Biotechnology Report. The content of these reports were obtained through industry sources and the Adis "R&D Insight" database based on the latest information. For the purpose of this report, only those products that involve recombinant DNA, monoclonal antibody/hybridoma, continuous cell lines, cellular therapy, gene therapy and vaccines technology are included.

http://www.phrma.org

Research

11. Corporate Research & Development Expenditures, Publicly Traded Companies

Corporate research & development (R&D) expenditure data are from Standard & Poor's COMPUSTAT database. These data are derived from publicly traded corporations' annual 10k report filings with the SEC. 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/

12. Patent Applications, Patent Awards, and Invention Disclosures

Patents per-capita data for the LTS are provided by the US Patent and Trademark Office (USPTO).

http://www.uspto.gov

Patent distribution by industry sectors are based on analyses developed by Jaffe et al: The NBER US Patent Citations Data File: Lessons, Insights, and Methodological Tools. These data comprise detailed information on almost 3 million US patents granted between January 1963 and December 1999, all citations made to these patents between 1975 and 1999 (over 16 million), and a reasonably broad match of patents to COMPUSTAT (the dataset of all firms traded in the US stock market). These datasets are described in detail in Hall, B. H., A. B. Jaffe, and M. Tratjenberg (2001). "The NBER Patent Citation Data File: Lessons, Insights and Methodological Tools." NBER Working Paper 8498. Further documentation on uses of the patent citation data is available in the book "Patents, Citations and Innovations: A Window on the Knowledge Economy," by Adam Jaffe and Manuel Trajtenberg, MIT Press, Cambridge (2002).

http://mitpress.mit.edu/main/home/default.asp?sid=944AB2DA-BD6F-4B39-8A43-6E97507A570E

Invention disclosures and patent applications data are from the Association of University Technology Managers' (AUTM) annual licensing survey of universities, hospitals, and research institutions. For this analysis, the Massachusetts universities which provided information for the AUTM report include: Massachusetts Institute of Technology (MIT), Harvard University, Boston University, Brandeis University, University of Massachusetts (all campuses, including the Medical School), Tufts University, and Northeastern University. Massachusetts hospitals/nonprofit research institutions include: Massachusetts General Hospital, Children's Hospital Boston, Brigham and Women's Hospital, Woods Hole Oceanographic Institute, Center for Blood Research, Dana-Farber Cancer Institute, New England Medical Center, Beth Israel-Deaconess Medical Center, St. Elizabeth's Medical Center of Boston, and Schepens Eye Research Institute.

http://www.autm.net

13. Technology Licenses and Royalties

Data on licensing agreements involving Massachusetts institutions are from the Association of University Technology Managers (AUTM). These data are derived from the same institutions providing patent and invention disclosure information in Indicator 12.

http://www.autm.net

INNOVATION CAPACITY

Resources

14. Investment Capital

Data for total venture capital investments, venture capital investments by industry activity, and distribution of venture capital by stage of financing are provided by PricewaterhouseCoopers LLP and the National Venture Capital Association 's MoneyTree Report. Industry category designations are determined by PricewaterhouseCoopers LLP and the National Venture Capital Association.

http://www.pwcmoneytree.com

Definitions for the industry classifications and stages of development used in the MoneyTree Survey can be found at the PricewaterhouseCoopers LLP website.

http://www.pwcmoneytree.com/moneytree/nav.jsp?page=definitions

15. Federal R&D Spending & Health R&D Spending

Data on federal R&D spending at academic and nonprofit research institutions are from the National Science Foundation (NSF). This includes university-associated federally funded R&D centers.

Data on federal health R&D spending are from the National Institutes of Health (NIH). 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 date 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

16. Intended College Major of High School Seniors and High School Dropout Rates

Data for intended majors of students taking the Scholastic Aptitude Test (SAT) Reasoning Test in Massachusetts and the LTS are provided by The College Board, Profile of College Bound Seniors. The Profile of College-Bound Seniors presents data collected from high school graduates who participated in the SAT Program. 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 a highly accurate description of the group.

http://www.collegeboard.com

Data on high school dropout rates are from the Massachusetts Department of Education. In this dataset, a dropout is defined as a student in grade nine through twelve who leaves school prior to graduation for reasons other than transfer to another school and does not re-enroll before the following October 1.

http://www.doe.mass.edu/infoservices/reports/dropout/

Data in the text on high school completion of people age 19-24 are provided by the US Census Bureau, Current Population Survey, Annual Social and Economic Supplement, 2003 through 2008.

http://www.census.gov/hhes/www/cpstc/cps_table_creator.html

17. Public Secondary & Higher Education Expenditures and Performance

Data on public and private college and university enrollments are derived from the National Center for Education Statistics (NCES). This survey, which is sent out to approximately 3,958 schools in the US, has been part of NCES survey work since 1966. Degree-granting institutions are defined as postsecondary institutions that are eligible for Title IV federal financial-aid programs and grant an associate's or higher degree. A private school or institution is one that is controlled by an individual or agency other than a state, a subdivision of a state, or the federal government, which is usually supported primarily by other than public funds, and the operation of whose program rests with other than publicly elected or appointed officials. Private schools and institutions can be either not-for-profit and proprietary institutions. A public school or institution is one that is controlled and operated by publicly elected or appointed officials and derives its primary support from public funds.

http://nces.ed.gov/

Data on public higher education appropriations per full-time equivalent (FTE) student is provided by the State Higher Education Executive Officers (SHEEO)'s State Higher Education Finance (SHEF) Early Release (FY 2007). The data consider only educational appropriations—state and local funds available for public higher education operating expenses, excluding spending for research, agriculture, 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 in the FY2006 publication:

http://www.sheeo.org/finance/shef-home.htm.

Public elementary-secondary school finance data are from the US Census Bureau. Figures are presented in 2007 dollars.

http://www.census.gov/govs/www/school.html

Historical state appropriations for higher education in Massachusetts are from Grapevine/ Illinois State University, An Annual Compilation of Data on State Tax Appropriations for the General Operation of Higher Education.

http://www.grapevine.ilstu.edu/tables/

Historical fall undergraduate enrollment in all Massachusetts public higher education institutions were provided by the Massachusetts Department of Higher Education, per special request.

18. Educational Attainment and Engineering Degrees Granted

Data on percent of population age 25 or older with a bachelor's degree or higher for Massachusetts, the LTS, and the US, are from the US Census Bureau, Current Population Survey, Annual Social and Economic Supplement. Data are collected in March. Because of sampling error, state data points fluctuate more than actual college attainment fluctuates. A

couple spikes in the Massachusetts data have been smoothed by **Index** staff within one standard error. CPS data includes persons in dormitories, but excludes institutionalized populations such as those living in prisons and nursing homes.

http://www.census.gov/hhes/www/cpstc/cps_table_creator.html

http://www.census.gov/population/www/socdemo/educ-attn.html

Data on total number of engineering degrees are provided by the American Association of Engineering Societies (AAES). The AAES tracks the number of engineering degrees awarded each year from over 300 accredited institutions throughout the United States.

http://www.aaes.org

Data in the text about degrees in biomedical engineering are from the IPEDS Completions Survey using the NSF population of institutions.

http://caspar.nsf.gov

19. Population Growth Rate and Migration

Data on population growth rate by state and the US as well as total foreign and domestic migration data are provided by 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

Data on population mobility come from the American Community Survey table BO7009: Residence one year ago by educational attainment, persons age 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

Data on population growth by educational attainment come from the US Census Bureau, Current Population Survey, Annual Social and Economic Supplement, 2005 through 2008, three year average.

http://www.census.gov/hhes/www/cpstc/cps_table_creator.html

20. Housing Affordability, Home Prices, and Housing Starts

Housing price data are provided by the Office of Federal Housing Enterprise Oversight (OFHEO)'s Housing Price Index (HPI). 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.ofheo.gov/Media/Archive/house/hpi_tech.pdf].

Data on homeownership rates are from the US Census Bureau.

http://www.census.gov

Data on total number of housing starts by state are provided by the US Census Bureau, Manufacturing, Mining, and Construction Statistics. Population data are for July and are also provided by the US Census Bureau.

http://www.census.gov/const/www/permitsindex.html

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

The North American Industry Classification System (NAICS) replaced the US Standard Industrial Classification (SIC) system in 1997. NAICS was jointly developed by the US, Canada, and Mexico to provide new comparability in statistics about business activity across North America. For more information about NAICS, visit: http://www.census.gov/epcd/www/naics.html.

The **Index** makes use of three-, four-, and five-digit NAICS codes for analysis of the key industry clusters. The analysis of key industry clusters within Massachusetts begins with a disaggregation and examination of all Massachusetts state industry activity to the three-, four-, and five-digit NAICS code level. Industry data are analyzed through the following measures:

- Cluster employment concentration relative to that of the United States
- Cluster employment as a share of total state employment

Modification to Cluster Definitions

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, & 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 exclusion of Advanced Materials in the 2007 edition, 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, while there is not a statistically significant concentration, it is included as it represents activity that supplies critical support to other innovation clusters via professional services such as legal, design. The eleven key industry clusters as defined by the **Index** reflect the changes in employment concentration in the Massachusetts Innovation Economy over time.

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/Pharmaceuticals, Medical Devices, & Hardware

3254 Pharmaceutical and Medicine Manufacturing

3391 Medical Equipment and Supplies Manufacturing

6215 Medical and Diagnostic Laboratories

4234 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 Scientific R&D Services
(*apportioned based on 5417102Biological R&D in the Economic Census)

3345 Navigational, Measuring, Medical, and Control Instruments Manufacturing
(*apportioned based on 334510 Electro Medical Apparatus Mfg. and 334517 Irradiation Apparatus Mfg. in County Business Patterns)

Business Services

5411 Legal Services

5413 Architectural, Engineering, and Related Services

5418 Advertising & Related Services

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

3351 Electric Lighting Equipment Manufacturing

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 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 Scientific R&D 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

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Renaissance Capital

Standard & Poor's

State Higher Education Executive Officers

US Bureau of Labor Statistics

US Census Bureau

US Citizenship & Immigration Services

US Department of Commerce

US Food and Drug Administration

US News & World Report

US Patent & Trademark Office

US Small Business Administration

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