

**THE INDEX OF THE  
MASSACHUSETTS  
INNOVATION  
ECONOMY  
2015/2016 EDITION**



**The INNOVATION INSTITUTE at the  
MASSACHUSETTS TECHNOLOGY COLLABORATIVE**

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

**To view the Index online visit our Innovation Index portal at: [index.masstech.org](http://index.masstech.org).**

**For more information on the Massachusetts innovation economy visit our website at: [www.masstech.org](http://www.masstech.org).**



# MASSACHUSETTS TECHNOLOGY COLLABORATIVE

## MASSTECH: WHO WE ARE

The Massachusetts Technology Collaborative, or MassTech, is an innovative public economic development agency which works to support a vibrant, growing economy across Massachusetts. Through our three major divisions - the Innovation Institute, the Massachusetts eHealth Institute (MeHI), and the Massachusetts Broadband Institute (MBI) - MassTech is fostering innovation and helping shape a vibrant economy.

We develop meaningful collaborations across industry, academia and government which serve as powerful catalysts, helping turn good ideas into economic opportunity. We accomplish this in three key ways, by:

**FOSTERING** the growth of dynamic, innovative businesses and industry clusters in the Commonwealth, by accelerating the creation and expansion of firms in technology-growth sectors;

**ACCELERATING** the use and adoption of technology, by ensuring connectivity statewide and by promoting competitiveness; and

**HARNESSING** the value of effective insight by supporting and funding impactful research initiatives.

## MASSTECH: OUR MISSION

Strengthen the innovation economy in Massachusetts, for the purpose of generating more high-paying jobs, higher productivity, greater economic growth, and improved social welfare.

## THE INNOVATION INSTITUTE AT MASSTECH

The Innovation Institute at MassTech was created in 2003 to improve conditions for growth in the innovation economy by:

- Enhancing industry competitiveness;
- Promoting conditions which enable growth; and
- Providing data and analysis to stakeholders in the Massachusetts innovation economy that promotes understanding and informs policy development.

The Innovation Institute convenes with and invests in academic, research, business, government and civic organizations which share the vision of enhancing the Commonwealth's innovation economy.

Using an innovative, stakeholder-led process, we have been implementing a "cluster development" approach to economic development. Projects, initiatives and strategic investments in key industry clusters throughout all regions of the Commonwealth are creating conditions for continued economic growth.

Our mission is to strengthen the innovation economy in Massachusetts, for the purpose of generating more high-paying jobs, higher productivity, greater economic growth and improved social welfare. The Institute manages programs which focus on Advanced Manufacturing in the state, driving support for emerging sectors such as Big Data and Robotics and spurring programs which keep talented workers in the Commonwealth, whether through the Intern Partnership program or on entrepreneurship mentoring.

# NEW BEDFORD



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## INTRODUCTION

Massachusetts continues to be one of the most innovative and prosperous states in the country. The Commonwealth's innovation economy has experienced larger job growth than the rest of the Massachusetts economy during the last year. Massachusetts posted positive job growth in 8 of 11 innovation economy sectors, led by Biopharmaceuticals & Medical Device Manufacturing, Software and Communication Services, and Health Care Delivery. Massachusetts' workers earn higher wages than their counterparts in the Leading Technology States (LTS) in 10 of 11 major occupational categories. Massachusetts' innovation economy sectors produce more output per capita than their counterparts in the LTS with Software and Communications Services being the driving force as output increased by \$7.7 billion from 2009-2014. Massachusetts continues to outperform the LTS in terms of R&D expenditures as a percent of GDP. Business establishment openings are at a twenty-one year high, and Massachusetts is a highly desired start up location due to the dense pockets of start-up networks and the ability to attract funding from investors at early stages in the growth process. A highly educated labor force and prioritized research and development (R&D) continue to keep Massachusetts at the leading edge of innovation.

However, the 2015 Annual Index of the Massachusetts Innovation Economy also provides a glimpse at areas where the Commonwealth is lagging in comparison to recent years. Since 2009, Computer and Communications Hardware has seen significant job loss (10.4%) and manufacturing exports as a percentage of GDP has continued to decrease (-4.7%). Despite a record number of utility patents issued to Massachusetts-based filers by the U.S. Patent and Trademark Office, California has surpassed Massachusetts in per-capita patenting since 2009. States are becoming more innovative and competition is increasing in areas where Massachusetts has been historically strong. Though Massachusetts maintains a strong commitment to public K-12 education funding, it is still trailing three LTS. Massachusetts produces more college graduates per capita than any LTS, but still remains below the U.S. average for State Higher Education Appropriations. The employment rate for those with a High School Degree or Equivalent has improved to 60%, but the employment rate for a Bachelor's Degree or higher has declined to 76% following a 6 year peak in 2012 (78%). As competition increases among states for innovation economy employment and R&D resources, Massachusetts will have to maintain an efficient network of actors in order to preserve its position as a leading innovation state.

## HIGHLIGHTS

### ECONOMIC IMPACT

Massachusetts sees great economic impact from the innovation economy. Innovation economy job growth exceeded job growth in the rest of the economy over the last year. Innovation economy wages are typically much higher than average wages and Massachusetts innovation economy employees earn more than their counterparts in the average LTS. All innovation economy sectors have experienced an increase in annual average wages over the last year, except for Healthcare Delivery, which has remained roughly constant. The Commonwealth's fastest growing innovation economy sector in terms of wage growth is BioPharmaceuticals & Medical Devices.

### TECHNOLOGY & BUSINESS DEVELOPMENT

Although the overall number of Small Business Innovation and Research/Technology Transfer (SBIR/STTR) awards has decreased over the last four years, award funding increased in 2014 for the first time since 2010 in Massachusetts. Massachusetts remains a clear leader in award dollars as a percentage of GDP, with more than twice the level of the next closest LTS. The National Aeronautics and Space Administration (NASA) surpassed the National Science Foundation in 2014, reaching 4th in terms of SBIR & STTR funding and awards. Massachusetts Utility and Technology patents have continued to increase since 2008, with Computer & Communications hardware making up the majority of Technology patents. Massachusetts ranks second behind California in Utility patents issued from 2009-2014. Massachusetts is second in the LTS to California in number of start-ups initiated from universities, hospitals, research institutions, and technology investment firms.

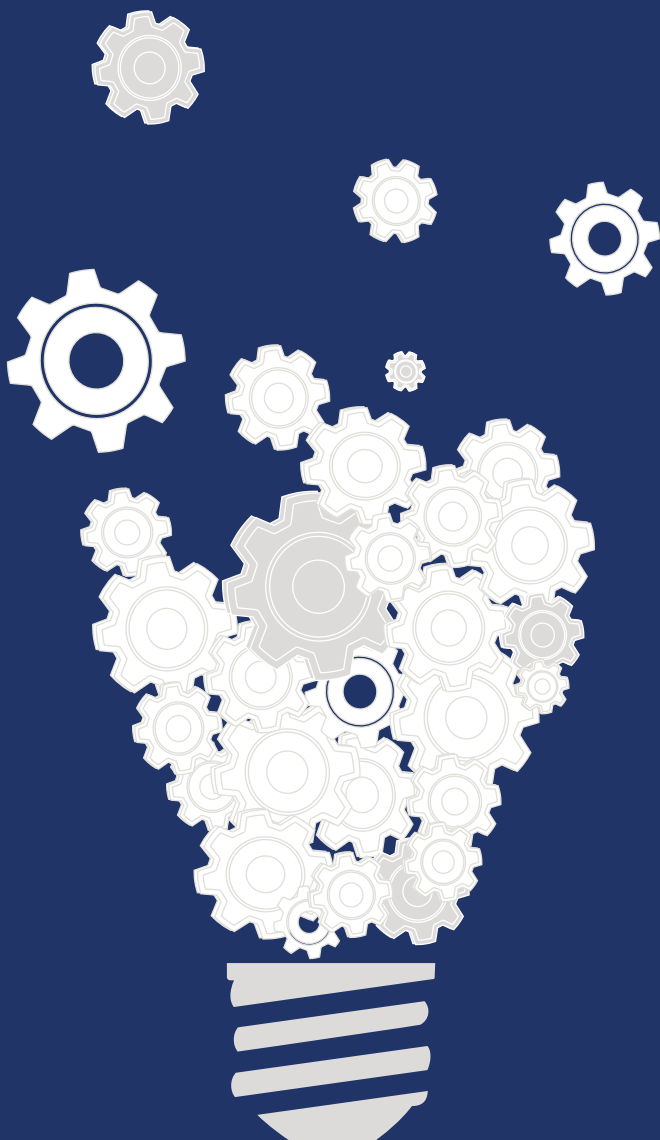
## HIGHLIGHTS

### RESEARCH

Massachusetts remains a leader in R&D across multiple metrics. The Commonwealth receives more R&D funding per capita, more National Institutes of Health (NIH) funding as a percentage of GDP, and invests more on R&D as a percentage of GDP than any of the LTS. In terms of total R&D expenditure, Massachusetts ranks second behind California. The bulk of R&D performed in Massachusetts (85.8%) is conducted by business and institutions of higher education.

### TALENT

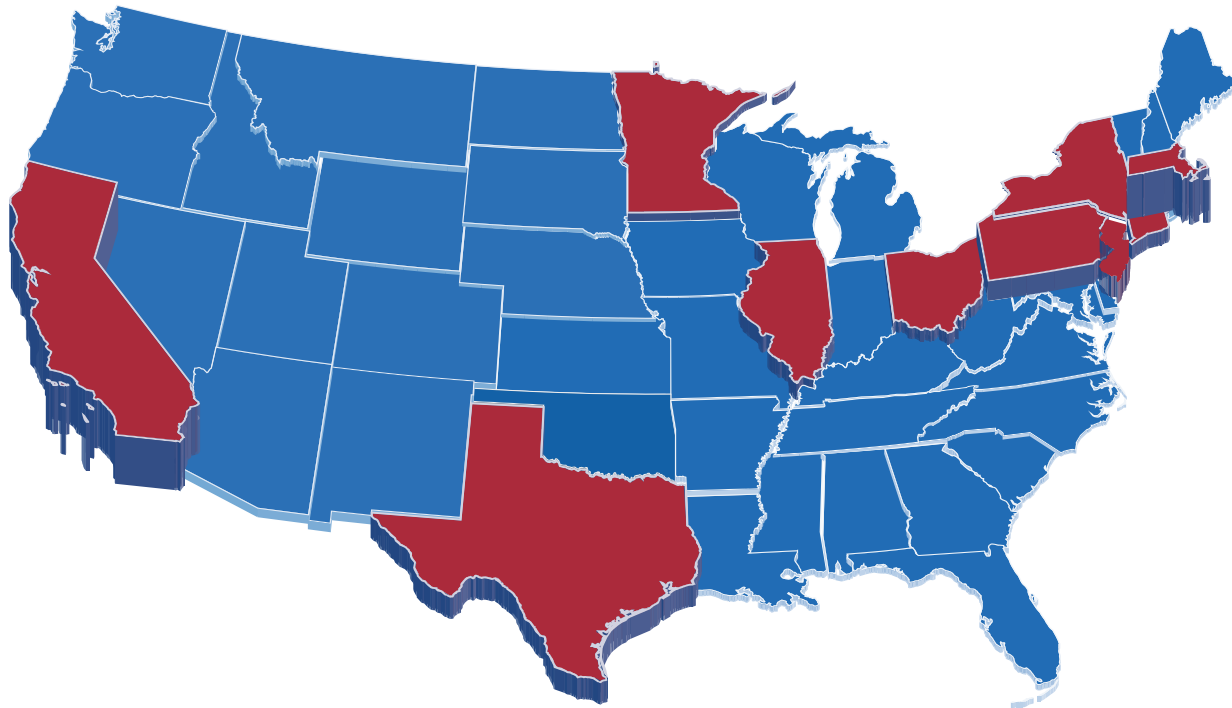
Massachusetts continues to have one of the most educated workforces in the U.S., with 67% of working age adults having at least some college education. 46.1% of working adults have bachelor's degrees, propelling Massachusetts ahead of the rest of the LTS. Massachusetts confers more postsecondary degrees per capita than any other LTS and is above-average in its public K-12 funding per pupil. Despite its cold climate, some of the highest housing prices in the LTS, and highest industrial electricity prices of the LTS, Massachusetts' has maintained a positive net migration since 2008. The Commonwealth maintains faster broadband speed than the rest of the LTS (15.3 Mbps), posting the 7th fastest speed nationwide as well as ranking 2nd in terms of access nationwide as well. The high quality of life and relatively high paying job opportunities have made Massachusetts a top relocation destination for college educated adults.



### CAPITAL

Massachusetts is a top destination for R&D funding from the Federal Government. In absolute terms, Massachusetts ranks behind only California and tops the LTS in per capita funding. The Commonwealth is second to California in federal R&D funding for universities and other non-profits as a percent of GDP as well. Industry funding for academic R&D in science and engineering (S&E) in Massachusetts reached a 10 year peak in 2013 at \$219 million. Massachusetts is a top destination for venture capital (VC) as well, ranking behind only California in both absolute terms and as a percent of GDP. Investors have shown great interest in younger start-up firms since 2005, with early stage start-ups receiving the most funding. In Massachusetts, Biotechnology and Software attract the vast majority of Massachusetts VC funding.

SELECTION OF THE LEADING TECHNOLOGY STATES



Every year, the Index compares Massachusetts’ performance on a number of metrics to a group of “Leading Technology States” (LTS). The LTS have economies with a significant level of economic concentration and size in the 11 key sectors that make up the Innovation Economy in Massachusetts. The Index accounts for three metrics deemed representative of not only the intensity of the innovation economy but also the size and breadth of a state’s innovation economy and evaluates them simultaneously.

**THE METRICS USED TO SELECT THE 2015 LTS:**

**Number of key sectors with significantly above average employment concentration**

This is defined as the number of innovation economy sectors in each state where employment concentration is more than 10% above the national average and is a measure of the breadth of a state’s innovation economy.

**Overall innovation economy employment concentration relative to the nation**

This is defined as the percent of a state’s workers who are employed in the innovation economy relative to the national level percentage and is a measure of the overall intensity of a state’s innovation economy.

**Total innovation economy employment**

This measures the number of employees who work within one of the innovation economy sectors in each state and is a measure of the absolute size of a state’s innovation economy. A score is then applied to all of the states in order to determine the top 10.

State	Score
<b>Top Ten</b>	
Massachusetts	2.27
California	2.21
Pennsylvania	2.04
New York	1.74
Connecticut	1.73
Ohio	1.66
Illinois	1.59
Minnesota	1.54
Texas	1.53
New Jersey	1.45
<b>Next Five</b>	
North Carolina	1.44
New Hampshire	1.39
Rhode Island	1.38
Missouri	1.35
Wisconsin	1.34



## LEADING TECHNOLOGY STATES (LTS)

**CALIFORNIA:** California is a \*leader in 5 of the 11 sectors used to define the innovation economy and has the highest number of innovation economy employees, despite having a slightly below average overall concentration of employees. California contains both San Francisco and Silicon Valley, home to well-known companies such as Google, Apple and Facebook. California consistently invests more in research and development from non-profits and academia than any other LTS. A key to this lead in research spending is that California is home to several top research universities such as Cal Tech, Stanford, UC Berkley and UCLA. California's strength in R&D has proven beneficial for patents, leading the LTS in patents per million residents. California is a highly desired location for business openings, with 26,205 business openings in key sectors since 2010. California's start-ups and venture capital have a mutually dependent relationship, with venture capital investment in California ranking higher than any other LTS.

**CONNECTICUT:** Despite its small size, Connecticut is a leader in 6 of 11 key sectors and has the second highest overall concentration of innovation economy employees. The state's defense, financial services, and diversified industrial manufacturing industries are particularly strong, represented by companies such as Pratt & Whitney, The Hartford Insurance and United Technologies. Scientific, Technical, & Management Services have been the fastest growing innovation sector during 2009-2014. Connecticut is host to a number of leading global technology consulting firms such as Accenture and Apex. Connecticut is also home to numerous top-tier colleges and universities including Yale and the University of Connecticut. The University of Connecticut has been especially important in the growth of the innovation economy. The UConn Innovation Institute provides several industry centers aligned with innovation economy sectors such as Advanced Materials and Biomedical Devices that give students the opportunity to complete research and partner with companies in those specific industries. UConn has also positioned itself to collaborate with other organizations to recruit SBIR/STTR funding for research, with Connecticut successfully granting \$124 per million GDP in SBIR/STTR award funding in 2014, 5th place among the LTS.

**ILLINOIS:** Illinois is a leader in 5 of 11 key sectors, has a relatively large number of innovation economy employees, and an above average overall innovation economy employment concentration. Illinois is particularly strong in manufacturing (John Deere & Caterpillar) and financial services (Chicago Mercantile Exchange). The state's Finance sector has continued to expand during 2009-2014, growing 2.7%. Illinois is home to well-known universities and colleges including Northwestern University, the University of Chicago and the University of Illinois. Illinois has not significantly increased its R&D expenditures over the last decade, remaining in the middle of the LTS. In 2012, Federally Funded R&D Centers played a larger role in R&D performance in the state than any other LTS (6.52%). Illinois contains the ingredients for innovative success - strong research institutions, private sector resources, and skilled labor - but has struggled in recent years in engaging start-ups and receiving venture capital funding. Illinois has tried to combat the scarcity of venture capital funding with the creation of the Technology Development Act, stating that the State Treasurer may divert up to 1% of the Treasurer's investment portfolio in the Technology Development Account which can be used to help attract, assist, and retain quality technology businesses in Illinois. This initiative has increased start up formation and venture capital assistance in Illinois with 10,714 business establishments opened from 2010-2014 and venture capital investment increased 128% from 2013-2014 to \$1.06 billion.

**MASSACHUSETTS:** Massachusetts is a leader in 8 of the 11 sectors used to define the innovation economy and has the highest overall concentration of innovation economy employees. Massachusetts is home to a large concentration of research institutions, biotech firms, and software firms. In addition to a diverse array of start-ups, Massachusetts is home to the headquarters or major operations of State Street Bank, EMC, Microsoft, Genzyme, Cisco and Raytheon. The state is home to many universities, colleges and research institutions including Harvard, Massachusetts Institute of Technology (MIT), Worcester Polytechnic Institute (WPI), Tufts, Boston University and the University of Massachusetts system. Massachusetts spent the second most among the LTS on R&D, and this has proved successful for the Commonwealth. Massachusetts ranks second behind California in start-ups initiated from universities, hospitals, research institutions, and technology investment firms.

**MINNESOTA:** Despite its relatively small population, Minnesota is a leader in 5 of 11 key sectors and has a high concentration of innovation economy employees. The state is particularly strong in Biopharma & Medical Devices, Manufacturing and Financial Services. Representative companies include the Mayo Clinic, Medtronic, 3M and U.S. Bancorp. Minnesota has led a state initiative to partner with the University of Minnesota in order to create Minnesota's Discovery, Research, and Innovation Economy (MnDrive). The partnership aligns the state of Minnesota with its state university's research strengths to address challenges and untapped industries in the state. In 2013, the Minnesota Legislature granted \$18 million in investments to four research areas identified by academia, industry, and the public: Robotics, Global Food, Environment, and Brain Conditions. To date, MnDRIVE funding has supported 210 projects, produced 41 potential patents or licenses, created 321 jobs and forged more than 75 external partnerships with companies throughout the state, many of which are in the food and agricultural sector.

**NEW JERSEY:** New Jersey is a leader in 5 of 11 key sectors and has an above average employment concentration. The state is home to many pharmaceutical companies and their R&D facilities and has strong financial services and software industries. The state is also home to many universities and colleges including Princeton, Rutgers, Stevens Institute of Technology, and New Jersey Institute of Technology (NJIT). In recent years, New Jersey has had issues with funding R&D, which propelled NJIT to create the New Jersey Innovation Institute. New Jersey Innovation Institute is a non-profit intended to match local firms with university researchers in order to accelerate research and development in health care, bio-pharmaceutical production, civil infrastructure, defense and homeland security and financial services. This program proved successful for New Jersey in 2014, with 20 start-ups initiated from universities, hospitals, research institutions, and technology investment firms, more than doubling the total amount from 2013.

\*In this section the term leader is used as short hand to indicate that a state has a significantly above average Location Quotient (1.1 or greater) in a certain number of innovation economy sectors. This is one of the selection criteria for the Leading Technology States and is a measure of the employment concentration of an industry within a state.

## LEADING TECHNOLOGY STATES (LTS)

**NEW YORK:** New York has a large number of innovation economy employees, a high overall employment concentration, and is a leader in 3 of 11 sectors that make up the innovation economy. As the home of Wall Street, the state's financial services sector is particularly strong. New York is also a leader in postsecondary education with universities such as Cornell, Columbia, Syracuse University, New York University and the State University of New York system. The Empire State Development's Division of Science, Technology, and Innovation promotes a network of industry-university partnerships throughout the state that will allow businesses to improve competitiveness through the use of innovative technologies. New York's innovation economy has outgrown the rest of the state economy over the past year, an outlier in the LTS.

**OHIO:** Ohio is a leader in 5 of the 11 key sectors, has a relatively large number of innovation economy employees, and has an above average innovation economy employment concentration. Ohio's strengths lie in manufacturing, business services and healthcare delivery, represented by companies such as GE Aviation and Cleveland Clinic. The fastest growing innovation sector from 2009-2014 in Ohio was Computer and Communications Hardware, which grew at 8.4%. The state is also home to many universities including Ohio State and Case Western Reserve. In order to better prepare high school students for the innovation economy, Ohio launched Believe in Ohio which introduces high school students and teachers to innovation economy workshops, competitions in Science Technology Engineering and Math, and scholarship funding.

**PENNSYLVANIA:** Pennsylvania is a leader in 7 of the 11 sectors used to define the innovation economy, in addition to having a large number of innovation economy employees and a high overall employment concentration. Companies representative of Pennsylvania's diversity within the innovation economy include PNC Financial, GE Transportation Systems, Comcast and Wyeth Pharmaceuticals. Pennsylvania is home to many research universities including Penn State, Carnegie Mellon, the University of Pennsylvania and the University of Pittsburgh. Pennsylvania is host to the largest urban research park in the world, Philadelphia's University City Science Center, which serves as an incubator for technology companies and has helped create more than 15,000 jobs.

**TEXAS:** While Texas is a leader in only 2 key sectors, it has the second highest number of innovation economy employees. Texas' strengths lie in computer & communications hardware and defense. Over the past five years Texas' Scientific, Technical, and Management services sector has grown rapidly (6.5%). Texas is also home to companies such as Dell, Texas Instruments, and NASA's Johnson Space Center, as well as an Apple campus. Texas placed third out of the LTS in total R&D expenditures in 2012 and has proved to be a desirable destination for businesses as Texas had 15,354 establishments open from 2010-2014. The state is also home to research universities including Rice, the University of Houston and the University of Texas. The universities in Texas are critical for the state's R&D environment as 22.50% of R&D was performed by universities and colleges in 2012.



# SPECIAL ANALYSIS: COLLABORATIVE WORKSPACES IN THE COMMONWEALTH



## SPECIAL ANALYSIS

Fostering the growth of start-ups is an essential task for maintaining and growing a prosperous innovation economy. The Kaufmann Foundation, a leading supporter of research on entrepreneurship issues, has found that new firms (less than 5 years old) are responsible for generating nearly all net job growth over the last two decades.<sup>1</sup> In some cases, a dorm room or garage-based business today could become the next Google or Facebook, creating thousands of jobs in the process. However, start-ups often face a problematic gap between the formation of an idea and its maturation into a sustainable business. This gap exists both in terms of physical space when a traditional lease is not flexible enough or even feasible for many start-ups; as well as business acumen since many start-ups often lack well-defined business plans, knowledge of legal and accounting matters, and experience raising capital. Collaborative workspaces are often an option that many start-ups utilize to help bridge this gap. Collaborative workspaces can be one way to support the pipeline of new firms in a regional economy.

As more cities work to create economic development opportunity through prescribed initiatives, such as “Innovation Districts”, collaborative workspaces can serve as anchors for a neighborhood or regional economic development initiatives. For example, instead of leasing to a single large company, landlords around the state are increasingly converting vacant buildings into shared workspaces, a model that large companies are also using to take advantage of underutilized space within their own facilities. Collaborative workspaces are becoming more prevalent across the Massachusetts innovation landscape, and represent a category within economic development that should be defined and examined.

### What is a Collaborative Workspace?

Compared to a few decades ago, startups now have a plethora of options to choose from when seeking relatively low-cost, flexible work spaces. Some of these spaces provide simple, functional necessities such as a shared lobby and basic infrastructure like bathrooms, while at the other end of the spectrum, the working space itself is secondary to the services provided such as mentorship and access to capital. Shared workspaces are becoming increasingly important to the innovation economy as more firms want to cluster in desirable locations and may not necessarily be able to afford a traditional private workspace at the outset. In some cases, the exchange of ideas among companies and individuals in shared workspaces result in fortuitous collaborations and exchanges of know-how that can make these spaces more desirable than a private space. On the following pages we define and discuss the different types of collaborative workspaces, highlighting the differences between the various types and outlining the advantages that each claim to provide.

## KEY FINDINGS

**Although the lines between different collaborative workspaces - coworking, makerspace, incubator, accelerator - may sometimes blur, there are some defining characteristics to each.**

**Geographic location matters greatly in how the collaborative workspaces are set up and how they operate.**

**All collaborative workspaces aim to create community and provide points of contact, but do so to different degrees and in different ways.**

**Those collaborative workspaces that aim to provide programming, often cite mentoring as a top priority.**

**Spaces outside of Greater Boston face greater challenges in attracting funding and a critical mass of start-ups but nevertheless there is significant demand for collaborative workspaces outside of Greater Boston.**

<sup>1</sup> “The Importance of Young Firms for Economic Growth,” Jason Wiems & Chris Jackson, Kauffman Foundation 2015

**SPECIAL ANALYSIS**

*Types of Collaborative Workspaces and the Services Offered in Massachusetts*

TYPE	# IN MA*	SERVICES OFFERED	EXAMPLES
Co-Working Spaces	33	General Office Amenities <ul style="list-style-type: none"> <li>• Internet</li> <li>• Print/Copy/Fax</li> <li>• Phones</li> <li>• Private Meeting Rooms</li> <li>• Desk Rentals</li> </ul>	WeWork (Boston, MA)
			Click Workspace (Northampton, MA)
			Running Start (Worcester, MA)
Makerspaces	25	Machine Tools <ul style="list-style-type: none"> <li>• Lathes</li> <li>• Drill Press</li> <li>• Laser Cutters</li> </ul>	Artisan's Asylum (Somerville, MA)
		Computer Lab <ul style="list-style-type: none"> <li>• 3D Printer</li> <li>• Computer Aided Design (CAD)</li> </ul>	Framingham Makerspace (Framingham, MA)
		Woodshop	Maker's Mill (North Adams, MA)
		Fiber Arts Equipment	
		Technical Mentorship for Equipment	
		Access to Basic Parts/Materials	

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**SPECIAL ANALYSIS**

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TYPE	# IN MA*	SERVICES OFFERED	EXAMPLES
Incubators	26	Business Assistance • Marketing • Development • Legal • Human Resources	Greentown Labs (Somerville, MA)
		Access to Specialized Tools & Software	North Shore InnoVentures
		Entrepreneurship Educational Events	SPARK (Holyoke, MA)
Accelerators	15	Business Assistance • Marketing • Development • Legal • Human Resources	Tech Stars (Boston, MA)
		Entrepreneurship Educational Events	MassChallenge (Boston, MA)
		Access to Capital	
		Mentorship from Successful Entrepreneurs & Venture Capitalists	TechSpring (Springfield, MA)

\*These totals are part of an on-going effort to identify and categorize collaborative workspaces, based on the definitions the Innovation Institute at the Massachusetts Technology Collaborative has developed, and are likely to change.

## SPECIAL ANALYSIS

### Co-Working Spaces

Within the spectrum of shared workspaces serving the innovation economy, co-working spaces offer the simplest arrangements, with a relatively low level of services provided. Co-working spaces allow an individual or start-up to maintain operational flexibility, offering the ability to rent desk space ranging from an hourly rate to a monthly membership. At a minimum, these types of workspaces give fledgling businesses and entrepreneurs a physical location, often in an otherwise expensive area, which appears more established than meeting in a coffee shop or hotel lobby. Basic business services such as reception and IT are typically provided as well as conferring a type of legitimacy that start-ups might not otherwise enjoy. Co-working spaces usually operate on a fee-for-service model and do not have an ownership interest in tenant companies.

A co-working space is not necessarily targeted at the Innovation Economy or start-ups with high growth potential. For fledgling companies with a handful of employees or individual entrepreneurs that either do not need or are not yet ready for the services of an accelerator program or incubator, co-working spaces may be a sensible option. As the size of a company increases, along with demand for more involved services, the economics of a co-working space may make less sense.

### Makerspaces

Makerspaces are typically a step up from co-working spaces in terms of access to infrastructure and, in some cases, the services provided. Makerspaces tend to be manufacturing-oriented and provide shared-use tools for residents, defraying the cost of purchasing often expensive machinery such as lathes and milling machines. Like co-working spaces, makerspaces operate on a fee-for-service business model, although there are special cases, such as university-based makerspaces, that are freely available to students and alumni.

While it is not entirely accurate to describe makerspaces as hardware focused co-working spaces, the analogy holds some merit. Makerspaces are not limited to start-up use as artists and hobbyists frequent them as well. Fostering a collaborative environment is still important for makerspaces as tenants often possess a unique range of skills to share with each other, often creating a community of interests. Some incubators and even accelerators will use the term 'makerspace' to describe the shared machine shop that tenants can access, an asset many incubators and accelerators are incorporating into their offerings in response to demands from their tenants.

### INCUBATORS & ACCELERATORS: CUTTING THROUGH THE CONFUSION

Incubators and accelerators offer the highest level of services within the shared workspace spectrum. The distinction between the two is somewhat permeable or inexact and the terms are sometimes used interchangeably, but one key difference is in the timeline. Incubators do not typically operate around timelines while Accelerators often do.

Accelerators and incubators often have a symbiotic relationship with many companies working in both types of facilities. For example, hardware-focused start-ups that graduate from an accelerator may not be ready to set up their own production facility. While they may have a proof-of-concept, further prototyping and design refinements might be necessary to ensure products can compete in the marketplace. One solution for start-ups in this situation is an incubator space like Somerville's Greentown Labs which allows clean tech companies up to 1,000 sq. ft. of flexible prototyping space. For start-ups without the capital needs of manufacturing a physical product, an accelerator can be necessary before they graduate into their own space.

### Incubators

Incubators provide a workspace to their tenant firms as well as basic business services. In addition, they also offer some mentorship and sometimes more formal educational resources to help firms refine their business models and learn about entrepreneurship. Incubators are not necessarily fee-based, although they often are. Some may take equity exchange for services or even make a cash investment in tenants. There is no fixed time limit for users of incubators and they are typically aimed at very early stage or seed stage firms.

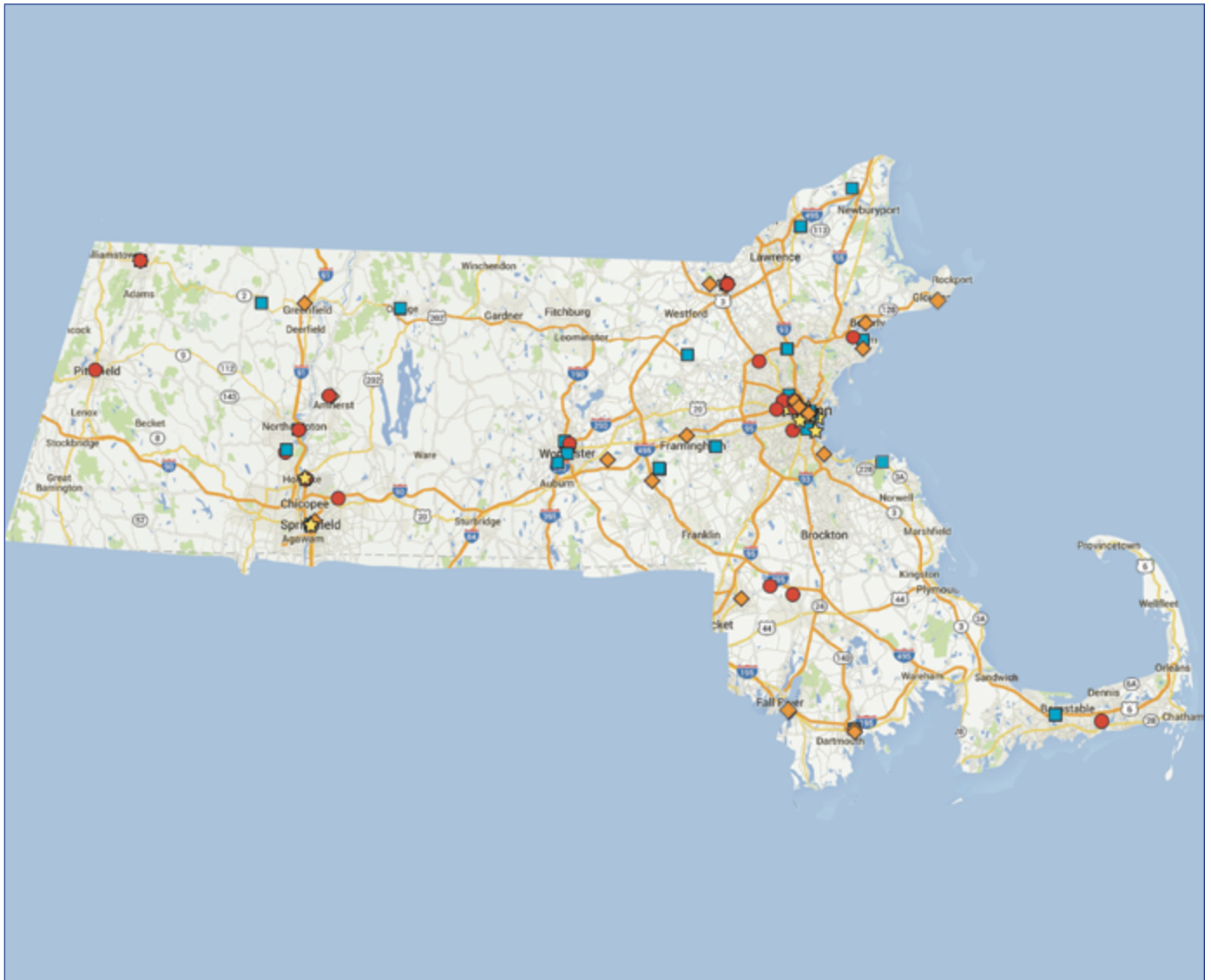
### Accelerators

Accelerators have many of the same attributes as Incubators: they are not usually fee-based, they provide business mentorship and educational opportunities aimed at helping companies progress, and they may take an equity stake for in-kind payment or make a cash investment. However, accelerators have a competitive and programmatic aspect to them that is unique among the shared workspace spectrum. Accelerator programs are structured around fixed beginning and end dates and tenant firms have the added pressure of knowing when they will have to leave. Programs are often analogous to a school setting where you must attend specific classes or events.



# SPECIAL ANALYSIS

## MASSACHUSETTS COLLABORATIVE WORKSPACES



**Key Code**    ● Makerspace    ■ Co-Working Spaces    ◆ Incubators    ★ Accelerators

Interactive versions of this map are available on [index.masstech.org](http://index.masstech.org)

## SPECIAL ANALYSIS

### OBSERVATIONS FROM THE FIELD

The different types of collaborative workspaces fill different niches within the Massachusetts Innovation Economy. The operational specifics of any one organization may not be directly transferrable to another region or city, however, some broader lessons are applicable.

#### Location, Location, Location

The location of a collaborative workspace is a deciding factor in what type of space should be developed and the particular mix of services offered and customers targeted. Kendall Square offers a different opportunity than Lowell, or even nearby Somerville. The Cambridge Innovation Center (CIC), one of the largest collaborative workspaces of any kind in the world, has a wealth of potential tenant companies from the dense, local economy and a ready pipeline of entrepreneurs coming out of nearby universities, which include MIT and Harvard. Kendall Square also provides a dense network of support services to start-ups for such needs as legal, accounting, and financial services. Because of its location, CIC found it need not provide these services itself since in many cases these service providers are located in nearby buildings. CIC has also found it better for all parties involved to attract firms locally whose core focus aligns with the needs of the start-ups located there.

An engaged community is also a necessity for an organization like CIC. CIC was instrumental in establishing the non-profit Venture Café, which partners with other non-profits, universities, and state and local government to provide a full range of mentoring and networking opportunities as well as infrastructure for greater public benefit. This model is not unique to Cambridge or Boston (where CIC operates another facility). CIC itself has facilities in St. Louis (where Cortex, a non-profit, oversees the development of an innovation district) and in Rotterdam. CIC asserts that its model is workable in dense locations with access to world-class research universities, high quality professional services, and governments that are committed to fostering innovation and entrepreneurship. Similar types of organizations exist in other cities around the world such as CoCo in Minneapolis, MN, American Underground in Durham, NC, and Warner Yard in London, UK.

While Massachusetts is one of the most densely populated states, most of the Commonwealth does not resemble Kendall Square or the South Boston Innovation District. Tapping into the entrepreneurial potential in suburbs, Gateway Cities<sup>2</sup>, and small towns requires a different approach. While these other regions of Massachusetts have professional services firms, they may not be located across the street; and marshalling the array of services needed by startups is not as simple as walking downstairs or jumping on the Red Line. Collaborative workspaces in other parts of the state often cannot rely on other organizations to handle the mentoring and networking aspects of the innovation ecosystem because there may not be anyone in the area offering these services. While there are research universities in many parts of the Commonwealth, access to them is not as easy as in Boston/Cambridge. The MetroWest, while it has a large population, high level of education, and many tech companies, does not contain a large research university, which means the pipeline of new ideas and potential entrepreneurs is thinner. Isolated suburban areas often lack the civic framework necessary to pool resources and undertake a group effort to support innovation; and most individual towns do not have the resources to go it alone.

#### Funding

For-profit entities have had clear successes in dense areas where they were able to tap into existing start-up ecosystems or work with other organizations to secure missing pieces, allowing the self-sustaining parts of the operation to fund themselves. What is less clear is whether this business model translates to other parts of the Commonwealth. Quality space is important to high potential start-ups and building out that space is often expensive. For-profits may have trouble raising the capital necessary to start creating the infrastructure for collaborative workspace in areas where the real estate market is less of a driver. Generally, government or foundation-based grant programs that would fund these types of spaces are only available to non-profit entities.

Being a non-profit, however, doesn't necessarily solve these fund raising problems. While there are existing grant programs to address the needs of nascent collaborative workspaces, both from government agencies and non-profit foundations, these resources are not centralized in any fashion. Collaborative workspaces are often founded by people looking to serve a particular community or a particular business or technical niche and while they may have intimate knowledge of the community and its needs, they may not have experience navigating the paths to myriad public and non-profit funding opportunities available. Grant writing is especially important for gaining access to such funding opportunities, but it is time consuming and collaborative workspace founders may not have any experience in this area. Makerspaces in particular face challenges raising capital as they typically require expensive machine tools and insurance due to a much higher risk of injury.

#### Mentoring

Mentoring was almost universally cited as important in our interviews at incubators and accelerators. Space is often the primary reason that start-ups seek out a collaborative workspace, but mentoring is often more important to their success than affordable real estate. Start-up founders may have a focused idea for a new product, but they do not always have the business skills necessary to turn an idea into a successful company. Founders can benefit from the advice of people who have successfully raised venture capital or have experience with supply chains. Law, accounting, and management are other common disciplines for mentors. CEO Roundtable events, offered at many Massachusetts-based incubators, let new CEOs interact with experienced ones in a private setting. Mentoring activities and levels of effort vary greatly; in some cases mentors may only interact with start-ups a handful of times while, in other cases, mentors seek to join or invest in the companies they are mentoring.

<sup>2</sup> Under M.G.L. c. 23A section 3A, a Gateway City is defined as a municipality with: A population greater than 35,000 and less than 250,000, median household income below the state average, and rate of educational attainment of a bachelor's degree or above that is below the state average.

## SPECIAL ANALYSIS

Attracting mentors is not a major problem reported by the organizations interviewed for this Special Analysis. People all over the Commonwealth are more than willing to donate their time and knowledge to help entrepreneurs. However, matching start-ups with appropriate mentors is a persistent challenge that can be expensive and time consuming, sometimes requiring dedicated staff. Valley Venture Mentors (VVM) of Springfield has taken a novel approach to this problem by, in effect, crowdsourcing their matching process. VVM started as a mentorship program and has since expanded to become an accelerator. Limited resources meant VVM had to be creative with how it matched mentors to start-ups. Instead of applying the traditional technique of using staff to do the matching, VVM hosts a series of events at which start-ups give quick pitches to a large group of potential mentors and then hold breakout sessions where mentors can choose the companies with which they would like to speak. The events are structured like ‘speed dating for start-ups’ so that potential mentors interact with multiple companies throughout the event. By surveying their start-ups, VVM has determined this process produces matches that often best suit the needs of the companies involved in the program.

### Points of Connection

Collaborative workspaces are also facilitators of connections, both between start-ups and potential customers and suppliers, as well as with the broader community. Greentown Labs, the largest clean tech incubator in the country, has a unique program to connect its start-ups with manufacturing companies in Massachusetts. Manufacturing is especially important to clean tech companies since they are largely focused on developing physical products. Engineers who establish clean tech start-ups may not have much exposure to design-for-manufacturing or know who in the area is best suited to making a batch of their product. At the same time, manufacturing companies often lack a single point of access to the start-up community and building relationships one-by-one with such small companies is often not seen as worth the effort, even though the potential exists to create significant customers in the future. Greentown solved this disconnect by inviting manufacturers to its facility, which is currently home to about 50 clean tech start-ups, and having the manufacturers discuss their needs with start-ups as a group. It found that manufacturers are generally willing to help and will even refer start-ups to other companies if theirs is not a good fit.

UMass Lowell’s Innovation Hub (iHub) has a dual mission of helping start-ups succeed and fostering economic growth in the City of Lowell and its surrounding area. Tenant companies have access to facilities in the university’s labs in addition to the co-working and makerspace layout within the iHub itself. It also has a partnership with the City of Lowell’s Office of Economic Development, which maintains a dedicated desk in the facility. The relationship with the Office of Economic Development is especially important when it comes time for start-ups to ‘graduate’ from the iHub. The city has an incentive to keep these companies local, and can utilize the iHub as a point of connection to support to growing companies in finding real estate in Lowell.

**Allison Lamey, Economic Development Director, City of Lowell**

*“The iHub creates an opportunity to show a side of Lowell that many don’t see – cutting-edge technology, state-of-the-art research facilities, and affordable work space – right in the heart of downtown Lowell. Our collaboration at the iHub affords us a chance to build relationships with the entrepreneurs working in the space. When they’re ready to grow their business we’re there to help them find new space in Lowell, navigate the local permitting process, and access the resources they need to make the transition as smooth as possible.”*

These are but two examples of how collaborative workspaces can be valuable facilitators for the fulfillment of unmet needs of both start-ups and their host communities.

### Community

Collaborative workspaces seek to provide - or at least advertise - a unique culture and community to their users and tenants. Many collaborative workspaces, and especially incubators and accelerators, use a selection process to determine whether or not potential companies are a good fit. Entrepreneurs and companies that are not open to the collaborative/community aspect of these spaces are typically not accepted. Even in spaces that are theoretically open to all comers, there is a target community that will find the space to be a ‘best fit’ and its amenities to be most useful. Like mentoring, people are attracted initially by the space, but a community of people willing to help each other be successful is potentially more important to the long-run success of tenant companies.

### Conclusion

While success stories abound for collaborative workspaces, there are certainly challenges that make them difficult to set up and maintain, especially outside of Boston and Cambridge.

The clearest finding to come out of this work is that there is no one-size-fits-all approach to collaborative workspaces. The various communities around the Commonwealth that could benefit from a collaborative workspace have, in many cases, very different needs from those in Boston and Cambridge and the type of space that is appropriate will be determined largely by existing regional assets. Different types of collaborative workspaces are generally not competitors as they are aimed at distinct communities of entrepreneurs/start-ups and for businesses at different stages of growth. Incubators and accelerators, in particular, can and do have a symbiotic relationship.

Collaborative workspaces have produced meaningful results for the Commonwealth to date. Although not all collect metrics, two of the largest, CIC and MassChallenge, have seen their companies raise \$3.1 billion in total since inception. The companies that have graduated from MassChallenge’s accelerator program were valued at a combined \$3.2 billion in 2015. While impressive, much work remains to be done to ensure the continued success of Collaborative Workspaces in the Commonwealth and in expanding their reach into underserved areas.

## SPECIAL ANALYSIS: CASE STUDIES



### NORTH SHORE INNOVENTURES (BIOTECH & CLEANTECH INCUBATORS) - LIFE SCIENCES CONSORTIUM

The Life Sciences Consortium of the North Shore ([www.lscnorthshore.org](http://www.lscnorthshore.org)) was created by Endicott College, Salem State University, Gordon College, North Shore Community College, and North Shore InnoVentures (NSIV) with the mission of accelerating growth of the regional life sciences industry through workforce development and support for entrepreneurial ventures. To achieve this mission, each institution assessed its strengths in faculty/scientific expertise, current instrumentation, research interests, undergraduate majors, facilities, industry collaborations, and the type of start-up companies attracted to the area. The North Shore Workforce Investment Board (NSWIB) also performed an industry assessment of 84 local life sciences companies of which 60% were early stage. The NSWIB obtained detailed feedback on industry and workforce needs from 35 companies. Half of the surveyed companies wanted specific high-end instrumentation that was beyond their budget. This is a commonality between early-stage companies and primarily teaching institutions; both rarely have sufficient capital to purchase high-end equipment, whether to advance research and development or provide students with hands-on experience that will benefit them and future employers.

A \$5 million Capital Grant from the Massachusetts Life Sciences Center to the Consortium created facilities for next-generation DNA sequencing (Endicott College), proteomics and cell-based assays (NSIV), cellular imaging (Gordon College), mass spectroscopy (Salem State University), and the development of a new Quality Assurance/Quality Control (QA/QC) program (North Shore Community College) to meet the needs of industry. This partnership of academia, industry, and government has created a collaborative community where students are trained on the latest scientific instrumentation that is also accessible to early-stage companies. As the industry member of the Consortium, NSIV and its startup companies have taken interns from each of the academic members and have collaborated with them to ensure that the curriculum and training that students are provided meet industry needs.



### UNIVERSITY OF MASSACHUSETTS LOWELL - INNOVATION HUB

The University of Massachusetts Lowell has established 22,000 sq. ft. of technology startup, prototype development and co-working space in a vacant manufacturing building in Lowell's Hamilton Canal Growth District.

This new facility includes an 11,000 sq. ft. expansion of our successful medical device incubator, M2D2<sup>®</sup>, to include a fully equipped shared wet lab and biotech safety labs. A newly opened Innovation Hub (October 2015), on the 3rd floor of 110 Canal Street in Lowell provides a combination co-working and technology incubator that supports other types of tech-based startup companies.

The site at 110 Canal St. was chosen because of its location in a targeted economic development zone and its proximity to the commuter rail. While some University startups will reside in the facility, this effort is focused on attracting startups from outside the region, helping them grow and then establishing themselves in Lowell.

The University has partnered with the City of Lowell's Planning & Development Office, and the Lowell Plan, a group of local business leaders dedicated to promoting economic development, to transform 15 acres of vacant downtown parcels into a thriving business and technology hub. The City's Planning and Development team staff a desk in the Innovation Hub and work closely with University staff to attract and retain startups. A research tax credit, the University's River Hawk Venture Fund and a recently launched New Venture Loan Fund all help direct financial resources to startups that choose to stay in Lowell.

This strong partnership is already yielding dividends. The expansion of M2D2<sup>®</sup> increases the region's ability to support upwards of 30 new biotech startup companies in Lowell. The Innovation Hub is quickly filling with tech entrepreneurs tired of the commute from southern New Hampshire and the Merrimack Valley into Boston. To date, the City of Lowell has received three proposals to develop parcels adjacent to the Innovation Hub with more expected in the future.

## SPECIAL ANALYSIS: CASE STUDIES



## GREENTOWN LABS

### GREENTOWN LABS - FORGING CONNECTIONS BETWEEN START-UPS AND MANUFACTURERS

Massachusetts is home to thousands of startups and that number continues to grow. The Commonwealth is also home to more than 7,000 manufacturers that have rich histories in producing cutting-edge technology. Until recently, no organization focused on connecting these two essential components of Massachusetts' economy.

That's why in November of 2014, MassDevelopment funded the Greentown Labs Manufacturing Initiative (Initiative) between Greentown Labs and the Massachusetts Manufacturing Extension Partnership (MassMEP) to identify opportunities for startup companies and Massachusetts-based manufacturers to work together. The goal of the program was to have more manufacturers work with startups and have more initial conversations result in a completed paid project as a means to support job growth in Massachusetts.

The Initiative provided office hours and workshops to educate startups and manufacturers, and a survey was conducted to determine each party's understanding of the other. Survey findings were released in April 2015 and again in October 2015, and data consistently showed new opportunities existed for startup companies and established manufacturers to effectively work together for mutual benefit. These connections could ultimately support growth in both sectors.

The workshops and educational materials were developed to ensure that gaps in knowledge and access between startups and manufacturers were addressed and improved. Overall, the Initiative has proven that there are misaligned expectations between startups and established manufacturers, and both sides desire a service like the one provided by Greentown Labs' Manufacturing Initiative.

To date, more than 14 contracts have been signed between startups and manufacturers that otherwise would likely not have occurred. This is a direct result of the best practice information, communication tools and one-on-one office hours provided by the Initiative. Greentown Labs' Manufacturing Initiative believes that by continuing to partner startups and manufacturers it will reinforce the notion that if you have a good idea in Massachusetts, you can make it Massachusetts.







## 2015 Special Analysis

This Special Analysis represents the early stages of an ongoing effort to identify and categorize all collaborative workspaces in Massachusetts. Innovation Institute staff used a preliminary list of workspaces being developed by the Executive Office of Housing and Economic Development to identify the collaborative workspaces that serve the Innovation Economy as defined in this Innovation Index (See pages 13-14). Workspaces were then organized into four broad categories: co-working, makerspace, incubator, and accelerator. The categories were chosen according to inherent similarities among the organizations in each group as well as a review of previously published literature on the subject. The categories are not meant to be all encompassing as there are spaces that do not conform neatly to any single category.

In-person interviews were the primary research method used to inform the Special Analysis. Interview subjects were chosen to obtain both geographic dispersion and to cover different types of collaborative workspaces. Interviews were conducted with the following collaborative workspaces and public officials:

Scott Bailey, Masschallenge

Samantha Joseph, Cambridge Innovation Center

Nick Bold, Technocopia

Tom Kinneman, North Shore InnoVentures

Brianna Drohen, Orange Innovation Center

Micaelah Morrill, Greentown Labs

Martha Farmer, North Shore Innoventures

Tom O'Donnell, UMass Lowell Innovation Hub

Barb Finer, TechSandbox

Emily Reichert, Greentown Labs

Helena Fruscio, Executive Office of Housing and Economic Development (EOHED)

Paul Silva, Valley Venture Mentors

Ann Haynes, MassDevelopment

Steven Tello, UMass Lowell



## **ECONOMIC IMPACT**

**A key goal of the Index is to convey how innovation impacts the state's economy. One way innovation contributes to economic prosperity in Massachusetts is through employment and wages in key industry clusters. Jobs created in the innovation economy typically pay high wages, which directly and indirectly sustain a high standard of living throughout the Commonwealth. Economic growth in key industry clusters hinges on the ability of individual firms to utilize innovative technologies and processes which improve productivity and support the creation and commercialization of innovative products and services. In addition, manufacturing exports are becoming an increasingly important driver of business, competitiveness and overall economic growth. Success in the national and global marketplaces brings in revenue that enables businesses to survive, prosper and create and sustain high-paying jobs.**

### **INDICATORS 1-5**

INDUSTRY CLUSTER EMPLOYMENT AND WAGES

Annual Average Wage in Key Sectors

Massachusetts, 2009-2014

2014 \$

Sector	2009 Average Wage	2014 Average Wage	2009-2014 % Change
Healthcare Delivery	\$67,507	\$67,428	-0.1%
Financial Services	\$123,540	\$139,500	12.9%
Software & Communications Services	\$110,694	\$120,067	8.5%
Business Services	\$98,206	\$107,148	9.1%
Postsecondary Education	\$61,265	\$63,997	4.5%
Scientific, Technical & Management Services	\$102,486	\$105,095	2.5%
Biopharma & Medical Devices	\$111,509	\$131,949	18.3%
Diversified Industrial Manufacturing	\$66,319	\$74,722	12.7%
Defense Manufacturing & Instrumentation	\$100,973	\$109,200	8.1%
Computer & Communications Hardware	\$102,086	\$111,987	9.7%
Advanced Materials	\$64,457	\$67,220	4.3%

Why Is It Significant?

Technology and knowledge-intensive industry clusters provide some of the highest paying jobs in Massachusetts. Increased employment concentration in these key sectors also indicates a competitive advantage for Massachusetts and potential for future economic growth as strength in these areas usually indicates innovation and business growth.

How Does Massachusetts Perform?

In most of the LTS, the innovation economy experienced slower employment growth than the economy as a whole between Q1 2014 and Q1 2015. This is not entirely unexpected because the rebound from the recent recession significantly benefits the construction industry, a major non-innovation economy employer. Strong job growth in this sector is outweighing gains in the innovation economy in many places. Among the LTS, Massachusetts and New York were the outliers where innovation economy growth exceeded that in the economy as a whole. While the Commonwealth's rate of overall job growth grew from 1.4% to 1.7% year-over-year, innovation economy job growth went from .9% growth to 2.0% growth.

Wage growth since 2009 has been particularly strong in a few innovation economy industries in Massachusetts. Interestingly, two of the three sectors with the fastest wage growth have also seen stagnant or even declining employment figures over the same period (Diversified Industrial Manufacturing and Financial Services). The Commonwealth's fastest growing sector in terms of wage growth, BioPharmaceuticals & Medical Devices (18.3%), only just a year ago had lost jobs relative to 2009. Several years of strong employment growth, particularly in Biotech R&D, have brought the sector into positive job growth relative to 2009, making this the fastest growing innovation economy sector in Massachusetts in terms of employment (3.6%), followed closely by Software & Communications Services (3.5%). Why this is occurring is not clear, but two possibilities include: 1) companies shifting lower wage jobs to cheaper locales while keeping high value-added activity in Massachusetts; or 2) a shortage of workers in those industries driving up wages. Healthcare Delivery, the Commonwealth's leading sector by employment, experienced a slight decline in wages, even though employment growth was relatively strong (10.0%). Healthcare Delivery, Postsecondary Education, Software & Communications Services, and Scientific, Technical, & Management Services are the sectors that have experienced the most consistent employment growth since 2009.

INDUSTRY CLUSTER EMPLOYMENT AND WAGES

Employment Growth in Key Sectors

Massachusetts & LTS, Q1 2014-Q1 2015

	Advanced Materials	Biopharma & Medical Devices	Business Services	Computer & Communications Hardware	Defense Manufacturing & Instrumentation	Diversified Industrial Manufacturing	Finance	Healthcare Delivery	Postsecondary Education	Scientific, Technical & Management Services	Software & Communications Services	Innovation Economy	Total Jobs
CA	2.0%	1.5%	0.5%	-2.1%	5.7%	2.6%	-0.1%	2.4%	1.7%	-0.5%	7.0%	2.0%	3.0%
CT	-3.4%	-1.2%	0.7%	-2.0%	-2.1%	-4.5%	0.3%	0.1%	1.6%	2.3%	1.9%	0.1%	1.0%
IL	-0.9%	2.7%	-2.8%	-0.9%	-0.9%	-0.3%	2.7%	0.4%	-1.4%	1.8%	3.8%	0.4%	1.3%
MA	-1.9%	3.6%	1.9%	0.5%	-2.2%	-0.2%	1.8%	2.7%	1.0%	2.4%	3.5%	2.0%	1.7%
MN	5.8%	1.8%	1.1%	2.2%	3.7%	2.2%	1.6%	0.8%	-0.6%	0.4%	0.7%	1.2%	1.7%
NJ	-1.3%	1.7%	-0.9%	-1.0%	1.9%	-1.3%	0.1%	4.1%	-1.7%	0.0%	-0.3%	0.9%	1.3%
NY	-1.3%	1.2%	1.8%	3.1%	-2.0%	-1.9%	2.0%	2.1%	3.9%	2.2%	2.7%	2.1%	2.0%
OH	2.6%	1.3%	0.2%	8.4%	-2.8%	2.7%	2.2%	0.9%	0.1%	1.1%	-0.3%	1.1%	1.6%
PA	-0.4%	1.0%	-1.0%	0.1%	0.1%	0.4%	-0.2%	0.6%	-0.1%	1.9%	2.9%	0.3%	1.1%
TX	1.2%	5.2%	3.7%	-2.8%	-1.2%	3.1%	1.8%	3.0%	1.8%	6.5%	4.0%	2.8%	3.3%

Employment by Industry Sector

Massachusetts, 2009-2014

Sector	2014 Employment Total	% Change in Employment 2009-2014
Healthcare Delivery	363,699	10.0%
Financial Services	155,755	-4.4%
Software & Communications Services	149,183	14.1%
Business Services	147,161	-0.6%
Postsecondary Education	141,695	3.0%
Scientific, Technical & Management Services	81,313	19.2%
Biopharma & Medical Devices	66,724	2.5%
Diversified Industrial Manufacturing	38,482	-6.4%
Defense Manufacturing & Instrumentation	37,319	-2.4%
Computer & Communications Hardware	35,884	-10.4%
Advanced Materials	29,359	-6.8%

Data Source for Indicator 1: Bureau of Labor Statistics (BLS) Quarterly Census of Employment and Wages (QCEW)

## OCCUPATIONS AND WAGES

## Why Is It Significant?

As a general rule, the innovation economy generates jobs with above average wages, thereby contributing to a higher standard of living in the Commonwealth. Changes in occupational employment and wages suggest shifts in job content and skill utilization. Generally, professional and technical employment tripled as a percentage of the workforce during the last century, so anything but continued employment growth would indicate a shift away from the historical norm.

## How Does Massachusetts Perform?

Business, Financial, Legal, Social Services and Computers & Math were the fastest growing Bureau of Labor Statistics occupational categories in Massachusetts in 2014 relative to 2009. Social Services pays below average wages (\$46,580 vs \$57,610); however Computers & Math wages are significantly above average (\$94,820). These two sectors are also highest in terms of employment concentration relative to the rest of the U.S. Healthcare is another growing sector in Massachusetts, which also pays roughly the state's average wage. Science & Engineering (S&E) was the only technology-oriented sector that shrank. Science & Engineering experienced negative employment growth in Massachusetts, the LTS, and the U.S. A decline in Science & Engineering occupations, as well as their pay, could be reflective of many long-term trends. People with STEM degrees may now have career opportunities that appeal to them more in non-Science & Engineering occupations. In addition, layoffs and restructurings at major employers of S&E talent over the last few years would subtract from the numbers while new jobs created in the innovation economy might not fall under the traditional S&E classification. In real terms, no occupational group in Massachusetts has recovered the pay lost during the recession although nominal pay is higher in all cases. Wages in Massachusetts are higher than both the LTS and U.S. in all occupational categories except for Social Services, where the LTS is slightly higher. The gap between Massachusetts and the LTS & U.S. is even greater in terms of overall wages than within any occupational category, at 15.1% higher than the LTS and 22.0% higher than the U.S, indicating that Massachusetts has a larger percentage of its employment in high paying occupational categories.

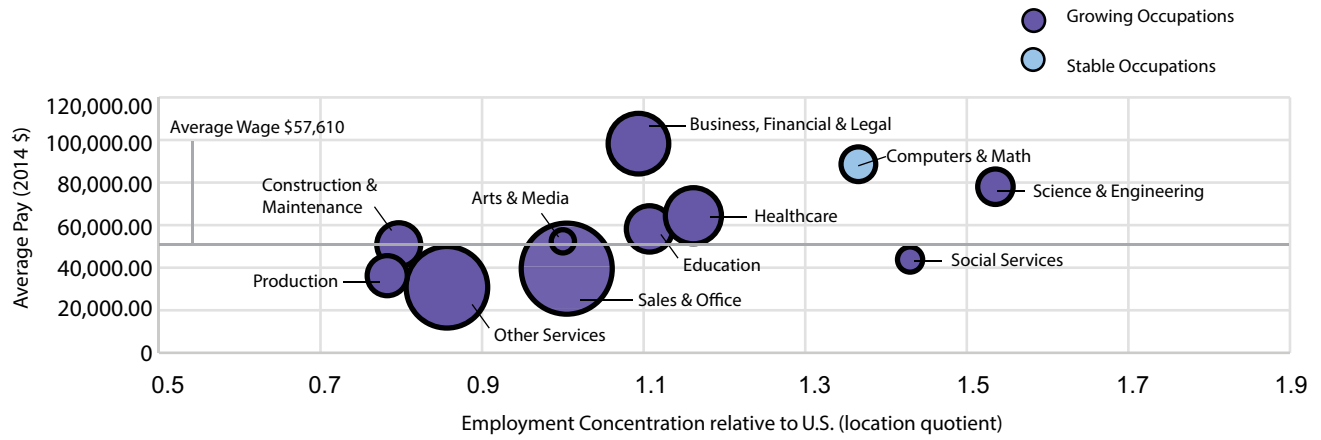
## Average Wages by Occupation

Massachusetts, LTS, & U.S., 2014

Occupation	Average Wage		
	Massachusetts	LTS	U.S.
Arts & Media	\$ 58,200	\$ 56,206	\$ 55,790
Business, Financial, Legal	\$ 105,130	\$ 97,834	\$ 92,954
Computers & Math	\$ 94,820	\$ 84,460	\$ 83,970
Construction & Maintenance	\$ 54,915	\$ 49,926	\$ 45,913
Education	\$ 62,980	\$ 55,942	\$ 52,210
Healthcare	\$ 69,625	\$ 62,061	\$ 60,244
Other Services	\$ 32,039	\$ 29,777	\$ 28,520
Production	\$ 39,110	\$ 36,632	\$ 35,490
Sales & Office	\$ 42,866	\$ 38,963	\$ 36,773
Science & Engineering	\$ 82,841	\$ 78,485	\$ 77,842
Social Services	\$ 46,790	\$ 47,667	\$ 45,310
All Occupations	\$ 57,610	\$ 50,063	\$ 47,230

OCCUPATIONS AND WAGES

Occupations by Employment Concentration and Annual Pay  
Massachusetts, 2014



Data Source for Indicator 2: BLS Occupational Employment Statistics, Consumer Price Index (CPI)

HOUSEHOLD INCOME

Household Income

% Change from Previous Year, 2010-2014

Year	MA	LTS Average	US
2010	-4.69%	-13.81%	-4.66%
2011	-1.79%	10.58%	1.02%
2012	1.82%	1.21%	-0.01%
2013	0.69%	0.05%	0.83%
2014	1.96%	0.58%	0.76%

Percentage of Households by Income Level

2014

Household Income	MA	LTS Average	US
Under \$35,000	27.5%	30.4%	33.1%
\$35,000 - \$99,999	38.2%	42.3%	43.3%
Above \$100,000	34.4%	27.3%	23.6%

Why Is It Significant?

Median household income tracks changes in the general economic condition of middle-income households and is a good indicator of prosperity. Rising household incomes enable higher living standards (increased purchasing power). The distribution of income also provides an indication of which Massachusetts economic groups are benefiting.

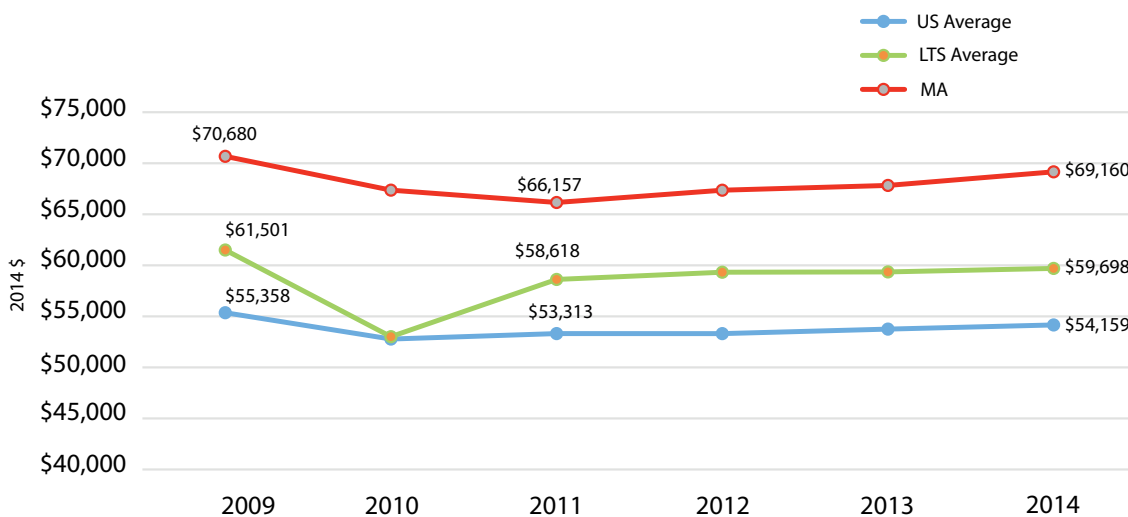
How Does Massachusetts Perform?

Massachusetts has consistently maintained a higher household income than both the average LTS and the U.S. as whole. However, after adjusting for inflation, median household income is still lower in Massachusetts, the LTS, and U.S. in 2014 than it was in 2009 prior to the Great Recession. Massachusetts has seen a faster recovery in household income than the LTS or U.S., although it experienced a slightly larger drop in 2010 than either the LTS or U.S. After a slowdown in 2013, income growth accelerated in the LTS (0.6%) and Massachusetts (2.0%) while remaining steady in the U.S. as a whole.

Massachusetts has proportionally many more households with incomes above \$100,000 than both the LTS and U.S. This could partly explain why incomes have recovered faster in Massachusetts than elsewhere since over the last several decades higher income households have seen larger gains in household income than the population as a whole. Massachusetts, being home to a high proportion of high income households, would see larger income gains than would otherwise be experienced elsewhere.

Median Household Income

MA, LTS, & U.S., 2009-2014

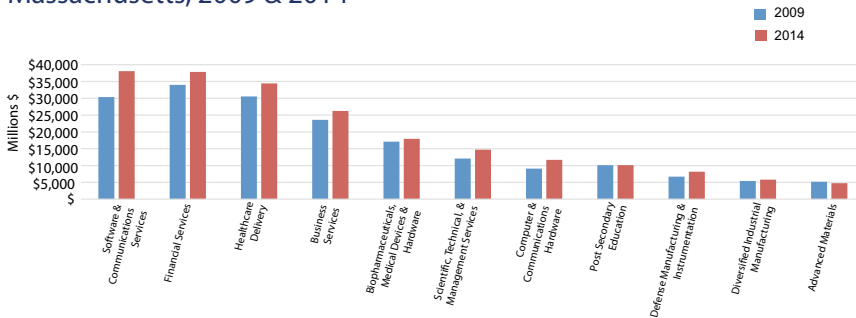


Data Source for Indicator 3: U.S. Census Bureau, Bureau of Economic Analysis (BEA)

OUTPUT

Output in Key Sectors

Massachusetts, 2009 & 2014



Why Is It Significant?

Industry Output is an important measure of the value of the goods and services produced by each sector of the innovation economy. Output per employed worker is a measure of labor productivity, which is a key driver of wage growth within an economy. It can also be viewed as an indicator of business cycles and used as a tool for GDP and economic performance forecasts.

How Does Massachusetts Perform?

Output increased between 2009 and 2014 in all of the Commonwealth's key sectors with the exception of Advanced Materials. Computer & Communications Hardware and Software & Communications Services were the fastest growing sectors during that period, growing by 28.7% and 25.4% respectively. In absolute terms, Software & Communications Services is a solid driver of growth in the economy as its output increased by \$7.7 billion, becoming the largest of the key sectors in Massachusetts. Advanced Materials output fell by 8.3% while Postsecondary Education output remained level, growing by only 0.2% from 2009-2014.

In per capita output, Massachusetts outperforms the LTS average in all key sectors except for Advanced Materials, which is also the Commonwealth's smallest sector in terms of output and employment. The performance gap between Massachusetts and the average LTS was striking in some cases, with Massachusetts having 3 sectors (Computer & Communications Hardware, Postsecondary Education, and BioPharma/Medical Devices) where per capita output was more than double the average LTS. Massachusetts led the LTS in output per capita in 6 of the 11 sectors.

Massachusetts' position as a leader in Biopharmaceuticals and Medical Devices has been further strengthened by the relocation of the headquarters or major R&D facilities of several pharmaceutical companies to the Greater Boston area. Despite its lack of growth since the recession, Postsecondary Education remains one of the Commonwealth's strongest sectors relative to the LTS, with output per capita 2.5 times that of the LTS average. A slowdown in enrollment growth, and even outright declines at smaller colleges, is a nationwide trend even as many colleges and universities are increasing efforts to lower the cost of attendance.

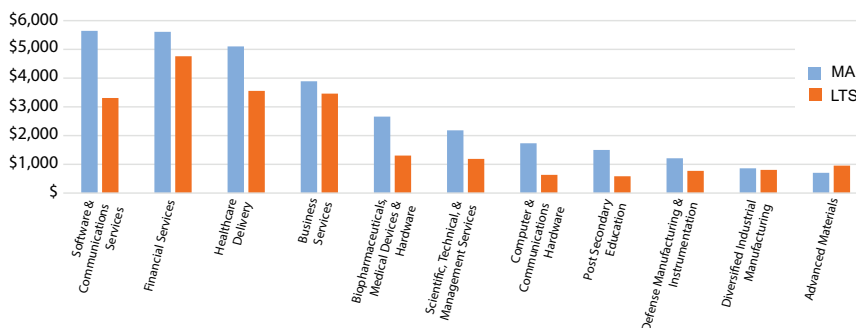
Output Growth in Key Sectors

Massachusetts, 2009-2014

Sector (In Order of Per Capita Output 2014)	% Growth	Absolute Growth
Software & Communication Services	25.4%	\$ 7,708
Financial Services	11.3%	\$ 3,853
Healthcare Delivery	12.7%	\$ 3,872
Business Services	11.2%	\$ 2,645
Biopharmaceuticals, Medical Devices & Hardware	5.0%	\$ 849
Scientific, Technical & Management Services	21.8%	\$ 2,639
Computer & Communications Hardware	28.7%	\$ 2,604
Postsecondary Education	0.2%	\$ 21
Defense Manufacturing & Instrumentation	21.9%	\$ 1,469
Diversified Industrial Manufacturing	7.3%	\$ 396
Advanced Materials	-8.3%	\$ (428)

Output per Capita in Key Industry Sectors

Massachusetts & LTS, 2014



Data Source for Indicator 4: U.S. Census Bureau, Moody's, QCEW

EXPORTS

**Massachusetts Exports:  
Top Ten Destinations and Value**  
(\$ Millions), 2011-2014

2014 Rank	Country	2011 \$	2014 \$	%Change 2011-2014
1	Canada	\$3,796	\$3,699	-2.6%
2	United Kingdom	\$3,285	\$2,349	-28.5%
3	Mexico	\$1,437	\$2,317	61.2%
4	China	\$2,088	\$2,291	9.7%
5	Japan	\$2,044	\$1,850	-9.5%
6	Germany	\$2,046	\$1,850	-9.6%
7	Netherlands	\$1,107	\$1,329	20.1%
8	South Korea	\$1,030	\$991	-3.8%
9	Hong Kong	\$751	\$963	28.2%
10	Switzerland	\$563	\$804	42.8%

**Massachusetts Exports as % of GDP**  
Massachusetts & LTS, 2009 & 2014

State	2009	2014
Texas	12.3%	13.3%
Ohio	7.2%	7.5%
Illinois	5.9%	7.0%
Minnesota	5.7%	5.7%
Connecticut	6.0%	5.6%
California	4.9%	4.8%
New Jersey	4.8%	4.8%
Pennsylvania	4.6%	4.8%
Massachusetts	6.0%	4.7%
New York	3.5%	3.0%

**Total Value of Exports**  
Massachusetts, 2009-2014

Year	2009	2010	2011	2012	2013	2014
Exports (Unadjusted Billions \$)	\$23.57	\$26.25	\$27.71	\$25.54	\$26.79	\$27.36

**Why Is It Significant?**

Manufacturing exports are an indicator of global competitiveness. Selling into global markets can bolster growth in sales and employment. In addition, diversity among products and export markets can offset domestic economic downturns. Manufacturing represents approximately ten percent of all private sector jobs in the Commonwealth and approximately twenty percent of manufacturing jobs are tied to exports. 111,000 jobs are supported by manufacturing exports in Massachusetts and 6.2 million jobs are tied to manufacturing exports nationwide.

**How Does Massachusetts Perform?**

Following two years of export growth after the Great Recession, Massachusetts exports fell by \$2.2 billion in 2012 to \$25.5 billion. In 2013, they rebounded by \$1.2 billion and rose another \$600 million in 2014. Although Massachusetts' exports have grown by 5.2% since 2009, they are down 6.2% from the post-recession high of \$27.7 billion in 2011. Massachusetts' exports have grown slower over the period than total U.S. exports, as evidenced by Massachusetts' declining overall share. Massachusetts' manufacturing exports made up a smaller percentage of GDP in 2014 than in 2009 despite increasing slightly in real terms, as the state's economy has grown much faster than manufacturing exports.

Massachusetts has seen some variability in the destination of its exports between 2011-2014, with exports to the UK, Hong Kong, and Switzerland having a tumultuous four years. Exports to Canada, Massachusetts' number one trading partner over the period, were stagnant, falling by 2.5%. However, significant growth occurred in Massachusetts' exports to Mexico (61.2%), Switzerland (42.8%), Hong Kong (28.2%), and the Netherlands (20.1%). Massachusetts' largest export category is computers & electronic products. After that, Massachusetts exports roughly equal amounts of chemicals, miscellaneous manufactured products, and machinery. The two LTS with the highest percent of GDP attributed to manufacturing exports are Texas, whose largest export categories are petroleum products, computers, and chemicals; and Ohio, whose exports are dominated by transportation equipment.



## **RESEARCH**

**The Index defines innovation as the capacity to continuously translate ideas into novel products, processes and services that create, improve or expand business opportunities. The massive and diversified research enterprise concentrated in Massachusetts' universities, teaching hospitals and government and industry laboratories is a major source of new ideas that fuel the innovation process. Research activity occurs on a spectrum that ranges from curiosity-driven fundamental science, whose application often becomes evident once the research has started, to application-inspired research, which starts with better defined problems or commercial goals in mind. Academic publications and patenting activity reflect both the intensity of new knowledge creation and the capacity of the Massachusetts economy to make these ideas available for dissemination and commercialization.**

**INDICATORS 6-9**

RESEARCH AND DEVELOPMENT

R&D Spending as Percent of GDP

Massachusetts & LTS - 2002, 2009, 2010, 2011 & 2012

	2002	2009	2010	2011	2012
Massachusetts	5.26%	5.62%	5.30%	5.67%	5.59%
California	4.15%	4.36%	4.30%	4.79%	4.49%
Connecticut	3.76%	5.36%	3.40%	3.88%	3.57%
New Jersey	3.25%	4.30%	3.70%	3.18%	3.33%
Minnesota	2.78%	3.08%	2.70%	2.64%	2.47%
Illinois	2.21%	2.00%	2.40%	2.38%	2.38%
Pennsylvania	2.24%	2.51%	2.30%	2.35%	2.10%
Ohio	2.15%	2.24%	2.20%	2.11%	1.99%
New York	1.55%	1.54%	1.50%	1.59%	1.42%
Texas	1.80%	1.77%	1.60%	1.56%	1.41%

Total R&D Expenditures

Millions of 2014 \$

	2011	2012	% Change
California	\$ 96,209	\$ 100,552	5%
Massachusetts	\$ 23,176	\$ 24,876	7%
Texas	\$ 21,703	\$ 21,313	-2%
New York	\$ 19,539	\$ 18,814	-4%
Illinois	\$ 16,811	\$ 16,736	0%
New Jersey	\$ 16,528	\$ 18,176	10%
Pennsylvania	\$ 14,366	\$ 13,619	-5%
Ohio	\$ 10,902	\$ 11,267	3%
Connecticut	\$ 9,194	\$ 8,950	-3%
Minnesota	\$ 7,781	\$ 7,610	-2%

R&D Expenditures from Non-Profits & Academia

Massachusetts & LTS, 2005, 2010, 2011 & 2012

	2005	2010	2011	2012	% change 2005-2010
California	\$ 8,826	\$ 9,840	\$ 9,691	\$ 9,638	9%
New York	\$ 4,823	\$ 5,861	\$ 5,945	\$ 5,891	22%
Texas	\$ 3,879	\$ 5,019	\$ 5,078	\$ 5,010	29%
Massachusetts	\$ 4,050	\$ 4,948	\$ 4,721	\$ 4,948	22%
Pennsylvania	\$ 3,401	\$ 3,736	\$ 3,787	\$ 3,646	7%
Illinois	\$ 2,245	\$ 2,545	\$ 2,571	\$ 2,526	13%
Ohio	\$ 2,148	\$ 2,494	\$ 2,529	\$ 2,418	13%
New Jersey	\$ 1,083	\$ 1,198	\$ 1,219	\$ 1,168	8%
Minnesota	\$ 904	\$ 1,181	\$ 1,177	\$ 1,141	26%
Connecticut	\$ 860	\$ 994	\$ 1,019	\$ 999	16%

Why Is It Significant?

R&D performed in Massachusetts is an indicator of the size and health of the science and technology enterprise. Although not all new ideas or products emerge from defined R&D efforts, R&D data provides a basis for estimating a region's general capacity for knowledge creation. The distribution of R&D expenditures by type of performer illustrates the diverse relationship states have with different performers and how a differentiated list of performers help produce an innovative ecosystem.

How Does Massachusetts Perform?

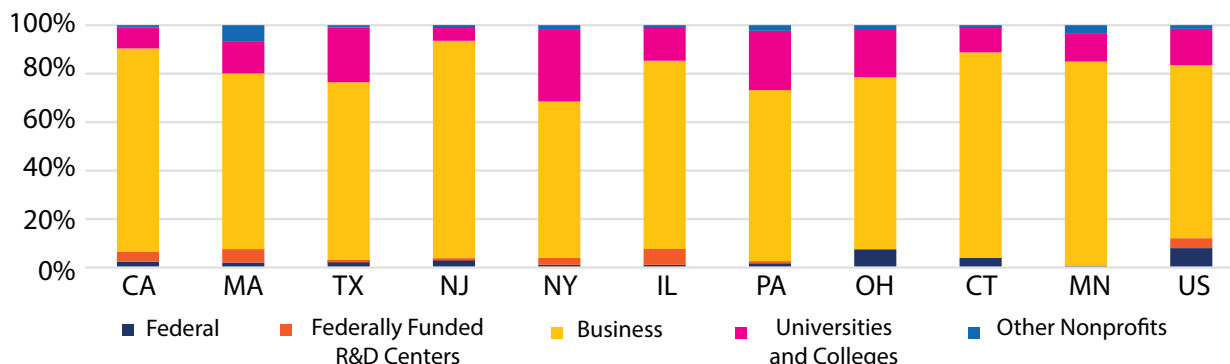
Massachusetts continued to be the top state in terms of R&D as a percentage of GDP in 2012 despite a 0.80% decrease from 2011. Massachusetts' R&D spending as a percentage of GDP has remained fairly stable over the period from 2002-2012, while states like Connecticut and New Jersey have experienced steady decreases since their spike in 2009 in R&D as a percentage of GDP. Massachusetts had the second highest overall level of R&D funding in the country in 2012 at \$24.88 billion, slightly ahead of Texas. California still maintains a significant lead in total R&D funding. The majority of R&D in 2012 was performed by private industry in all of the LTS. 72.5% of R&D in Massachusetts is performed by private industry; however this is a decline from 75.0% in 2008 and places Massachusetts behind all but three LTS. Still, Massachusetts outperforms the U.S. average of just over 71.4%.

Massachusetts ranks fourth among LTS in terms of R&D performed by universities, colleges, and non-profits with \$4.948 billion. Massachusetts also saw a 17% increase in R&D expenditures from Universities and Non-profits from 2005-2011, although expenditures decreased by \$224 million from 2010-2011 as Federal R&D spending declined. Massachusetts was the only LTS to have an increase in R&D expenditures from universities and non-profits from 2011-2012 with an increase of \$227 million as Massachusetts captured a larger share of the smaller resource pool. The combination of private industry, universities & colleges, and non-profits account for 92.38% of all R&D performed in Massachusetts

RESEARCH AND DEVELOPMENT

Distribution of R&D by Performer

Massachusetts, LTS & U.S., 2012



R&D Expenditures

Massachusetts, 2011 & 2012

Performing Sector	Source of Funding	Expenditures 2011	Expenditures 2012
Federal	Federal	\$ 548,000,000	\$ 507,000,000
Federally Funded R&D Centers	Federal	\$ 1,358,000,000	\$ 1,387,000,000
	Non-Federal	\$ 3,000,000	\$ 2,000,000
Business	Own Funds	\$ 13,378,000,000	\$ 14,596,000,000
	Federal	\$ 967,000,000	\$ 900,000,000
	Non-Federal	\$ 2,201,000,000	\$ 2,537,000,000
Universities & Colleges	Federal	\$ 2,311,000,000	\$ 2,290,000,000
	Other Government	\$ 18,000,000	\$ 19,000,000
	Business	\$ 202,000,000	\$ 219,000,000
	Universities & Colleges	\$ 260,000,000	\$ 425,000,000
	Non-Profit	\$ 313,000,000	\$ 274,000,000
Non-Profit Institutions	Federal	\$ 1,618,000,000	\$ 1,635,000,000
	Total	\$ 23,176,000,000	\$ 24,790,000,000

Data Source for Indicator 6: National Science Foundation (NSF), BEA, CPI

ACADEMIC ARTICLE OUTPUT

Science and Engineering (S&E) Academic Article Output per Million Residents  
Massachusetts & International, 2011

	S&E Article Output per million residents
Massachusetts	1,583
Switzerland	1,266
Denmark	1,090
Sweden	1,003
Norway	964
Netherlands	929
Australia	922
Finland	905
Singapore	876
Canada	848
Iceland	810

Why Is It Significant?

In contrast to R&D expenditures, which are inputs to research, academic article publication is a measure of research output and can be viewed as a leading indicator of patents and business development. In addition, the ratio of articles produced per dollar spent on research and articles produced per researcher measures the productivity of research activity.

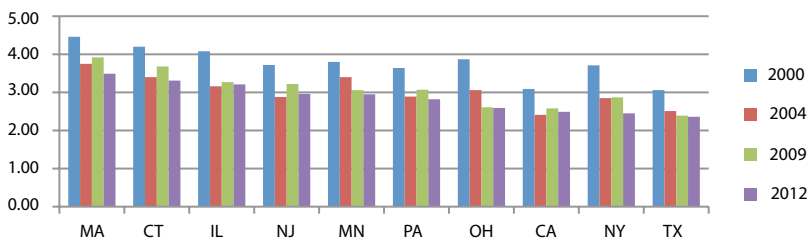
How Does Massachusetts Perform?

Massachusetts maintains a high rate of science and engineering academic article output relative to its population. This rate increased substantially (10.4%) between 2004 and 2011. In 2011, S&E academic article output climbed to 1,583 academic articles per million residents, nearly three times the U.S. average. Massachusetts also stands out internationally. In 2011, Massachusetts outperformed second-place Switzerland by roughly 320 articles per million residents.

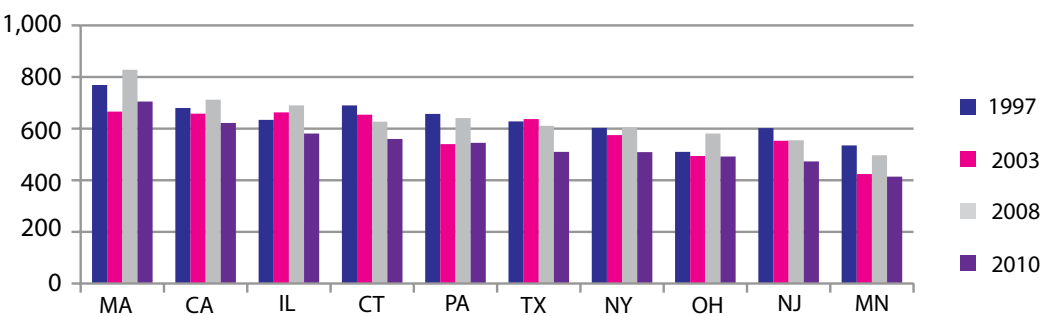
Massachusetts also ranks highly in terms of academic productivity. In 2004, 2009 and 2012, Massachusetts produced more S&E academic articles per R&D dollar than the other LTS and the nation overall. In 2012, the state reported 3.5 articles per million academic R&D dollars spent. Massachusetts is also the leader in a second measure of research productivity, articles per 1,000 S&E doctorate holders. California, the next closest state, produces 12% fewer articles per 1,000 S&E doctorate holders.

Articles per researcher and articles per research dollar have declined in both the U.S. and Massachusetts over the last few years. The decline in articles per research dollar is not surprising given the increasing complexity and cost of scientific research; the low hanging fruit has mostly been picked. The decline in articles per researcher is surprising, but could reflect the transition of PhDs away from academic research in a time of declining federal grants towards private sector research, where the impetus to publish is not as great (or not even desired).

Science and Engineering (S&E) Academic Article Output per Million Academics R&D \$  
Massachusetts & LTS, 2000, 2004, 2009 & 2012



Science and Engineering (S&E) Academic Article Output per 1,000 S&E Doctorate Holders  
Massachusetts & LTS, 1997, 2003, 2008 & 2010

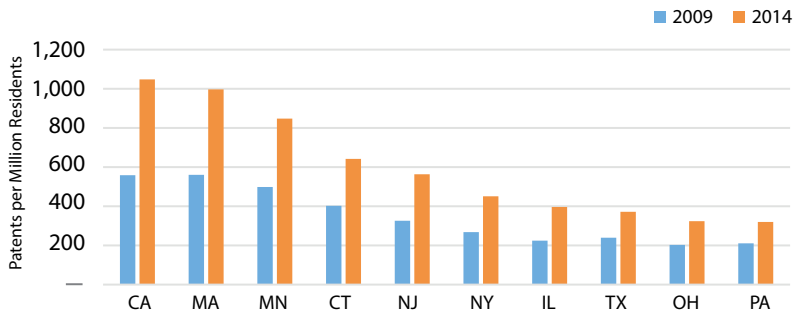


Data Source for Indicator 7: NSF, CPI

PATENTS

Patents per Million Residents

Massachusetts, LTS, U.S., 2009 & 2014



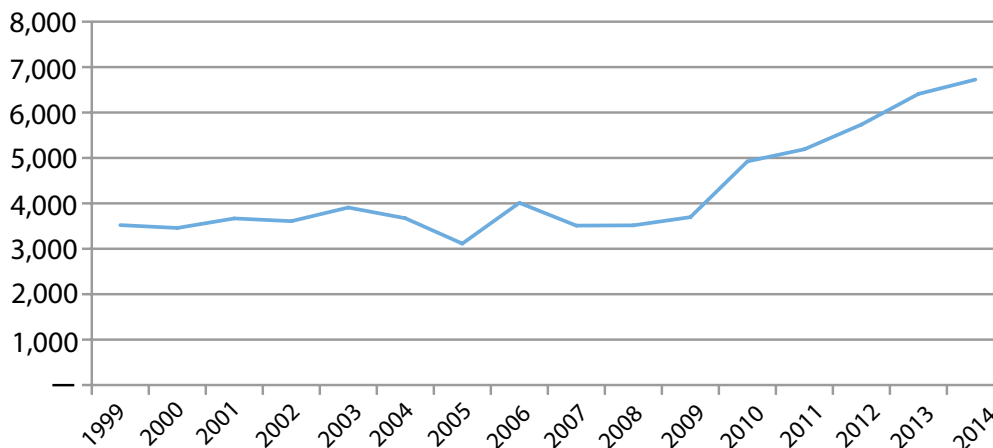
Percent Change in Utility Patents

Massachusetts & LTS, 2009-2014

State	Percent Change
California	88.0%
Massachusetts	77.9%
Illinois	76.6%
New Jersey	72.8%
Minnesota	70.0%
New York	68.3%
Ohio	60.0%
Connecticut	59.5%
Texas	55.3%
Pennsylvania	51.8%

Utility Patents Issued

Massachusetts, 1999-2014



Why Is It Significant?

Patents are the leading form of legal codification and ownership of innovative thinking and its application. A patent award is particularly important for R&D-intensive industries when the success of a company depends on its ability to develop, commercialize, and protect products resulting from investments in R&D. High levels of patenting activity indicate an active R&D enterprise combined with the capacity to codify and translate research into ideas with commercial potential. U.S. Patent and Trademark Office (USPTO) patents represent one-fifth of global patents.

How Does Massachusetts Perform?

Massachusetts again saw record numbers of patents granted in 2014, reaching a total of 6,725. Its share of U.S. patents was 4.7% even though the Commonwealth accounts for only 2.1% of the U.S. population. Massachusetts' growth rate in patents granted per million residents from 2009-2014 was 77.9% placing it second among the LTS after California which experienced 88.0% growth in patents granted per capita. All of the LTS experienced strong growth in patent activity with each state registering at least a 50.0% increase in per capita terms. Massachusetts ranks fourth among the LTS in total numbers of patents granted, behind California, Texas and New York; Massachusetts is second behind only California in patents granted per capita.

Data Source for Indicator 8: U.S. Patent and Trademark Office (USPTO), Census Bureau, World Intellectual Property Organization, U.S. Department of Commerce, World Bank

TECHNOLOGY PATENTS

Technology Patents by Category Percent  
Massachusetts, 2014

Category	Percent of Patents
Computer & Communications	45.9%
Drugs & Medical	31.7%
Analytical Instruments & Research Methods	15.2%
Advanced Materials	3.9%
Business Methods	3.3%

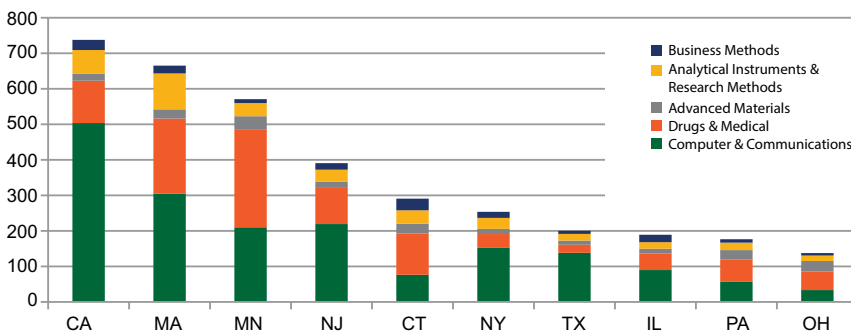
Why Is It Significant?

The amount of patenting per capita by technology category indicates those fields in which Massachusetts' inventors are most active and suggests comparative strengths in knowledge creation, which is a vital source of innovation. The patent categories in this comparison are selected and grouped on the basis of their connection to key industries of the Massachusetts innovation economy.

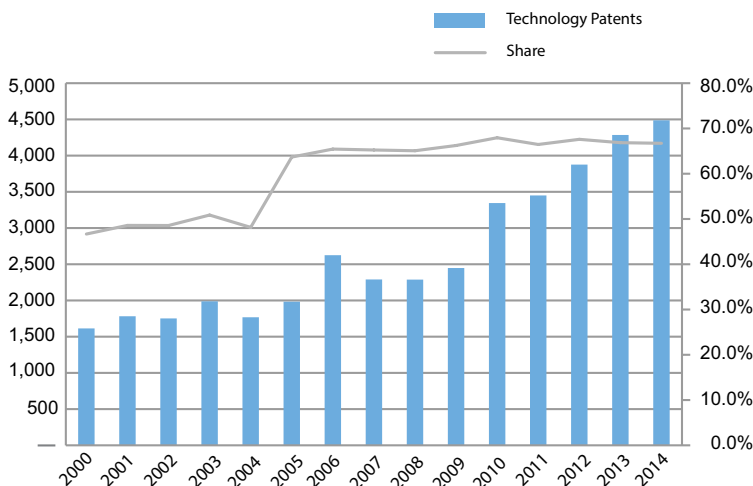
How Does Massachusetts Perform?

The combination of Computer & Communications patents and Drugs & Medical patents accounted for 77.6% of all Massachusetts technology patents in 2014. Massachusetts again placed second in Computer & Communications Hardware and Drug & Medical patents with 305 and 211 patents per million residents respectively. Although Massachusetts saw an increase in both categories, California maintained its lead in Computer & Communication Patents and Minnesota maintained its lead in Drugs and Medical patents. Massachusetts ranked first in Analytical Instrument & Research Method patents for the fifth year in a row with 101 per million residents, around 50% more than the next highest state, California. California and Massachusetts are home to some of the world's most prolific research universities and institutions which helps explain their strong performance on this metric relative to the other LTS. Massachusetts' Business Method patents fell in 2014, yet still ranked third among LTS, trailing Connecticut and California, where these patents also fell. Massachusetts' Advanced Materials patents decreased slightly from 27 to 26 per million residents and the Commonwealth dropped from fourth to fifth place in this category. Technology patents have continued to increase since 2007, and their share of total Massachusetts patents is roughly 62% since 2005. The U.S. patent approval rate was 55.9% in 2000, which dropped to 37.8% in 2005 and rebounded back to 50.7% in 2014.

Technology Patents  
per Million Residents by Field  
Massachusetts & LTS, 2014



Technology Patents and Share of Total Patents  
Massachusetts, 2000-2014



Data Source for Indicator 9: USPTO, Census Bureau

## **TECHNOLOGY DEVELOPMENT**

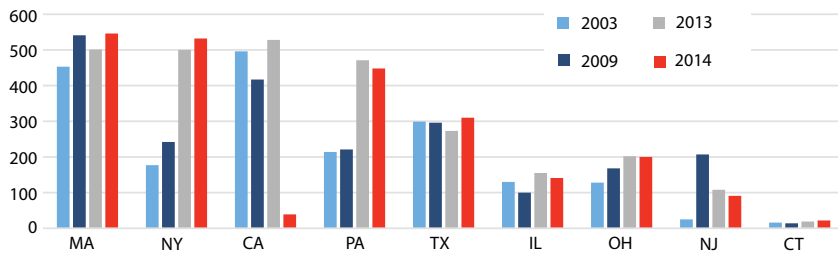
**In close interaction with research activities, but with a specific application as a goal, product development begins with research outcomes and translates them into models, prototypes, tests, and artifacts that help evaluate and refine the plausibility, feasibility, performance, and market potential of a research outcome. One way in which universities, hospitals, and other research institutions make new ideas available for commercialization by businesses and entrepreneurs is through technology licensing. Small Business Innovation Research (SBIR) and Technology Transfer (STTR) grants enable small companies to test, evaluate, and refine new technologies and products. In the medical device and biopharma industries, both significant contributors to the Massachusetts innovation economy, regulatory approval of new products is an important milestone in the product development process.**

**INDICATORS 10-11**

TECHNOLOGY LICENSING

Technology Licenses and Options Executed

Massachusetts & LTS, 2003, 2009, 2013, 2014



Why Is It Significant?

Technology licenses provide a vehicle for the transfer of codified knowledge in the form of intellectual property (IP) from universities, hospitals, and non-profit research organizations to companies and entrepreneurs seeking to commercialize the technology. License royalties are evidence of the value of IP in the marketplace and are typically based on revenue generated from the sales of products and services using the licensed IP or from the achievement of milestones on the path to commercialization. Increases in royalty revenue totals are important, validating the original research and innovation and generating funds that can be reinvested in new or follow-on R&D.

How Does Massachusetts Perform?

Massachusetts has remained a leader in the number of technology licenses and options executed over the last eleven years, edging out New York for the top spot in the LTS in 2013 and 2014. New York and Pennsylvania were also big movers, more than doubling the number of licenses and options executed from 2009-2014. Massachusetts experienced a drop in the number of technology licenses and options executed from 2012-2013 owing to a decrease from Massachusetts General Hospital (-33), which accounted for 84.62% of the drop. Since 2003, there has been a shift among the types of institutions in Massachusetts that comprise a majority of licenses and options executed from universities to research institutions and hospitals. This situation is unique among the LTS. Massachusetts research institutions and hospitals accounted for 54.6% of the technology licenses and options executed within the LTS in 2014 by these types of organizations. Revenue from IP licenses in Massachusetts remained fairly steady from 2008-2014 except for a 26% increase between 2011 and 2012 which reversed itself in 2013. The two-year spike in 2006 and 2007 was due to a spike in revenues from Massachusetts General Hospital, which resulted from a one-time legal settlement.

Technology Licenses and Options Executed

Research Institutions, Hospitals & Universities

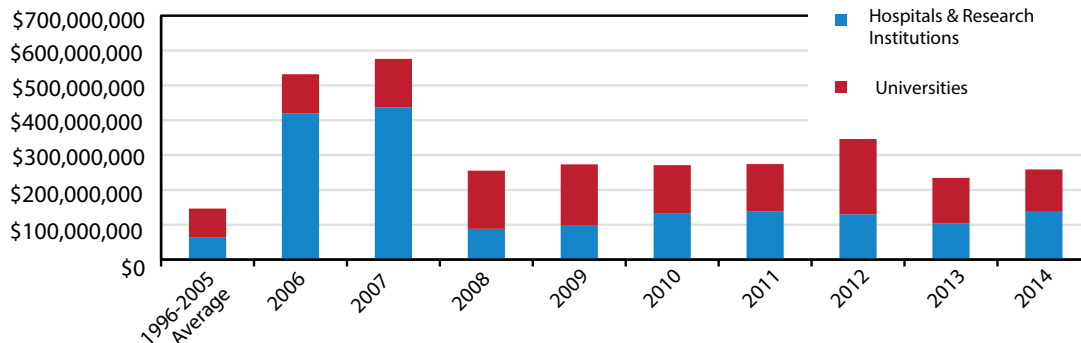
Massachusetts, 2003, 2009, 2013, 2014

	2003	2009	2013	2014
<b>Research Institutions &amp; Hospitals</b>	<b>186</b>	<b>303</b>	<b>264</b>	<b>292</b>
<b>Universities</b>	<b>267</b>	<b>238</b>	<b>237</b>	<b>254</b>

Revenues from Technology Licenses and Options Executed

Universities, Hospitals & Non-profit Research Institutions

Massachusetts, 2006-2014 (2014 \$)



Data Source for Indicator 10: Association of University Technology Managers (AUTM), CPI



SBIR/STTR AWARDS

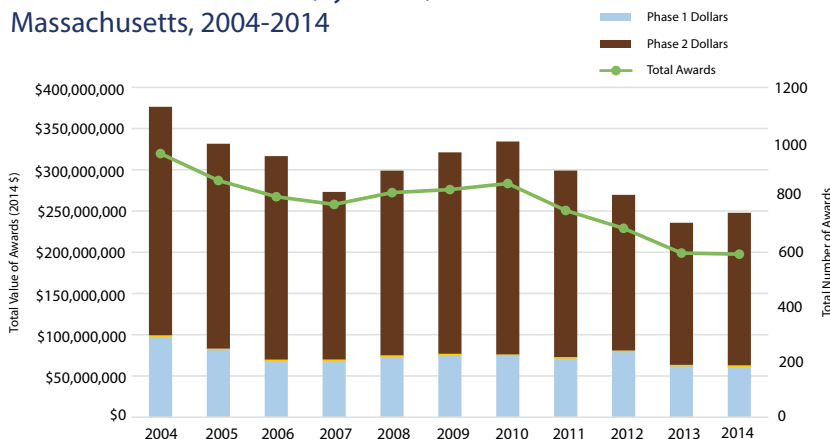
**SBIR/STTR Awards Funding**  
per \$1 Million GDP  
Massachusetts & LTS, 2014

State	Awards Funding
Massachusetts	\$539
California	\$206
Ohio	\$144
Pennsylvania	\$137
Connecticut	\$124
New Jersey	\$92
Minnesota	\$87
New York	\$71
Illinois	\$57
Texas	\$49

**SBIR & STTR Awards by Agency**  
Massachusetts, 2014

Agency	Funding	# of Awards
Department of Defense	\$109,491,915	304
Health & Human Services	\$87,594,321	140
Department of Energy	\$20,458,397	48
National Aeronautics & Space Administration	\$14,574,105	46

**SBIR & STTR Awards**  
Total Number and Value (by Phase) of Awards Granted  
Massachusetts, 2004-2014



**Why Is It Significant?**

The Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) Programs are highly competitive federal grant programs that enable small companies to conduct proof-of-concept (Phase I) research on technical merit and idea feasibility and prototype development (Phase II) building on Phase I findings. Unlike many other federal research grants and contracts, SBIR and STTR grants are reserved for applicant teams led by for-profit companies with fewer than 500 employees. Participants in the SBIR and STTR program are often able to use the credibility and experimental data developed through their research to design commercial products and to attract strategic partners and investment capital.

**How Does Massachusetts Perform?**

The decline in the number of SBIR and STTR awards that began in 2010 stopped in 2014, with the value of SBIR/STTR awards in Massachusetts growing by 5% from 2013-2014. The decline in awards since 2010 was steep and the Commonwealth had 26% less award funding in 2014 than it did in 2010. Meanwhile, SBIR/STTR award funding nationwide has fallen 18% since 2010. Massachusetts has led the LTS in award funding per \$1 million GDP since 2010. Although California receives nearly double the amount of funding that Massachusetts receives (\$475 mil. vs. \$248 mil.), the state's smaller size means its SBIR and STTR funding per \$1 million GDP is 160% larger than that of California. Among the SBIR and STTR awards, the Department of Defense accounts for the most funding (44%) and awards (304).

Data Source for Indicator 11: U.S. Small Business Administration, CPI

## **BUSINESS DEVELOPMENT**

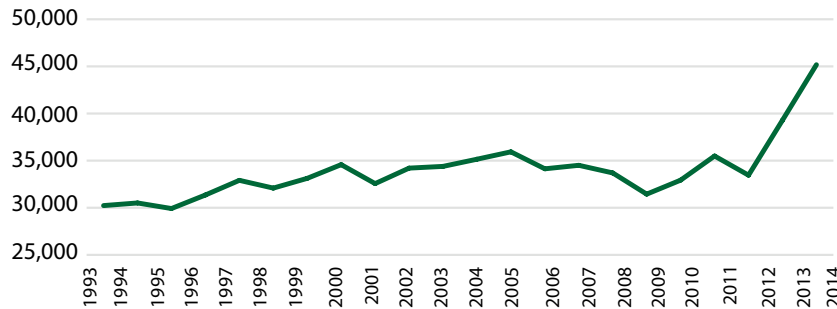
**Business development involves commercialization, new business formation and business expansion. For existing businesses, growing to scale and sustainability often involves an initial public offering (IPO), a merger, or an acquisition (M&A). Technical, business and financial expertise all play a role in the process of analyzing and realizing business opportunities, which result after research and development are translated into processes, products, or services.**

**INDICATORS 12-13**

BUSINESS FORMATION

Business Establishment Openings

Massachusetts, 1993-2014



Why Is It Significant?

New business formation is a key source of job creation and cluster growth, typically accounting for 30 to 45 percent of all new jobs in the U.S. It is also important to the development and commercialization of new technologies. The number of 'spin-out' companies from universities, teaching hospitals, and non-profit research institutes (including out-licensing of patents and technology) is an indicator of the overall volume of activity dedicated to the translation of research outcomes into commercial applications.

How Does Massachusetts Perform?

After three consecutive years of business establishment growth from 2009 through 2011, Massachusetts experienced a drop of 3,000 establishments in 2012 to 33,288. It has since experienced strong growth, reaching 45,176 in 2014. This represents the most business establishment openings in the state in the last 21 years. Massachusetts also saw an increase in the number of business establishments in key sectors per million employees relative to 2010, with over 2,900 net new establishments opened within those sectors. This places Massachusetts only fifth among the LTS and outpaced by California, Texas, and Illinois, but just behind Pennsylvania. California had nearly nine times as many establishment openings over the same period. In 2014, start-up formation from universities, hospitals, research institutions and technology investment firms in Massachusetts increased for the second straight year reaching a total of 67, although this is still down from the 2011 total of 71. Massachusetts' 2014 totals are second to California's 2013 totals and also California's expected 2014 totals. New York and Texas saw major increases in spinouts in 2014, reaching 64 and 60 respectively. Texas' spinouts nearly doubled in one year, while New York's increased by 50%. Massachusetts annual growth was a much more modest 6%.

Net Change in Number of Business Establishments

Key Industry Sectors

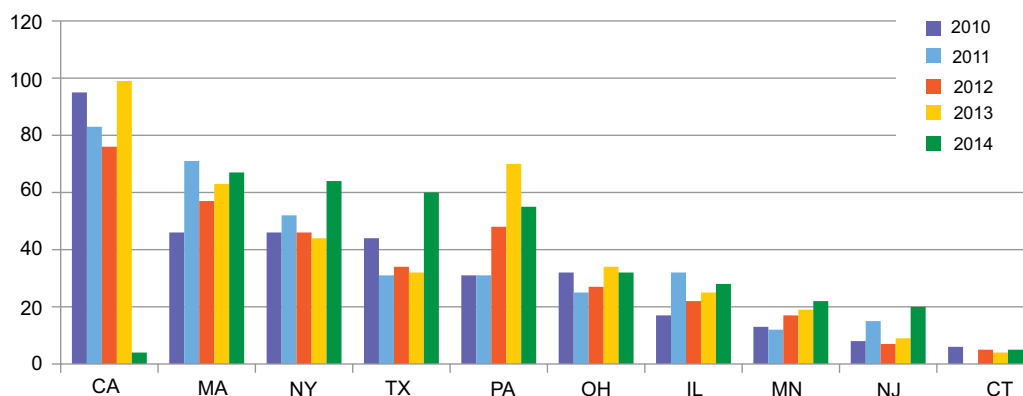
Massachusetts & LTS, 2010-2014

State	Net Change
California	26,205
Texas	15,354
Illinois	10,714
Pennsylvania	3,472
Massachusetts	2,982
New York	2,142
Ohio	1,984
Minnesota	1,539
Connecticut	781
New Jersey	(3,958)

Start-up Companies Initiated

From Universities, Hospitals, Research Institutions & Technology Investment Firms

Massachusetts and LTS, 2010-2014

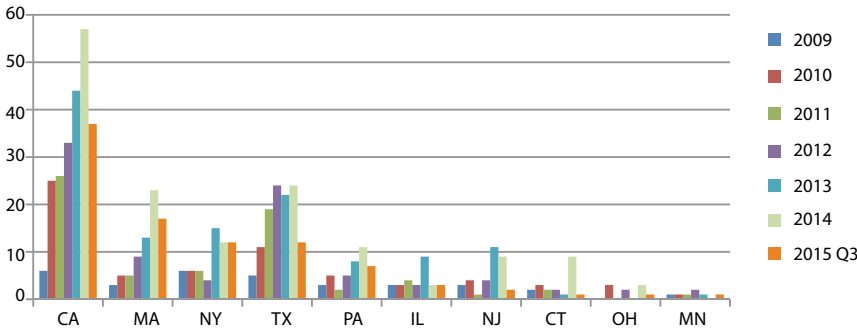


\*NOTE: California universities did not report any data in 2014 so their total of 4 is likely inaccurate

Data Source for Indicator 12: BLS Business Employment Dynamics, QCEW, Census Bureau, AUTM, 2010 Kauffman Index of Entrepreneurial Activity

IPO AND M&A

Number of Initial Public Offerings (IPO)  
Massachusetts and LTS-2009-2014, 2015 Q3



Why Is It Significant?

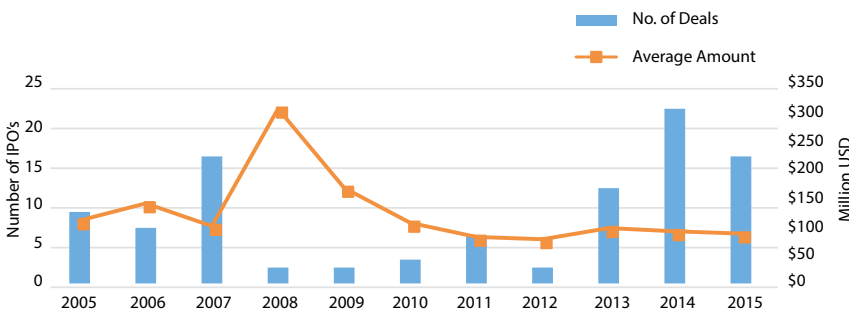
Initial Public Offerings (IPOs) and Mergers & Acquisitions (M&As) represent important business outcomes with which emerging companies can access capital, expand operations, and support business growth. IPOs and M&As are opportunities for early-stage investors to liquidate their investments and free up capital for future investment. IPOs of venture-backed companies can reflect investor confidence in the market.

How Does Massachusetts Perform?

IPOs, which are heavily concentrated in a few states, seem to have recovered from lows in 2009, but have decreased year-to-date in 2015 relative to 2014. California, Texas and Massachusetts are traditionally major generators of IPOs due to their focus on technology and in the case of Texas, the additional strength of the petroleum industry. After remaining stagnant in most of the LTS post-2009, Massachusetts-based IPOs continued to grow in 2014, totaling 23 for the year. As of November 2015, there have been 17 Massachusetts-based IPOs. Massachusetts IPOs were dominated by biotech companies in 2014 and 2015. In 2015, fourteen IPOs were biotech or pharmaceutical companies. The average dollar amount raised in the IPO of these companies has remained steady from 2010-2015, at a five year average of \$91 million. The number of M&As increased to a four-year peak in 2014 in each of the LTS. Massachusetts' five year (2010-2014) ratio of buyers to seller is 1.12; the highest ratio of buyers to sellers in the LTS belongs to New York (1.48). The rate of increase from 2013-2014 for buyers and sellers ranged from 17% in Pennsylvania to 49% in Minnesota. Massachusetts' amount of participating companies grew by 40% from 2013-2014.

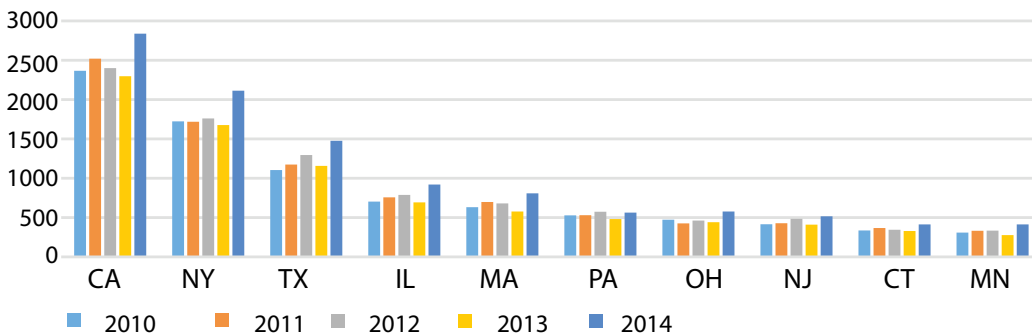
Venture Backed IPOs

Number of Deals and Average Value (2014 \$)  
Massachusetts, 2005-2015



Number of Participating Companies

Mergers & Acquisitions  
MA and LTS, 2010-2014



Data Source for Indicator 13: Renaissance Capital, IPO Home, National Venture Capital Association (NVCA), Mergerstat

## **CAPITAL**

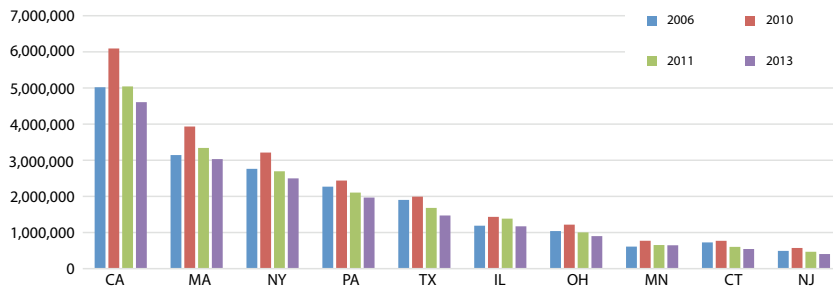
**Massachusetts attracts billions of dollars of funding every year for research, development, new business formation and business expansion. The ability to attract public and private funds sustains the unparalleled capacity of individuals and organizations in the state to engage in the most forward looking research and development efforts. Universities in Massachusetts benefit from industry's desire to remain at the cutting edge of research and product development through university-industry interactions. For new business formation and expansion, Massachusetts' concentration of venture capitalists and angel investors is critical. Investors in these areas, capable of assessing both the risk and opportunities associated with new technologies and entrepreneurial ventures, are partners in the innovation process and vital to its success.**

**INDICATORS 14-16**

FEDERAL FUNDING FOR ACADEMIC AND HEALTH R&D

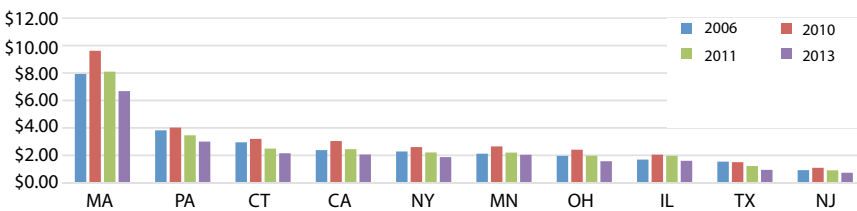
Federal Funding for R&D

Universities, Colleges and Non-profit Organizations  
Massachusetts & LTS - 2006, 2010, 2011 & 2013



Federal Funding for R&D per \$1,000 GDP

Universities, Colleges and Non-profit Organizations  
Massachusetts & LTS - 2006, 2010, 2011 & 2013



National Institutes of Health (NIH) R&D Funding

per \$1 million GDP  
Massachusetts & LTS, 2014

	Awards	Funding
Massachusetts	4,818	\$ 5,102.90
Pennsylvania	3,309	\$ 2,209.90
Connecticut	1,101	\$ 1,807.30
Minnesota	998	\$ 1,560.70
California	7,495	\$ 1,470.30
New York	4,765	\$ 1,417.80
Ohio	1,567	\$ 1,102.30
Illinois	1,859	\$ 964.70
Texas	2,453	\$ 588.90
New Jersey	533	\$ 378.80

Data Source for Indicator 14: NSF, BEA, National Institutes of Health (NIH), Census Bureau

Why Is It Significant?

Universities and other non-profit research institutions are critical to the Massachusetts innovation economy. They advance basic science and create technologies and know-how that can be commercialized by the private sector. This R&D also contributes to educating the highly-skilled individuals constituting one of Massachusetts' greatest economic assets. The National Institutes of Health (NIH) is the federal government's main source of funding for medical research. Awards from the NIH help fund the Commonwealth's biotechnology, medical device, and health services industries which together comprise the Life Sciences cluster.

How Does Massachusetts Perform?

Massachusetts remains second in federal R&D funding awarded to universities and non-profit institutions following California. Due to federal budget cuts, funding declined in all the LTS in 2013, with most falling below 2006 levels. At \$3.0 billion, Massachusetts trails California by roughly \$1.6 billion; however California's population is nearly six times the size of Massachusetts'. Minnesota was the only state among the LTS that received a larger amount in federal R&D funding for universities and non-profits in 2013 than it received in 2006, prior to the onset of the Great Recession. Each of the LTS received their highest amount of federal R&D funding for universities and non-profit institutions in 2010, as federal spending on research increased as part of the national economic stimulus program to combat the recession. Now that the LTS economies are growing faster than federal funding, its share of GDP decreased for every LTS in 2013.

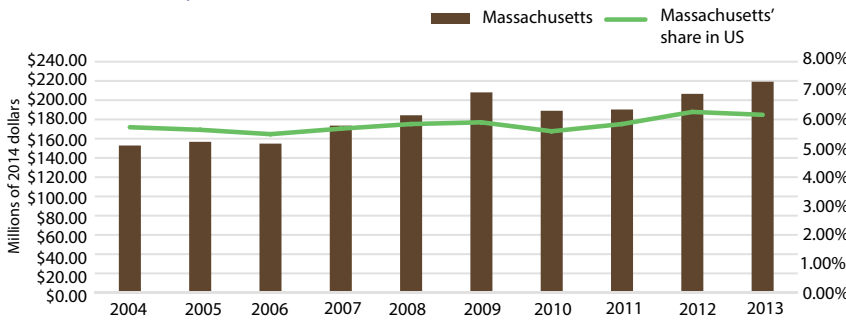
Massachusetts continues to maintain a lead in federal funding for R&D per \$1,000 GDP at \$6.68, more than twice as much as second ranked Pennsylvania, which also benefits from a large concentration of research hospitals and medical schools. Despite leading the LTS, Massachusetts has suffered a 31% decrease in federal funding for R&D per \$1,000 GDP since 2010.

Of the 2,323 organizations which received National Institute of Health (NIH) funding in the United States, Massachusetts accounts for 163, or 7.02%. Eleven of these organizations attracted more than \$100 million in NIH funding, combining for 3,488 awards and over \$1.8 billion in funding. Boston and Cambridge together combined for a total of 4,007 awards and more than \$2.0 billion in funding specifically because of the high density of hospitals, universities, and pharmaceutical companies in the area. Massachusetts continues to attract the largest share of NIH funding per \$1 million GDP. Although it declined slightly to \$5.10 per \$1,000 GDP in 2013, Massachusetts still receives more than twice as much NIH funding by this measure as any other LTS. Massachusetts received the second highest total of NIH awards (4,818), following California (7,495). On the absolute amount of NIH funding, Massachusetts ranked second to California as well with \$2.3 billion. On a per capita basis, however, Massachusetts ranks first with \$348 compared to second place California with \$87.

INDUSTRY FUNDING OF ACADEMIC RESEARCH

Industry Funding for Academic Research in S&E

Massachusetts, 2004-2013



Why Is It Significant?

Industry funding of academic research is one measure of industry-university relationships and the ability to transfer academic research into the commercial market. Industry-university research partnerships may result in advances in technology industries by advancing basic research that may have commercial applications. Moreover, university research occurring in projects funded by industry helps educate individuals in areas directly relevant to industry needs.

How Does Massachusetts Perform?

After a decline in 2010, industry funding for academic research and development in science and engineering (S&E) in Massachusetts recovered in subsequent years, reaching a 10-year peak in 2013 at \$219 million.

Over the last 5 years, Massachusetts' share of the U.S. total has remained relatively steady, averaging 5.95% each year. Massachusetts' share of the U.S. total in 2013 reached 6.16%. Despite a 0.10% drop in the share of U.S. total industry funding for academic R&D from 2012-2013, Massachusetts still experienced a \$15 million increase in funding.

Although Massachusetts ranks first among LTS in industry funding for academic research in S&E per \$100,000 GDP, Massachusetts, as with most of the LTS, experienced a negative growth rate from 2009-2013. Three LTS experienced significant declines during that period, with Pennsylvania seeing the largest at -37%, Illinois at -33% and Minnesota at -29%. Only two of the LTS saw growth over this period. New York was the leader among LTS with an impressive 49% growth in industry funding for academic research in S&E relative to GDP, followed by 34% growth in Connecticut. Since industry funding for academic research in S&E for each of the LTS are relatively small compared with the total research enterprise in each state, they can change dramatically from year to year. In some states, a single large grant or collaboration from a big company can significantly impact the total.

Industry funding as a share of total academic S&E research funding decreased in Massachusetts relative to 2012 and has fallen to the middle of the LTS at 6.11%. New York was the leader in 2013 at 7.73%, followed by Ohio at 7.72%, and Texas at 6.29%. States strong in defense and medical research, traditionally funded by the federal government, will usually have lower shares of industry funded R&D. Connecticut and Minnesota are good examples of this given their strength in the defense and medical sectors respectively.

Industry Share of States' Total Academic R&D Funding in S&E

Massachusetts & LTS, 2013

State	Share
New York	7.73%
Ohio	7.72%
Texas	6.29%
California	6.26%
Massachusetts	6.11%
Illinois	4.74%
Pennsylvania	4.57%
Connecticut	3.83%
Minnesota	3.32%

Rank in 2013 and Growth Rate in Industry Funding for Academic Research in S&E per \$100,000 GDP

Massachusetts, LTS & U.S., 2009-2013

Rank	Entity	Growth Rate
1.	Massachusetts	-7.63%
2.	New York	49.14%
3.	Ohio	-15.91%
4.	California	-14.18%
	U.S.	-9.65%
5.	Pennsylvania	-37.04%
6.	Texas	-10.99%
7.	Illinois	-33.02%
8.	Connecticut	33.90%
9.	Minnesota	-29.20%
10.	New Jersey	-13.84%

Data Source for Indicator 15: NSF, BLS, Census Bureau

VENTURE CAPITAL

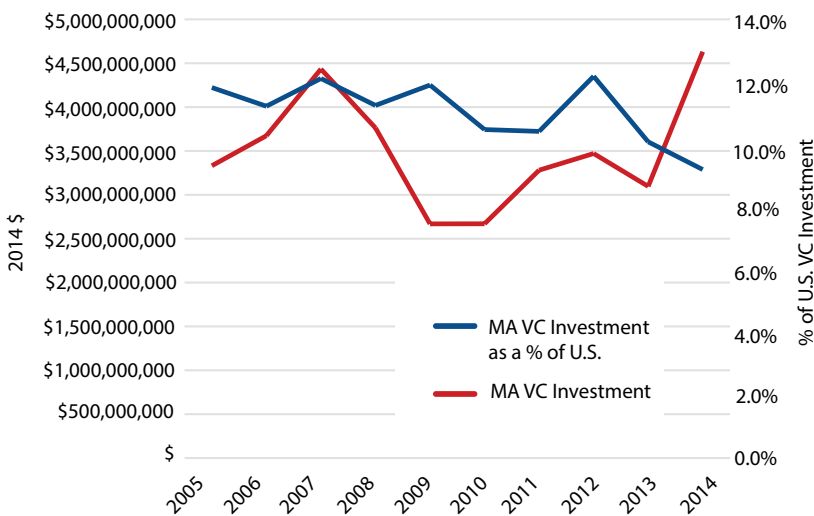
VC Investment by Sector

Massachusetts, 2014

Biotechnology	\$ 1,822,294,200
Software	\$ 1,059,746,500
Medical Devices	\$ 338,705,300
IT Services	\$ 233,346,600
Retail & Distribution	\$ 223,657,100
Electronics & Instrumentation	\$ 189,158,000
Media & Entertainment	\$ 146,199,100
Business Products	\$ 129,581,000
Industrial & Energy	\$ 128,282,300
Consumer Products	\$ 100,178,900
Computers & Peripherals	\$ 69,749,800
Semiconductors	\$ 67,952,000
Telecommunications	\$ 12,250,000
Healthcare Services	\$ 3,000,000
Other	\$ 1,484,000

VC Investment

Massachusetts, 2005-2014



Why Is It Significant?

Venture capital (VC) firms are an important source of funds for the creation and development of innovative new companies. VC firms also typically provide valuable guidance on strategy as well as oversight and governance. Trends in venture investment can indicate emerging growth opportunities in the innovation economy. There is some empirical research to suggest that the amount of VC in a region has a positive effect on economic growth.

How Does Massachusetts Perform?

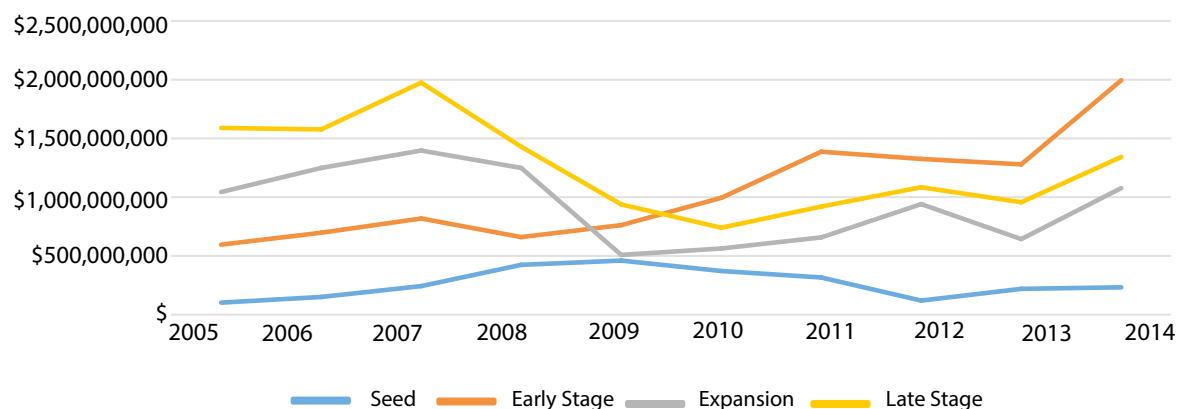
Biotechnology and Software were by far the largest destination industries for VC funding in Massachusetts in 2014, attracting more capital than all other sectors combined. This reflects the Commonwealth's strengths in these sectors as well as their broader popularity among investors. Software start-ups are also popular due to their relatively low up-front costs when compared with energy or semiconductor firms. Early stage financing in the state grew by 58% from 2013 and has tripled since 2008, highlighting investors' interest in younger start-up firms. Expansion financing by VC firms rebounded in Massachusetts from a decline of 30% in 2013 to grow by 70% in 2014, to its highest level since 2008. Late stage financing in Massachusetts declined rapidly between 2008 and 2010; however, it has recovered during the past four years to its highest level since 2008. Massachusetts' share of annual U.S. VC investment has ranged from around 9% to 12% since 2005. Massachusetts VC investment fell to 9.2% of the U.S. total in 2014 despite its strong 2013-2014 growth, as the level of investment nationwide has expanded dramatically over the last year. California was a particular beneficiary of this expansion, as investment grew by \$12.8 billion. The Commonwealth fell behind California VC funding as a share of GDP despite funding increasing from \$7.68 to \$9.88 per \$1,000 GDP in 2014. Angel investors provide an increasingly important source of seed capital for start-ups around the state. Massachusetts is home to 14 different identifiable groups of angel investors, more than the 10 found in Texas, although New York (17) and California (20) have more. Start-up/Seed financing from VC firms in Massachusetts has declined since 2008, falling by more than 50% in 2012, but recovering to \$232 million in 2014.



VENTURE CAPITAL

VC Investment by Stage

Massachusetts, 2005-2014



Venture Capital Investment

Massachusetts & LTS, 2009-2014

State	2009	2013	2014	2013-2014 % Change	2009-2014 Absolute Change	2009-2014 % Change	2014 VC Investment per \$1,000 GDP
CA	\$ 11,281,884,075	\$ 15,374,383,894	\$ 28,214,968,352	84%	\$ 16,933,084,277	150%	\$12.18
MA	\$ 2,648,805,787	\$ 3,075,262,321	\$ 4,601,004,367	50%	\$ 1,952,198,580	74%	\$9.88
NY	\$ 1,231,443,813	\$ 2,847,969,255	\$ 4,386,446,979	54%	\$ 3,155,003,166	256%	\$3.13
TX	\$ 744,212,351	\$ 1,346,318,036	\$ 1,409,233,083	5%	\$ 665,020,733	89%	\$0.88
IL	\$ 281,174,536	\$ 466,933,887	\$ 1,062,463,922	128%	\$ 781,289,386	278%	\$1.42
PA	\$ 491,176,997	\$ 469,322,467	\$ 781,982,191	67%	\$ 290,805,193	59%	\$1.17
CT	\$ 152,628,128	\$ 214,245,380	\$ 515,497,440	141%	\$ 362,869,313	238%	\$2.02
MN	\$ 335,872,503	\$ 271,916,443	\$ 354,631,153	30%	\$ 18,758,650	6%	\$1.12
NJ	\$ 692,708,724	\$ 339,432,582	\$ 304,674,215	-10%	\$ (388,034,510)	-56%	\$0.55
OH	\$ 121,360,540	\$ 256,342,856	\$ 265,974,341	4%	\$ 144,613,801	119%	\$0.46

Data Source for Indicator 16: PricewaterhouseCoopers MoneyTree Report, CPI, BEA, NVCA

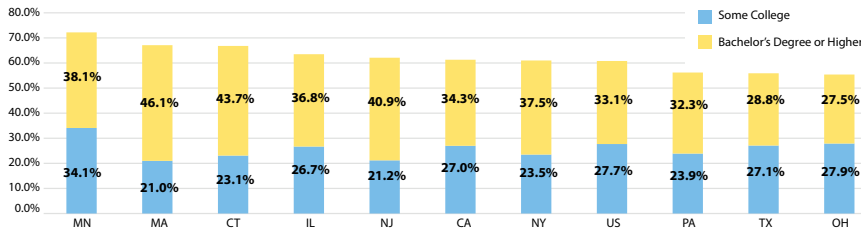
## **TALENT**

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

**INDICATORS 17-22**

EDUCATIONAL ATTAINMENT

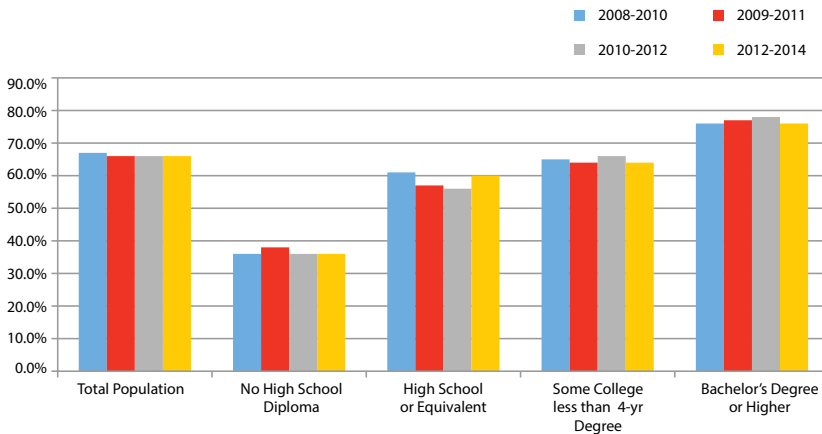
**Educational Attainment of Working Age Population**  
Massachusetts, LTS & U.S., 2012-2014 Average



**Why Is It Significant?**

A well-educated workforce constitutes an essential component of a region's capacity to generate and support innovation-driven economic growth. Without a trained workforce, business will not expand or relocate to an area and, in some cases, may move away. Challenges to maintaining a suitably trained labor force in Massachusetts include the need to continually increase skill levels and technical sophistication of workers. A highly educated workforce often results in a lower-than-average unemployment rate. Education plays an important role in preparing Massachusetts residents to succeed at their evolving job requirements and adapt to shifting career trajectories. A strong education system also helps attract and retain workers who want excellent educational opportunities and skills for themselves and their children. Economic growth in Massachusetts is highly dependent upon maintaining a high level of skills, as well as diverse skills, within the workforce.

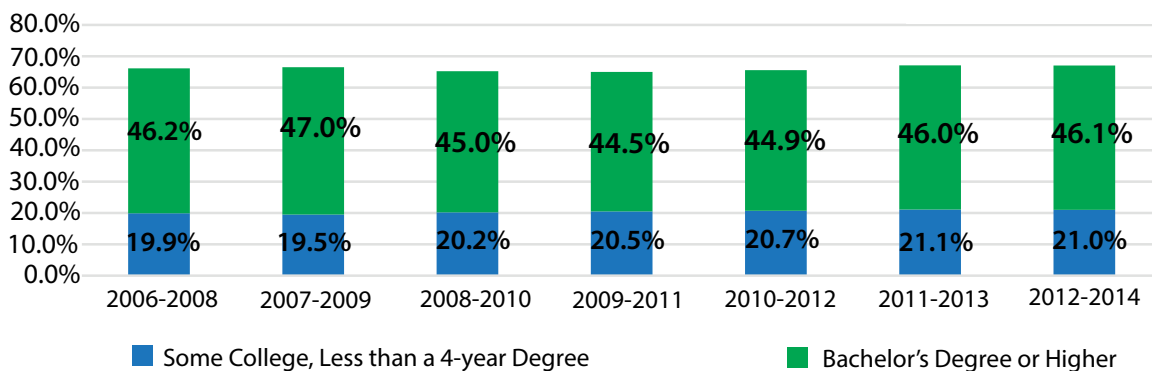
**Employment Rate by Educational Attainment**  
Massachusetts, Three Year Rolling - 2008-2014



**How Does Massachusetts Perform?**

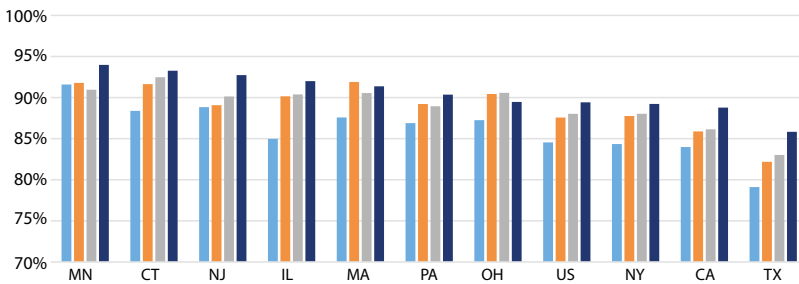
Massachusetts remains a leader among LTS in workforce educational attainment with the second highest overall level. Massachusetts has the highest percentage of adults with a bachelor's degree or higher (46.1%) compared to the LTS average (35.5%) and that of the U.S. (33.1%). While the percentage of adults with at least a bachelor's degree is still lower than it was at its peak in 2009 (47.0%), it is slightly higher than in 2012 (45.0%). The employment rate among adults with at least a bachelor's degree in Massachusetts has remained comparatively high, but flat since 2011 (76.0%), remaining 16 percentage points higher than that of those with only a high school diploma and more than double that of those without a high school diploma.

**College Attainment of Working Age Population**  
Massachusetts, Three Year Rolling Average, 2006-2014

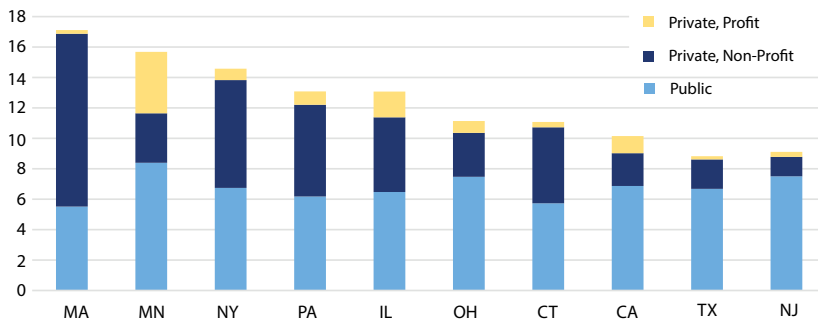


EDUCATIONAL ATTAINMENT

High School Attainment of Persons 19-24  
Massachusetts, LTS & U.S., Three Years Rolling

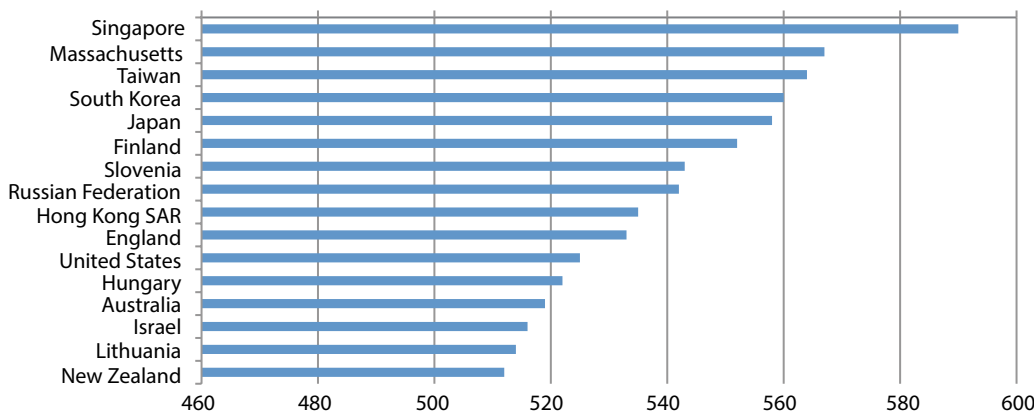


Post-Secondary Degrees Conferred per 1,000 People  
Massachusetts & LTS 2012-2013



Since the onset of the Great Recession, Massachusetts has maintained a lower unemployment rate than the U.S. as a whole for all but November 2013-January 2014. Meanwhile college attainment has remained relatively stable in Massachusetts since 2006 with 65.0%-67.5% (currently 67.0%) of the state's working age population having at least some college education. Three-year rolling averages of high school attainment data show relative stability in Massachusetts over the last four years. Although recent attainment rates are down from the level seen in 2009-2011, they are still significantly higher than the period from 2003-2005, which is the earliest available data. Although Massachusetts High School Attainment increased between 2010 and 2014, the Commonwealth has fallen behind New Jersey and Illinois on this metric, states that have both made steady improvement while Massachusetts has experienced ups and downs. On an international scale, Massachusetts moved up to second place in the Trends in International Math and Science Study (TIMSS) which measures 8th grade science evaluation, while Singapore remains the leader. Massachusetts' performance improved from the 2007 TIMSS assessment and it remains significantly higher (567) than the U.S. average (525). Massachusetts continues to be the clear leader in the number of postsecondary degrees conferred per 1,000 residents, with 17 degrees. Although Minnesota is close, it gets a large share of its graduates from private, for-profit institutions (4 post-secondary degrees per 1,000 people). Minnesota is the headquarters of one of the nation's largest private for-profit institutions, but many of its graduates take courses online and live in other states. Massachusetts is somewhat unusual in that the largest share of its graduates are from private, non-profit institutions, rather than public institutions of higher education

International  
Top 15 Nations Participating in 8th Grade  
TIMSS Science Evaluation with Massachusetts, 2011



Data Source for Indicator 17: Census Bureau Current Population Survey (CPS), National Center for Education Statistics (NCES), American Community Survey (ACS)

## PUBLIC INVESTMENT IN EDUCATION

## Per Pupil Spending

Public Elementary/Secondary School Systems  
Massachusetts, LTS, and U.S., 2012

State	Per Pupil Spending
New York	\$20,132
New Jersey	\$17,852
Connecticut	\$16,895
Massachusetts	\$14,746
Pennsylvania	\$14,084
Illinois	\$12,484
Ohio	\$11,374
Minnesota	\$11,266
U.S.	\$10,870
California	\$9,366
Texas	\$8,431

**State Higher Education Appropriations**  
per Full-Time Equivalent Student  
Massachusetts, LTS, and U.S., 2014

State	2014	5 Year % Change
Illinois	\$ 12,293	49.5%
New York	\$ 8,454	-2.4%
Texas	\$ 8,050	-9.5%
California	\$ 7,509	-5.4%
<b>U.S.</b>	<b>\$ 6,552</b>	<b>-13.3%</b>
Massachusetts	\$ 6,073	-10.8%
New Jersey	\$ 5,520	-23.4%
Minnesota	\$ 5,327	-20.2%
Ohio	\$ 4,314	-25.3%
Pennsylvania	\$ 3,654	-35.3%

## Why Is It Significant?

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

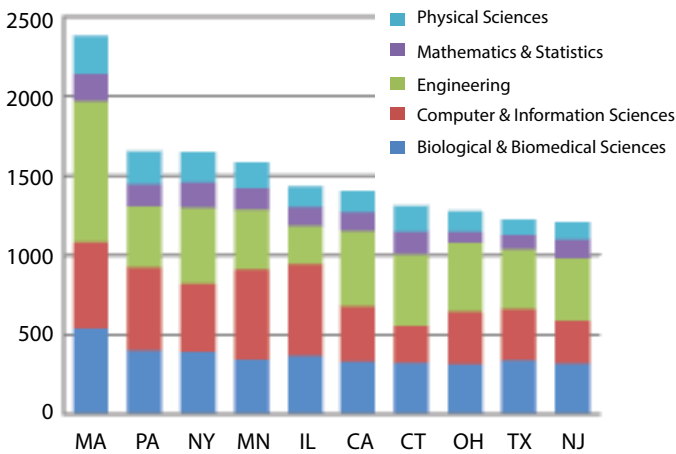
## How Does Massachusetts Perform?

Massachusetts continues its above-average spending per pupil on public elementary and secondary school systems. Of the LTS, New York, New Jersey, and Connecticut spend more per student than Massachusetts, which spends around \$3,900 per student more than the national average. In terms of higher education appropriations per full-time-equivalent student (FTE), Massachusetts (\$6,073) continues to be lower than most of the LTS (avg. \$6,890) and the U.S. average (\$6,552). Of the LTS, only Pennsylvania, Minnesota, New Jersey and Ohio had a lower level of appropriations per student. Over the period 2009-2014, all of the LTS, except Illinois and the U.S. as a whole, experienced a decline in higher education appropriations per student which tends to increase the cost of attendance for students and families. In appropriations per student, Massachusetts declined 10.8% while the U.S. averaged a 13.3% decline during that period.

STEM CAREER CHOICES AND DEGREES

Degrees Granted in STEM Fields

per 1 Million Residents  
Massachusetts & LTS, 2012-2013



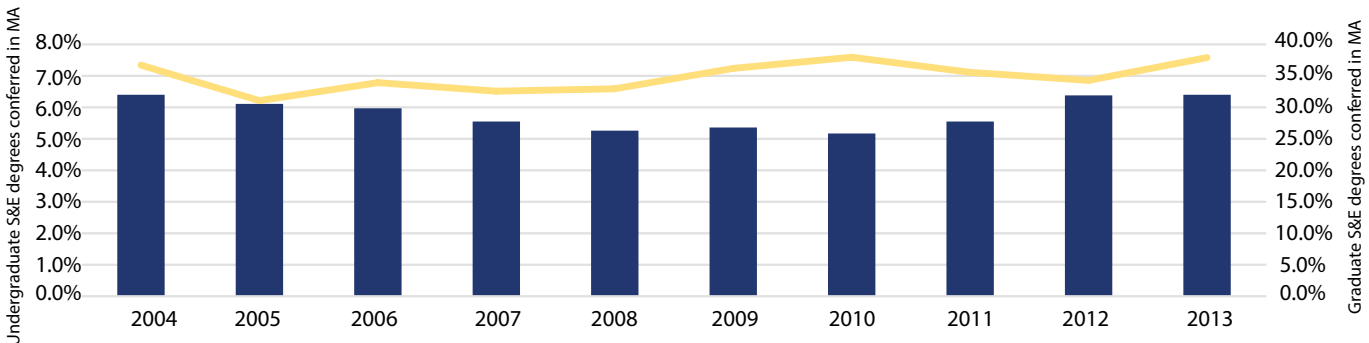
Life-Science Major Graduates

per 1 Million Residents  
MA & LTS, 2012-2013

State	Graduates
Massachusetts	657
Illinois	457
Pennsylvania	454
New York	449
Ohio	429
Connecticut	409
Minnesota	398
California	384
Texas	377
New Jersey	359

S&E Degrees Conferred to Temporary

Non-permanent Residents  
Universities in Massachusetts, 2004-2013



Data Source for Indicator 19: College Board, ACS, NCES, IPEDS

Why Is It Significant?

Science, technology, engineering, and math (STEM) education provides the skills and know-how that can help increase business productivity, create new technologies and companies, and establish the basis for higher-paying jobs. STEM degree holders are also important to the wider economy as nearly 75% of them hold non-STEM occupations.

How Does Massachusetts Perform?

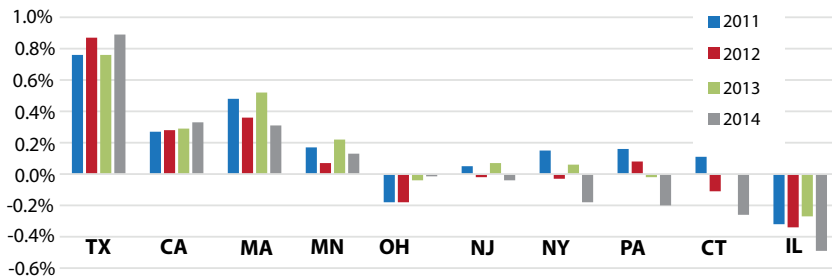
Massachusetts leads the LTS in degrees (graduate & undergraduate) granted in STEM fields per 1 million residents and that number is 44% higher than the second state, Pennsylvania. Among the STEM fields, engineering is the most popular major, with 37.2% of STEM degrees granted in Massachusetts and 29.4% on average in the LTS. Computer and Information Sciences comes in second, accounting for 22.8% in Massachusetts and 27.3% on average in all of the LTS. Degrees granted in STEM fields in Massachusetts rose in all fields except Computer and Information Sciences and Support Services over the period from 2003-2012. Total STEM degrees granted from 2003-2013 in Massachusetts rose 30%.

Foreign students attracted to the Commonwealth's high quality universities and colleges are an important source of STEM talent for Massachusetts' companies and research institutions. After rising to 38.0% in 2010, graduate degrees granted in S&E to temporary, non-permanent residents dropped slightly in the following years but reached 37.9% of all S&E degrees conferred in Massachusetts in 2013. Undergraduate S&E degrees conferred to temporary, non-permanent residents matched a ten-year peak in 2012 (6.4%), and maintained this level in 2013. However, these are comparably small numbers with Massachusetts institutions granting only 43 additional undergraduate degrees to foreign students in science and engineering (S&E) in 2013 for a total of 650. This is in contrast to the 2,307 graduate S&E degrees granted to foreign students in 2013, which increased by 360 students between 2012 and 2013.

TALENT FLOW AND ATTRACTION

Net Migration as a % of Population

Massachusetts & LTS, 2011-2014



Why Is It Significant?

Migration patterns are a key indicator of a region's attractiveness. Regions that are hubs of innovation have high concentrations of educated, highly-skilled workers and dynamic labor markets refreshed by inflows of talent. In-migration of well-educated individuals fuels innovative industries by bringing in diverse and high-demand skill sets.

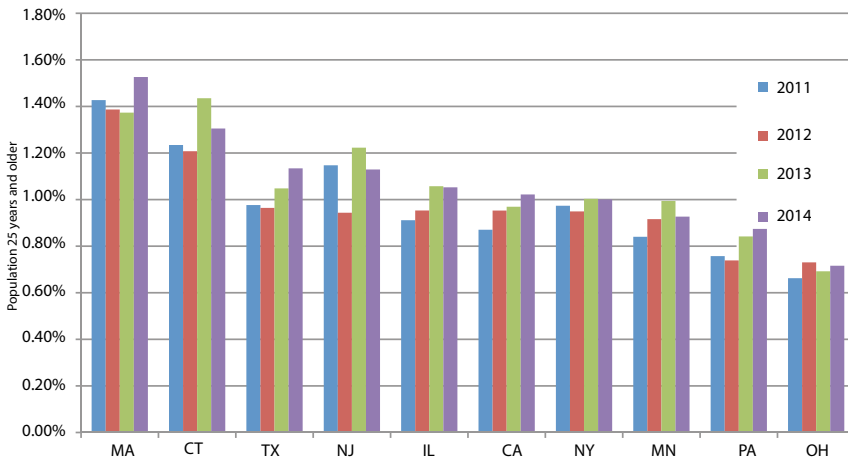
How Does Massachusetts Perform?

In recent years, most LTS have experienced low or negative net migration as a percentage of population, the exceptions being Massachusetts, California, and Texas. California and Texas are traditional migration destinations due, in part, to their weather; Texas also benefits from a low cost of living and abundant natural resources. Massachusetts does not possess either of these attributes. The high quality of life, cultural institutions, and relatively high-paying job opportunities draw people to Massachusetts despite its cold climate and relatively high cost of living. In 2014, Massachusetts experienced a distinct slowdown in net migration with the lowest level since 2010. International migration held steady at 37,285 while domestic migration worsened from -2,175 in 2013 to -16,354 in 2014. Despite the slowdown, Massachusetts has had positive net migration every year since 2008, representing a strong rebound from the early-mid 2000's when the state experienced six consecutive years of negative net migration. After losing the top spot among the LTS in 2013, Massachusetts has once again become the top relocation destination for college-educated adults.

Relocation by College Educated Adults

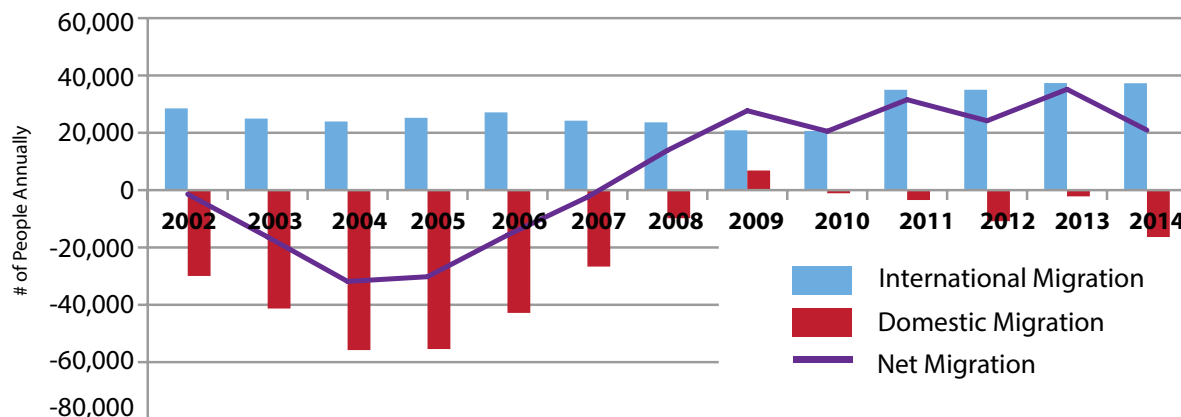
To the LTS from Out of State or Abroad

Massachusetts & LTS, 2011-2014



Domestic & International Migration

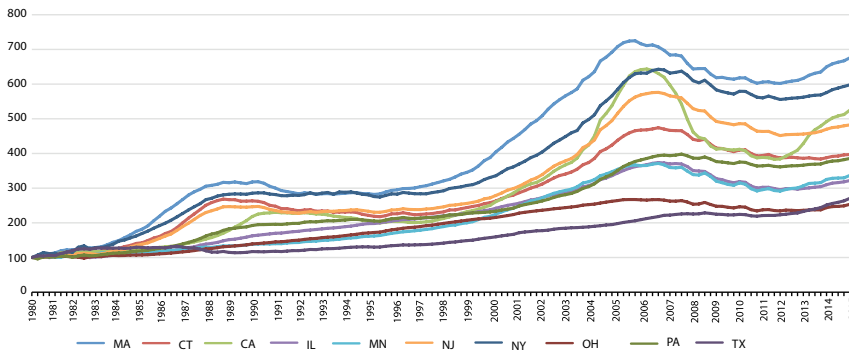
Massachusetts, 2002-2014



Data Source for Indicator 20: Census Bureau, ACS

HOUSING AFFORDABILITY

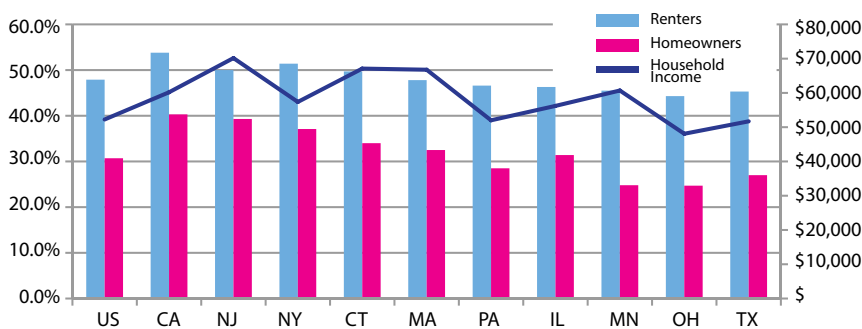
**Housing Price Index**  
Massachusetts & LTS  
Q1 1980 - Q2 2015



**Percent of Households Spending at least 30% of Income on Housing**  
Massachusetts & U.S., 2010-2014

	2010	2011	2012	2013	2014
MA Renters	47.8%	48.9%	46.8%	47.5%	47.8%
U.S. Renters	48.9%	49.3%	48.1%	47.6%	47.9%
MA Homeowners	39.0%	38.6%	35.1%	33.7%	32.5%
U.S. Homeowners	37.8%	37.8%	33.7%	31.6%	30.7%

**Households Spending 30% or more of Income on Housing Costs**  
Massachusetts, LTS & U.S., 2014



**Why Is It Significant?**

Assessments of 'quality of life', of which housing affordability is a major component, influence Massachusetts' ability to attract and retain talented people. Availability of affordable housing for essential service providers and entry-level workers can enable individuals to move to the area, thus facilitating business' ability to fill open positions and fuel business expansion in the region.

**How Does Massachusetts Perform?**

Nearly 48% of Massachusetts renters qualify as "burdened" by housing costs (spending more than 30% of their income on housing). Massachusetts tracks the national rate for renters (47.9%) and sits in the middle of the LTS on this measure.

California, New Jersey, New York, and Connecticut have less affordable housing, while the rest of the LTS is more affordable. Massachusetts and the U.S. as a whole have seen little change in this figure over the last five years. Over 40% of renters spend more than 30% of their income on housing in every LTS. Homeowners in both Massachusetts and the U.S. have become less burdened in the past two years with annual 2.5-3.0 percentage point decreases in the number of homeowners who spend more than 30% of their income on housing.

Overall, homeowners are significantly less likely to be burdened by housing costs. Homeowners face differing rates of housing cost burden with roughly 40% of homeowners in California and New Jersey spending more than 30% of their income on housing, and fewer than 30% doing so in Pennsylvania, Ohio, Minnesota, and Texas. On the surface, the situation seems to be improving, yet home prices and rents are increasing in Massachusetts and incomes are still lower than they were prior to the recession. The situation for renters and potential buyers contains some good news, however, as demand for more housing is having a positive effect on the Commonwealth's economic growth and driving a boom in construction jobs. Nearly 6,900 such jobs were created between Q1 2014 and Q1 2015.

Over the last three decades, housing prices have risen dramatically in Massachusetts, which currently has the highest Federal Housing Finance Authority Housing Price Index (HPI) among the LTS. While prices in the state haven't recovered to mid-2000s levels, they have risen by 11.3% since the market bottomed out in 2012. California has experienced an especially sharp rise in prices (36.9%) after a deep decline following the housing bubble burst. Texas (21.2%) and Minnesota (15.5%) also experienced faster increases in the Housing Price Index, although both from much lower starting points.

Data Source for Indicator 21: Federal Housing Finance Agency, Census Bureau, The Boston Globe, U.S. Department of Labor, Corelogic



INFRASTRUCTURE

Broadband Speed and Access

Massachusetts & LTS, Q2 2015

State	Average Connection Speed (Mbps)	15 Mbps Broadband Access (% of Population)	Speed Rank (in U.S.)	Access Rank (in U.S.)
MA	15.3	33%	2	2
NJ	14.1	32%	7	5
NY	14	27%	9	8
CA	13.7	26%	10	11
PA	13.4	27%	13	9
CT	13.1	25%	14	16
MN	12.4	20%	18	28
TX	12.1	21%	26	25
IL	12	21%	27	26
OH	10.7	14%	35	41
U.S.	11.8	21%	28	25

\*Delaware is the top state in speed and access.

Why Is It Significant?

A state's infrastructure is more than just the sum of its roads and bridges. Infrastructure is comprised of the transportation, communication, and energy systems within a state. It plays a crucial role in allowing goods and services to be moved into, within, and out of Massachusetts, whether physically or electronically. Energy is the unseen input that allows business to operate. Everything from data centers and offices, to factories and hospitals consume it. Fast broadband connections increase business productivity and allow consumers to access a wider range of goods and services online. Additionally, the amount of time people spend commuting to and from work imposes a hidden cost on the economy, consuming time that could otherwise be spent productively elsewhere. The more productive workers become, the more the cost of this lost time increases.

How Does Massachusetts Perform?

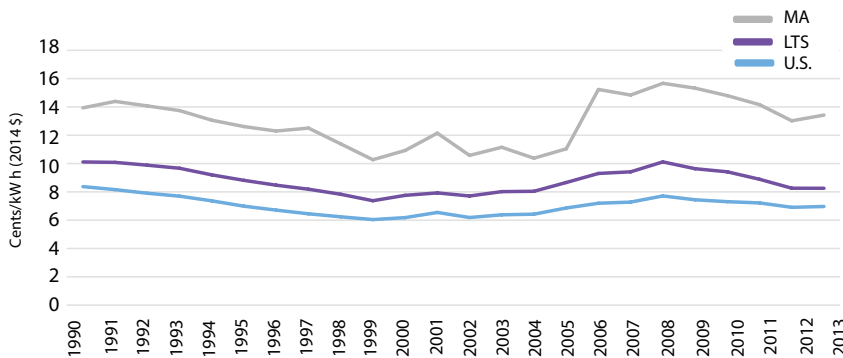
Massachusetts maintains faster average broadband speeds than the rest of the LTS (15.3 Megabits per second, or Mbps), a full 1.2 Mbps faster than New Jersey, the next closest state. Broadband speeds have increased dramatically since 2012 when Massachusetts, still the top ranked state among the LTS, had an average speed of 9.1 Mbps. Massachusetts also has the highest level of access to broadband speeds above 15 Mbps among the LTS, a benchmark for high quality broadband. Access to 15 Mbps broadband is, however, far from evenly distributed across all states. In Massachusetts for instance since the state's average connection speed is over 15 Mbps, but only 33% of the population has access to speeds faster than that, a relatively small segment of the state has access to very fast speeds while the rest can only obtain slower service.

Since 1990, Massachusetts has consistently maintained higher industrial electricity prices than either the LTS or the U.S. as whole. After a trend in declining prices from 1990-2006, Massachusetts experienced a relatively large increase in industrial electricity prices compared to the LTS and the U.S. Whereas Massachusetts industrial electricity prices were typically 47% higher than the LTS average in 1990 and as of 2013 they were 63% higher. Adjusted for inflation, industrial electricity prices are lower than they were in 1990 in Massachusetts, the LTS, and the U.S. The difference between Massachusetts and much of the country in prices is due to a number of persistent factors, including the lack of generating capacity in New England, lack of interconnections with other regions, and a mix of energy sources with higher input costs. The other New England states also have higher prices than the LTS, with only Maine being below 10 cents/kWh.

Finally, Boston is well known for its heavy rush hour traffic and indeed, Massachusetts metropolitan areas with more than 250,000 commuters have longer commutes than those in California. However, New York, New Jersey, and Illinois commuters spend even more time in traffic. Metropolitan areas in Connecticut, Minnesota, and Ohio have shorter commutes than the U.S. average.

Industrial Electricity Prices

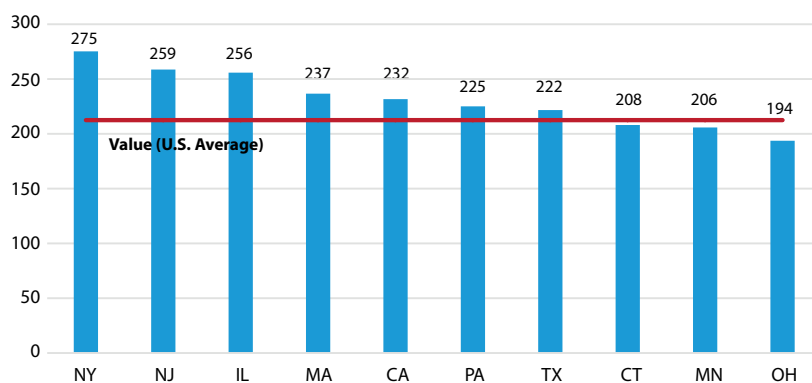
Massachusetts, LTS & U.S., 1990-2013



Average Metropolitan Commute Time Large Metros (above 250K commuters)

Hours/Year

Massachusetts & LTS, 2013



Data Source for Indicator 22: Census Bureau, ACS, State Technology Magazine, Energy Information Administration

APPENDIX

DATA SOURCES FOR INDICATORS AND SELECTION OF LEADING TECHNOLOGY STATES (LTS)

**Data Availability**

Indicators are calculated with data from proprietary and other existing secondary sources. In most cases, data from these sources were organized and processed for use in the Index. Since these data are derived from a wide range of sources, content of the data sources and time frames are not identical and cannot be compared without adjustments. This appendix provides information on the data sources for each indicator.

**Price Adjustment**

The 2014 Index uses inflation-adjusted figures for most indicators. Dollar figures represented in this report, where indicated, are 'chained' (adjusted for inflation) to the latest year of data unless otherwise indicated. Price adjustments are according to the Consumer Price Index for all Urban Consumers, U.S. City Average, All Items, Not Seasonally Adjusted. Bureau of Labor Statistics, US Department of Labor (www.bls.gov/data).

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

The Index benchmarks Massachusetts performance against other leading states and nations to provide the basis for comparison.. The LTS list includes: California, Connecticut, Illinois, Minnesota, New Jersey, New York, Ohio, Pennsylvania, and Texas. In 2014 the LTS were chosen using three criteria: (i.) by the number of select key industry sectors with a high concentration (10% above average) of employment, (ii.) the percent of employment in these sectors, and (iii.) the size of each states' innovation economy (measured by number of employees). The sectors used to represent the Innovation Economy include: Bio-pharma & Medical Devices, Computer & Communication Hardware, Defense Manufacturing & Instrumentation, Financial Services, Postsecondary Education, Scientific, Technical, & Management Services, and Software & Communications Services. The sector employment concentration for each state measures sector employment as a percent of total employment to the same measure for the US as a whole. This ratio, called the 'location quotient' (LQ), is above average if greater than one. The three criteria are assessed simultaneously and with equal weighting. The score assigned to each state for each criterion is between 0 and 1, with 1 going to the leading state and 0 going to the bottom state. The scores for the rest of the states are determined by their relative position within the spread of data. The criteria scores are added together to get an overall score. The states with the 10 highest overall scores are then chosen for the LTS.

**II. Notes on Selection Of Comparison Nations**

For all the indicators that include international comparisons, countries displayed on the graph are the top performers for that measure. Some countries were excluded from comparison due to a lack of data reported for required years.

**III. Notes on International Data Sources**

For countries where the school year or the fiscal year spans two calendar years, the year is cited according to the later year. For example, 2004/05 is presented as 2005. All international population estimates are obtained from the World Bank. Total population is based on the de facto definition of population, which counts all residents regardless of legal status or citizenship—except for refugees not permanently settled in the country of asylum, who are generally considered part of the population of their country of origin. The numbers shown are mid-year estimates. The World Bank estimates population from various sources including census reports, the United Nations Population Division's World Population Prospects, national statistical offices, household surveys conducted by national agencies and Macro International.

State	Score
<b>Top Ten</b>	
Massachusetts	2.27
California	2.21
Pennsylvania	2.04
New York	1.74
Connecticut	1.73
Ohio	1.66
Illinois	1.59
Minnesota	1.54
Texas	1.53
New Jersey	1.45
<b>Next Five</b>	
North Carolina	1.44
New Hampshire	1.39
Rhode Island	1.38
Missouri	1.35
Wisconsin	1.34

Source: BLS QCEW

## V. Notes On Data Sources For Individual Indicators

### Indicator 1: Industry Cluster Employment and Wages

Data on sector wages are from the Bureau of Labor Statistics' Quarterly Census of Employment and Wages ([www.bls.gov/cew](http://www.bls.gov/cew)). This survey derives employment and wage data from workers covered by state unemployment insurance laws and federal workers covered by the Unemployment Compensation for Federal Employees program. Wage data denote total compensation paid during the four calendar quarters regardless of when the services were performed. Wage data include pay for vacation and other paid leave, bonuses, stock options, tips, the cash value of meals and lodging, and contributions to deferred compensation plans. Definitions for each key industry sector are in Appendix B.

### Indicator 2: Occupations and Wages

The U.S. Bureau of Labor Statistics, Occupational Employment Estimates (OES) ([www.bls.gov/oes/oes\\_dl.htm](http://www.bls.gov/oes/oes_dl.htm)) program estimates the number of people employed in certain occupations and wages paid to them. The OES data include all full-time and part-time wage and salary workers in non-farm industries. Self-employed persons are not included in the estimates. The OES uses the Standard Occupational Classification (SOC) system to classify workers. MassTech aggregated the 22 major occupational categories of the OES into 10 occupational categories for analysis.

The occupational categories in the Index are:

- Arts & Media: Arts, design, entertainment, sports and media occupations.
- Construction & Maintenance: Construction and extraction occupations; Installation, maintenance and repair occupations.
- Education: Education, training and library occupations.
- Healthcare: Healthcare practitioner and technical occupations; Healthcare support occupations.
- Computer and Mathematical: Computer and mathematical occupations.
- Science, Architecture and Engineering Occupations: Architectural and engineering occupations; life, physical and social science occupations.
- Business, Financial and Legal Occupations: Management occupations; Business and financial operations occupations; and Legal occupations.
- Production: Production occupations.
- Sales & Office: Sales and related occupations; Office and administrative support occupations.
- Community and Social Service: Community and social service 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.

S&E Occupations as a Percent of the Workforce: Data taken from Table 8-33: Individuals in S&E Occupations as a Percent of the Workforce, NSF Science & Engineering Indicators.

### Indicator 3: Household Income

#### Median Household Income

Median household income data are from the U.S. Census Bureau, American Community Survey using figures adjusted to 2013 dollars.

#### Income Distribution

Data for Distribution of Income are from the American Community Survey from the U.S. Census Bureau. Income is the sum of the amounts reported separately for the following eight types of income: wage or salary income; net self-employment income; interest, dividends, or net rental or royalty income from estates and trusts; Social Security or railroad retirement income; Supplemental Security Income; public assistance or welfare payments; retirement, survivor, or disability pensions; and all other income.

#### Wages and Salaries Paid.

Wage and salary data from the Bureau of Economic Analysis, SQ7N Wage and salary disbursements by major NAICS industry, wage and salary disbursements by place of work (millions of dollars) ([www.bea.gov](http://www.bea.gov)).

**Indicator 4: Output****Output**

Industry output data are obtained from the Moody's economy.com Data Buffet. Moody's estimates are based on industry output data for 2 and 3 digit NAICS produced by the Bureau of Economic Analysis.

**Indicator 5: Exports**

Manufacturing exports data are from the U.S. Census Bureau, Foreign Trade Division.

**Indicator 6: Research and Development****Research and Development (R&D) Performed**

Data are from the National Science Foundation (NSF), "Table: U.S. research and development expenditures, by state, performing sector and source of funding". Data used are the totals for all R&D, Federal, FFRDCs, Business, U&C and Other Nonprofit.

**Industry Performed Research and Development (R&D) As a Percent of Industry Output**

Data on industry performed R&D are from the NSF Science & Engineering Indicators, "Table 8-45: Business-performed R&D as a percentage of private-industry output, by state: 2000, 2004 and 2008."

**Research and Development (R&D) as a Percent of Gross Domestic Product (GDP)**

Data for Massachusetts' R&D as a percent of GDP are from the NSF, "Table: U.S. research and development expenditures, by state, performing sector, and source of funding" and the Bureau of Economic Analysis (bea.gov).

Data for the LTS are from the NSF National Patterns of R&D Resources, "Table - Research and development expenditures, by state, performing sector, and source of funds". Data used are the totals for all R&D, Federal, FFRDCs, Business, U&C and Other Nonprofit. [www.nsf.gov/statistics](http://www.nsf.gov/statistics).

**Indicator 7: Academic Article Output**

LTS data are from the NSF "Table 8-49 - Academic science and engineering article output per \$1 million of academic S&E R&D, by state: 1998-2009" and "Table 8-48- Academic S&E Articles per 1,000 S&E Doctorate Holders in Academia by state: 1997, 2003 and 2008. International data is from the NSF. "Table 5-27 - S&E articles in all fields, by region/country/economy: 1999 and 2009". The NSF obtained its information on science and engineering articles from the Thomson Scientific ISI database. LTS population data are from the U.S. Census Bureau ([www.census.gov/popest/data/index.html](http://www.census.gov/popest/data/index.html)).

**Indicator 8: Patents****United States Patent and Trademark Office (USPTO) Patents Granted**

The count of patents granted by state are from the US Patent and Trademark Office (USPTO). Patents granted are a count of Utility Patents only. The number of patents per year are based on the date patents were granted ([www.uspto.gov](http://www.uspto.gov)). Population estimates are from the U.S. Census Bureau, Population Estimates Branch ([www.census.gov/popest/data/index.html](http://www.census.gov/popest/data/index.html)).

**Patents Published Under the Patent Cooperation Treaty**

International patents published under the Patent Cooperation Treaty (PCT) are from the World Intellectual Property Organization (WIPO) (<http://patentscope.wipo.int/search/en/structuredSearch.jsf>). Intellectual property data published in this report are taken from the WIPO Statistics Database, which is primarily based on information provided to WIPO by national/regional IP offices and data compiled by WIPO during the application process of international filings through the PCT, the Madrid System and the Hague System. The number of patents per year are based on the date of publication. GDP data is from the World Bank ([data.worldbank.org](http://data.worldbank.org)).

**Indicator 9: Technology Patents**

The count of patents granted by state and patent class are from the U.S. Patent and Trademark Office ([www.uspto.gov](http://www.uspto.gov)), Patenting By Geographic Region, Breakout by Technology Class. State population data come from the U.S. Census Bureau, Population Estimates Branch. ([www.census.gov/popest/data/index.html](http://www.census.gov/popest/data/index.html)). The number of patents per year are based on the date the patents were granted. Patents in “computer and communications” and “drugs and medical” are based on categories developed by in Hall, B. H., A. B. Jaffe, and M. Trajtenberg (2001). “The NBER Patent Citation Data File: Lessons, Insights and Methodological Tools.” NBER Working Paper 8498. Patents in “advanced materials” and “analytical instruments and research methods” are based on categories developed by MTC’s John Adams Innovation Institute. The “business methods” category has its own USPTO patent class.

**Indicator 10: Technology Licensing**

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

**Indicator 11: Small Business Innovation Research (SBIR) and Technology Transfer (STTR) Awards**

This indicator includes SBIR award and Small Business Technology Transfer (STTR) award data. SBIR/STTR award data are from U.S. Small Business Administration ([www.sbir.gov/sbirsearch/technology](http://www.sbir.gov/sbirsearch/technology)), state population data come from the U.S. Census Bureau, Population Estimates Branch ([www.census.gov/popest/data/index.html](http://www.census.gov/popest/data/index.html)) and GDP Data is from U.S. Bureau of Economic Analysis ([www.bea.gov](http://www.bea.gov)).

**Indicator 12: Business Formation****Business Establishment Openings**

Data are from the Business Employment Dynamics database of the Bureau of Labor Statistics’ (BLS) Business Employment Dynamics ([www.bls.gov/bdm](http://www.bls.gov/bdm)).

**Net Change In Business Establishments In the Key Industry Sectors**

The net change in business establishments was calculated using BLS ([www.census.gov/econ/cbp/index.html](http://www.census.gov/econ/cbp/index.html)) Quarterly Census of Employment and Wages. Definitions for each key industry sector are in Appendix B.

**Start-up Companies**

Data on spinout “start-up” companies are from the Association of University Technology Managers (AUTM). Institutions participating in the survey are all AUTM members ([www.autm.net](http://www.autm.net)).

**Indicator 13: Initial Public Offerings and Mergers and Acquisitions****Initial Public Offerings (IPOs)**

The number and distribution by industry sector of filed initial public offerings (IPOs) by state and for the U.S. are from Renaissance Capital's, IPOs Near You ([www.renaissancecapital.com/IPOHome/Press/MediaRoom.aspx#](http://www.renaissancecapital.com/IPOHome/Press/MediaRoom.aspx#)) Data on venture-backed IPOs for 2012 are from the National Venture Capital Association (NVCA) ([www.nvca.org](http://www.nvca.org)).

**Mergers & Acquisitions (M&As)**

Data on total number of M&As are from Factset Mergerstat, deals include acquired company by location.

**Indicator 14: Federal Funding for Academic and Health R&D****Federal Expenditures For Academic And Nonprofit Research And Development (R&D)**

Data are from the NSF, "Federal obligations for research and development for selected agencies, by state and other locations and performer" ([www.nsf.gov/statistics](http://www.nsf.gov/statistics)). Data used are the entries for federal funding for universities and nonprofits, excluding university and nonprofit federally funded research and development centers (FFRDCs).

**National Institutes of Health (NIH) Funding per Capita, per GDP and Average Annual Growth Rate**

Data on federal health R&D are from the NIH (<http://report.nih.gov/award/>). The NIH annually computes data on funding provided by NIH grants, cooperative agreements and contracts to universities, hospitals and other institutions. The figures do not reflect institutional reorganizations, changes of institutions, or changes to award levels made after the data are compiled. Population data is from U.S. Census Bureau (<http://www.census.gov/popest/data/index.html>). GDP data is from Bureau of Economic Analysis ([bea.gov](http://bea.gov)), U.S. Department of Commerce.

**Indicator 15: Industry Funding of Academic Research**

Data are from the NSF Survey of Research and Development Expenditures at Universities and Colleges and Survey of Research and Development Expenditures at Universities and Colleges, Business Financed Higher Education R&D Expenditures for S&E (<http://www.nsf.gov/statistics/srvyrdexpenditures/>). Since FY 1998, respondents have included all eligible institutions. Population data is from U.S. Census Bureau (<http://www.census.gov/popest/data/index.html>).

**Indicator 16: Venture Capital (VC)**

Data for total VC investments, VC investments by industry activity, and distribution by stage of financing are provided by PricewaterhouseCoopers (PwC) in the MoneyTree Report (<https://www.pwcmoneytree.com/MTPublic/ns/nav.jsp?page=historical>). Industry category designations are determined by PwC. Definitions for the industry classifications and stages of development used in the MoneyTree Survey can be found at the PwC website (<http://www.pwcmoneytree.com/moneytree/nav.jsp?page=definitions>). GDP data are from Bureau of Economic Analysis ([bea.gov](http://bea.gov)), U.S. Department of Commerce.  
PWC Stage Definitions: <https://www.pwcmoneytree.com/MTPublic/ns/nav.jsp?page=definitions#stage>

**Indicator 17: Educational Attainment**

For this indicator, the workforce is defined as the population ages 25-65. Data on educational attainment of this population are from the US Census Bureau (<http://www.census.gov/cps/data/cpstalecreator.html>), Current Population Survey, Annual Social and Economic Supplement, 2012. Figures are three-year rolling averages. Data on employment rate by educational attainment are based on the full-time employment rate of the workforce.

**High School Attainment by the Population Ages 19-24**

Data on high school attainment are from the US Census Bureau, Current Population Survey (<http://www.census.gov/cps/data/cpstalecreator.html>), Annual Social and Economic Supplement, 2008 through 2012. Figures are three year rolling averages.

**College Degrees Conferred**

Data for the U.S. states comes from the National Center for Education Statistics using the sum of all degrees conferred at the bachelor's level or higher.

TIMSS 8th Grade Science data are from Trends in International Mathematics and Science Study 2011 International Results in Science, TIMSS and PIRLS International Study Center, Lynch School of Education, Boston College, 2012.

**Indicator 18: Public Investment Education**

This indicator looks only at public investments in education, but it should be noted that Massachusetts is unusual in the size of the private education sector. Forty-three percent (198,000 of 463,000) of higher education students attend public institutions in Massachusetts compared to 72% nationally with the remainder attending non-public institutions. These figures are from the National Center for Education Statistics (NCES), Integrated Postsecondary Education Data System (IPEDS) Enrollment Survey using the NCES population of institutions available at [webcaspar.nsf.gov](http://webcaspar.nsf.gov). While private higher education is an export industry in Massachusetts, 48% of Massachusetts high school graduates indicate that they will attend public higher education institutions compared to 32% indicating they will attend private institutions, with the remainder not attending college. This difference is even more dramatic for Hispanics (50% and 18% respectively), a growing component of the Massachusetts population. These figures are from the Massachusetts Department of Education, Plans of High School Graduates, Class of 2008 (<http://www.doe.mass.edu/infoservices/reports/hsg/data.html?yr=08>).

**Per Pupil Spending in K-12**

Public elementary & secondary school finance data are from the U.S. Census Bureau, Table 19, "Per Pupil (PPCS) Amounts and One-Year Percentage Changes for Current Spending of Public Elementary-Secondary School Systems by State: 2006-2012". Figures are presented in 2012 dollars. Data excludes payments to other school systems and non K-12 programs.

**State Higher Education Appropriations per FTE**

Data on public higher education appropriations per full-time equivalent (FTE) student is provided by the State Higher Education Executive Office (<http://www.sheeo.org/finance/shef-home.htm>). The data consider only educational appropriations—state and local funds available for public higher education operating expenses, excluding spending for research, agriculture, and medical education and support to independent institutions and students. The State Higher Education Finance 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.

**Indicator 19: Science, Technology, Engineering, and Math (STEM) Career Choices and Degrees****STEM Degrees**

Data about degrees conferred by field of study are from NCES, IPEDS Completions Survey using the NSF population of institutions. Data were accessed through the NSF WebCASPAR (<http://caspar.nsf.gov>). Fields are defined by 2-digit Classification of Instructional Program (CIP), listed below.

- Science: 26-Biological & Biomedical Sciences and 40-Physical Sciences
- Technology: 11-Computer & Information Science & Support Services
- Engineering: 14-Engineering
- Math: 27-Mathematics & Statistics

**Science & Engineering Talent by Categories**

Data for Science & Engineering (S&E) Talent provided by the United States Census Bureau, Decennial Census and American Community Survey Public Use Microdata Samples (PUMS). A list of S&E occupations were divided into six categories: Computer, Physical Engineers, Design, Biological, Mathematics and Aerospace Engineers & Scientists. Design includes Designers and Artists & Related Workers. Both were added to the S&E occupations to try to capture the employment in Graphic Designers and Multi-Media Artists & Animators. According to BLS Occupation Employment Statistics (May 2009), both occupations represent almost 60 percent of employment in both Designers and Artists & Related Workers.

**Science & Engineering Doctorates**

Data for S&E doctorates comes from the Science and Engineering Doctorates report, table 9, published by the NSF.

**Life Science Major Graduates**

Data for life science major graduates was obtained from the National Center for Education Statistics College Navigator.

**Indicator 20: Talent Flow and Attraction****Relocations to LTS by College Educated Adults**

Data on population mobility come from the US Census Bureau, American Community Survey; Table B07009-Geographic Mobility in the Past Year by Educational Attainment, 1-year estimate. This is the number of people moving in and includes no information about the number moving out. It can be used as a measure of the ability to attract talent.

**Net Migration**

Net Migration figures are derived from the US Census Bureau's population estimates program using annual data.

**Indicator 21: Housing Affordability****Housing Price Index**

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

**Housing Affordability**

Housing affordability figures are from the U.S. Census Bureau, American Community Survey, R2513: "Percent of Mortgaged Owners Spending 30 Percent or More of Household Income on Selected Monthly Owner Costs" and R2515: "Percent of Renter-Occupied Units Spending 30 Percent or More of Household Income on Rent and Utilities".

**Median Household Income**

Median household income data are from U.S. Census Bureau, American Community Survey, B19013: "Median Household Income in the Past 12 Months", 3-year estimate.

**Indicator 22: Infrastructure****Broadband Speed**

Data is taken from Akamai Technologies State of the Internet report.

**Industrial Electricity Rates**

Data is taken from the United States Energy Information Administration.

**Median Commute Time**

Data is taken from the U.S. Census Bureau American Community Survey County Level Statistics. Metro area median commutes were determined using the median commute time of each component county and its proportion of total metro area commuters.



The Index makes use of 4, 5 and 6 digit North American Industry Classification System (NAICS) codes to define key industry sectors of the Massachusetts Innovation Economy. The Index's key industry sector definitions capture traded-sectors that are known to be individually significant in the Massachusetts economy. Consistent with the innovation ecosystem framework, these sector definitions are broader than 'high-tech'. Strictly speaking, clusters are overlapping networks of firms and institutions which would include portions of many sectors, such as Postsecondary Education and Business Services. For data analysis purposes the Index has developed NAICS-based sector definitions that are mutually exclusive.

### Modification to Sector Definitions

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

With the exception of Advanced Materials, sectors 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 sector, it is included because it represents activity that supplies critical support to other key sectors. In the 2009 Index, the definition of Business Services was expanded to include 5511-Management of Companies and Enterprises. According to analysis by the Bureau of Labor Statistics, this category has at least twice the all-industry average intensity of technology-oriented workers. All time-series comparisons use the current sector definition for all years, and, as such, may differ from figures printed in prior editions of the Index. The slight name change in 2009 of the Bio-pharma and Medical Devices sector does not reflect any changes in the components that define the sector.

### 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

### Biopharmaceuticals, Medical Devices & Hardware

- 3254 Pharmaceutical and Medicine Manufacturing
- 3391 Medical Equipment and Supplies Manufacturing
- 6215 Medical and Diagnostic Laboratories
- 42345 Medical Equipment and Merchant Wholesalers
- 42346 Ophthalmic Goods Merchant Wholesale
- 54171 Physical, Engineering and Biological Research

With 2007 NAICS, apportioned based on 541711 R&D in Biotechnology

- 334510 Electro Medical Apparatus Manufacturing
- 334517 Irradiation Apparatus Manufacturing

### Business Services

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

### Computer & Communications Hardware

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

### Defense Manufacturing & Instrumentation

- 3329 Other Fabricated Metal Product Manufacturing
- 3336 Engine, Turbine and Power Transmission Equipment Manufacturing
- 334511 Search, Detection, Navigation, Guidance, Aeronautical and Nautical System and Instrument Manufacturing
- 334512 Automatic Environmental Control Manufacturing for Residential, Commercial and Appliance Use
- 334513 Instruments and Related Products Manufacturing for Measuring, Displaying and Controlling Industrial Process Variables
- 334514 Totalizing Fluid Meter and Counting Device Manufacturing
- 334515 Instrument Manufacturing for Measuring and Testing Electricity and Electrical Signals
- 334516 Analytical Laboratory Instrument Manufacturing
- 334518 Watch, Clock and Part Manufacturing
- 334519 Other Measuring and Controlling Device 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**

- 6211 Offices of Physicians
- 6212 Offices of Dentists
- 6213 Offices of Other Health Practitioners
- 6214 Outpatient Care Centers
- 6216 Home Health Care Services
- 6219 Other 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 Research and Development Services \*  
\*Minus the portion apportioned to the Bio sector
- 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
- 5415 Computer Systems Design and Related Services
- 8112 Electronic and Precision Equipment Repair and Maintenance

With 2007 NAICS add 51913 Internet publishing and broadcasting and web search portal

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**INDEX STAFF****Content Creation**

**Project Director: James F. Byrnes, Jr.**, Operations Manager, Innovation Institute, Massachusetts Technology Collaborative

**Lead Researcher: William R. A. Fuqua**, Program Research Analyst, Innovation Institute, Massachusetts Technology Collaborative

**Assistant Researcher: Vaske Gjino**, Research & Analysis Intern, Innovation Institute

**Report Design**

**Kathryn A. Murphy**, Digital Media Specialist, Massachusetts Technology Collaborative

**PHOTOGRAPHS**

**Front and Back Cover:** Springfield Data Center in Springfield, Massachusetts.

**Page 3:** Artist Tim Cole working on the mural at the Groundwork co-working space, located in downtown New Bedford.

**Page 11:** District Hall, located in the Innovation District of Boston, is a "dedicated civic space where the innovation community can gather and exchange ideas," according to the Venture Café Foundation, the group that manages the space.

**Page 20:** Silverside Detectors, a startup housed at Greentown Labs in Somerville, manufactures an "inexpensive radiation sensor" that can help "governments reduce the threat of nuclear terrorism". In addition to being a collaborative space for the startup to grow, they also note that Greentown acted as a "bridge" between their firm and manufacturers.

**Page 21:** Collaborative workspaces provide various benefits for startups, delivering both a sense of community and points of interconnection with other innovators and entrepreneurs. Here we see one of Venture Café's many meeting spaces being utilized.

In May 2015, Springfield's Valley Venture Mentors handed out awards to 12 startups that took part in VVM's inaugural accelerator program. Here, VVM board members Jay Leonard and Scott Foster (from right) give award to Laurel Wider (center), CEO and Founder of WonderCrew.

**Page 22:** Bridgette Wallace, Founder and President of SkyLab Boston, speaks at the opening of the Roxbury Innovation Center in September 2015.

Entrepreneurs from the South Coast region take advantage of the Groundwork co-working space, located in downtown New Bedford.



**THE INNOVATION INSTITUTE**

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at the MassTech Collaborative

75 North Drive - Westborough, MA 01581 - P | 508.870.0312 - F | 508.898.2275

2 Center Plaza, Suite 200 - Boston, MA 02108 - P | 617.371.3999

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