



THE INNOVATION INSTITUTE

at the MassTech Collaborative



The Annual Index of the  
MASSACHUSETTS INNOVATION ECONOMY

*22nd Edition*

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**For more information visit: [masstech.org/index](https://masstech.org/index)**



## The INDEX of the MASSACHUSETTS INNOVATION ECONOMY 22nd Edition

Welcome,

It is my pleasure to welcome you to the *22nd Edition of the Index of the Massachusetts Innovation Economy*. Published annually by the MassTech Collaborative, the *Index* offers important perspective on the state of Massachusetts' Innovation Economy – a sector that accounts for nearly 40% of employment in the state. We are proud to be a national leader in innovation and we are committed to strengthening our position through holistic investments and collaboration.

Since 1997, the *Index* has enabled analysis of the growth and sustainability of the state's Innovation Economy, as well as opportunities and potential barriers to growth. These unique insights help inform our economic development strategy, as we work across the state to ensure the high quality of life and job opportunities that attract people from around the world to Massachusetts.

Despite a robust economy, Massachusetts is confronted with the challenge of accelerating innovation and job growth in the face of growing competition from other states, while at the same time adapting to the rise of disruptive technologies with the potential to reshape entire industries. *The 22nd Edition of the Index* includes a 'Special Analysis' section that highlights the Commonwealth's world-class education and training system, as well as ongoing efforts to maintain our biggest competitive advantage through workforce development projects that are helping individuals to expand their skillsets in order to meet the long-term needs of our economy. The goal of this analysis is to inspire dialogue and actions that will enable Massachusetts to strengthen the talent pipeline statewide, and eventually increase opportunity – and prosperity – throughout the Commonwealth.

Thank you for your interest in the *Index* and the critical issues that are impacting the Massachusetts Innovation Economy. Whether you're based in Massachusetts or are located outside of the state, we encourage you to dig into the data to see why Massachusetts is the #1 state for innovation, and join the conversation around ways we can grow more game-changing technologies and talent that are 'Made in Massachusetts.'





A handwritten signature in black ink, appearing to read 'Mike Kennealy'.


Mike Kennealy  
Secretary of Housing and Economic Development

# EXECUTIVE SUMMARY


The 22nd Edition of the *Index of the Massachusetts Innovation Economy* shows that the Commonwealth is still a top state for innovation, bolstered by our well-trained and talented workers, network of top-tier colleges and universities, and a research & development (R&D) enterprise that, compared to the size of our economy, is second to none. Despite the continued improvement of other states and a handful of challenges faced by the Commonwealth, based on the Massachusetts Technology Collaborative’s analysis of 22 indicators that cover the categories of Economic Impact, Research, Technology & Business Development, Capital, and Talent (pages 18-55), we found several areas where Massachusetts’ performance continues to stand out:


 **Superior Workforce and Talent Pipeline:** In Massachusetts, 48.7% of working age adults had at least a bachelor’s degree as of 2017 (1st nationally) while the state also produced more than 121,000 college graduates (8th nationally);


 **STEM Leadership:** Massachusetts produced 22,500 STEM graduates in 2017 (7th nationally) and more STEM graduates per capita than any state in the country; and

 **Healthy R&D:** Massachusetts had the second highest level of National Institute of Health (NIH) awards in the country in 2017 (\$2.7 billion), behind first place California (\$3.9 billion) and ahead of third place New York (\$2.4 billion). Given the Commonwealth’s smaller size relative to these nearest competitors, the total NIH awards show how Massachusetts ‘punches above its weight’ when it comes to healthcare R&D.

While a top performer on many metrics, Massachusetts does face some headwinds. The *Index* also shows several areas where Massachusetts needs to improve relative to other Leading Technology States (LTS) and national trends facing Massachusetts and most LTS, including:

 **Venture Capital Investment Lags U.S. Growth:** Venture capital (VC) investment in Massachusetts grew by 5% in 2017 to a total of \$6.9 billion, but the Commonwealth’s share of U.S. VC investment fell 7.9%.

 **Increasingly Long Commute Times:** The average commuter in a Large Metro area (250,000+ commuters) in Massachusetts spends 253 hours a year commuting, up 19 hours from 2012. Massachusetts has the 5th longest commute time among the LTS.

 **Middling Innovation Economy (IE) Job Growth:** From 2016-2017, Massachusetts Innovation Economy jobs increased by 1.5%, similar to the Commonwealth’s overall rate of job creation of 1.3%. Massachusetts placed 8th in the LTS on this measure.

This year’s *Index* contains a Special Analysis section highlighting education and training efforts focused on preparing people to succeed in a future of work driven by increasingly intelligent and capable machines (pages 6-16). MassTech asked four leaders from the business, youth education, higher education, and adult education fields in Massachusetts to provide commentary on how education and training organizations around the state can improve their offerings to meet the needs of the economy in the decades to come.

For this edition, continued from 2016 and 2017, the *Index* has kept the expanded field of LTS, comparing Massachusetts with 14 other states.

All of the 2017 LTS made the list in 2018.

We have included profiles for each state that list key data points, economic sectors, major universities & research institutions, and a selection of representative innovation economy companies.

We have also provided three examples of unique economic development initiatives that impact and support the development of the Innovation Economy for each LTS member (pages 56-62).

| MASSACHUSETTS  |
|--|
| <p><b>2017 POP: 6,859,819</b><br/> <b>2017 GDP (\$M): \$456,176</b><br/> <b># of Innovation Economy (IE)</b><br/> <b>Jobs: 1,319,706</b><br/> <b>% of IE Jobs: 37.3%</b></p>   |
| KEY SECTORS  |
| <ul style="list-style-type: none"> <li>• Biopharma &amp; Medical Devices</li> <li>• Computer &amp; Communications Hardware</li> <li>• Defense Manufacturing &amp; Instrumentation</li> <li>• Financial Services</li> <li>• Healthcare Delivery</li> <li>• Postsecondary Education</li> <li>• Scientific, Technical, &amp; Management Services</li> <li>• Software &amp; Communications Services</li> </ul> |

| 2018<br>Leading Technology States |
|-----------------------------------|
| California                        |
| Connecticut                       |
| Florida                           |
| Illinois                          |
| Massachusetts                     |
| Minnesota                         |
| New Hampshire                     |
| New Jersey                        |
| New York                          |
| North Carolina                    |
| Ohio                              |
| Pennsylvania                      |
| Rhode Island                      |
| Texas                             |
| Wisconsin                         |

## MASSACHUSETTS PERFORMS WELL



### Economic Impact

- Massachusetts has higher wages than the average LTS in all occupational groups aside from social services.
- Massachusetts' median household income is more than \$10K higher than the LTS average and is 6th in the U.S.
- Massachusetts' output per capita is higher than the LTS average in all key sectors except Advanced Materials.



### Research

- Massachusetts is a national leader in R&D, with \$28.7 billion in R&D investment in 2015. This places the Commonwealth 2nd nationally, behind only California, and 1st among the LTS as a percent of GDP.
- Massachusetts is 1st nationally in utility patents granted per capita and 1st nationally in tech patents per capita.



### Technology and Business Development

- Business Formation: Massachusetts had strong growth in both business establishments, with a net gain of 2,620; and start-ups initiated from universities, hospitals, and research centers; where it was 2nd in the LTS behind California.
- Massachusetts received \$270M in Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) awards in 2017, the second highest amount in the U.S. and placing the Commonwealth first as a percentage of GDP.



### Capital

- Massachusetts had 20 IPOs in 2018, 2nd most behind California, and was 4th in the LTS in both companies acquired and acquiring companies.
- Venture Capital investment in Computer Hardware & Services and Software both had strong growth from 2016 into 2017, at 31% and 19% respectively.

## MASSACHUSETTS NEEDS IMPROVEMENT



### Economic Impact

- Massachusetts lags many LTS members in innovation economy employment growth, falling 8th out of 15.
- Massachusetts falls behind many LTS members in exports as a percentage of GDP, coming in 12th, with Canada, Mexico, and China as the largest export destinations.



### Talent

- Massachusetts' housing costs are high, with the third highest FHA Housing Price Index in the nation and over a quarter of homeowners and almost half of all renters burdened by housing costs.

## SPECIAL ANALYSIS

### THE FUTURE OF WORK: How Organizations around Massachusetts are Preparing Students and Employees for the Jobs of the Future



## SPECIAL ANALYSIS

### The Commonwealth's Most Valuable Resource:

Massachusetts is rightfully known for its high-quality workforce and the strength of its talent pipeline. The Commonwealth is home to a network of world-class higher educational institutions that stretches statewide and includes major public and private research universities, small liberal arts colleges, and community colleges. These schools produce a combined 121,000 graduates annually, 22,500 of which are Science, Technology, Engineering, and Math (STEM) graduates, placing Massachusetts as the top state per-capita in both measures (NCES, 2016).

While employers choose Massachusetts for many reasons, the Commonwealth's well-educated workforce and robust talent pipeline is one of the biggest, a factor which has helped keep the state's economy competitive even as individual industries rise and fall. That said, business leaders and education providers in Massachusetts must remain at the forefront of innovation when it comes to training and education, as disruptive technologies such as artificial intelligence (AI) and robotics reshape jobs and entire industries. Massachusetts has been well served by its traditional education infrastructure in the past, but businesses and non-profit training programs will need to become larger actors in providing education and training pathways if the Commonwealth is to continue its strong track record of adapting to economic shifts.

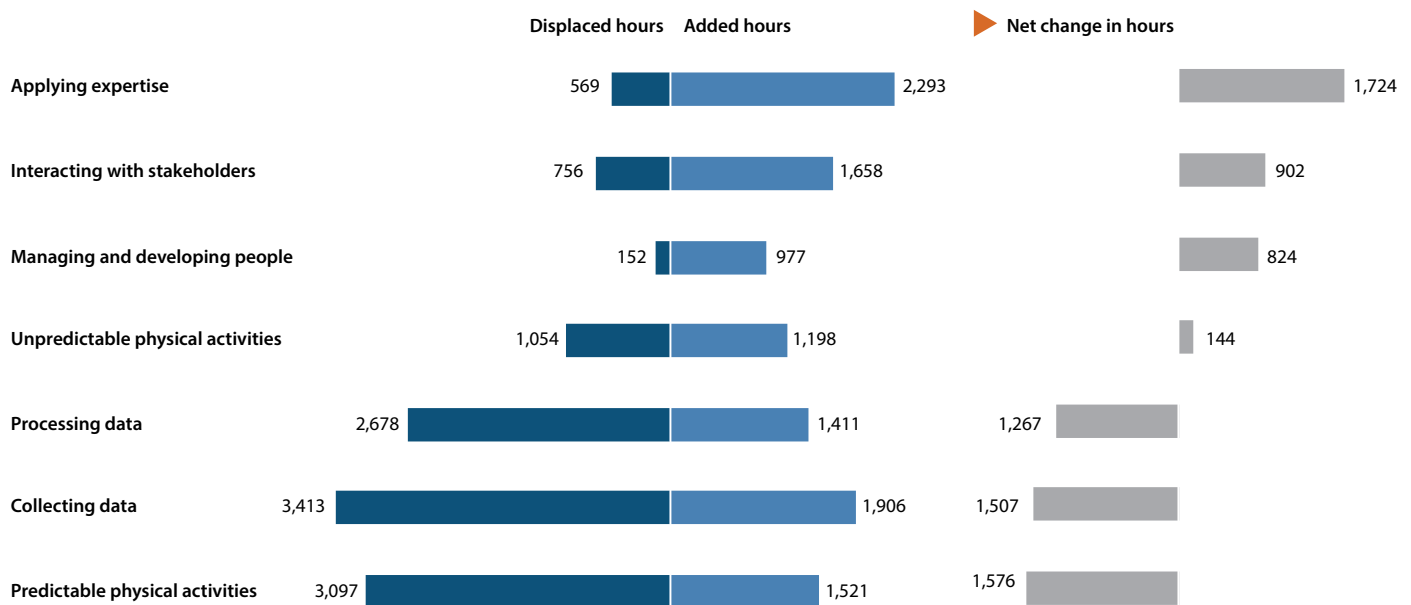
### Historical Lessons and a Look at the Future:

Textile mills, one of the earliest mass manufacturing industries in Massachusetts, represented a disruptive innovation in their day, powered by advances in machinery which allowed for greatly increased productivity and lower costs, resulting in booming demand for textiles. Cities such as Lowell and Lawrence in the Merrimack Valley owe their existence to this disruption. Many new jobs were created as this disruptive technology took hold, creating demand for machine operators, maintenance technicians, engineers, and new managerial positions, jobs which required very different skillsets from the artisans who were previously employed in weaving.

McKinsey Global Institute estimates that half of all current work activities could be automated using currently demonstrated technologies, but that only 5% of jobs are at risk of being entirely automated (McKinsey Global Institute, 2017). Despite the automation of many tasks formerly performed by people, human involvement in the economy does not appear likely to diminish. Just as the advent of textile mills and power looms decimated weaving employment while at the same time spurring new factory jobs, today's disruptive technologies will create previously unheard of positions, and not just in software and hardware engineering. McKinsey expects one-third of the U.S. workforce (54 million people) will change occupations by 2030 due to automation and up to 9% of the workforce will be employed in occupations that do not exist today (McKinsey Global Institute, 2017).

#### Activities within all occupations will shift: New work will involve more application of expertise, interaction, and management

Total hours by activity type, Germany example<sup>1</sup>, 2016–30 (midpoint automation, step-up demand)  
Million FTE hours



"Jobs Lost, Jobs Gained: Workforce Transitions in a Time of Automation," McKinsey Global Institute, December 2017

NOTE: Some occupational data projected into 2016 baseline from latest available 2014 data. SOURCE: US Bureau of Labor Statistics; McKinsey Global Institute analysis.

<sup>1</sup>See appendix page 63.

## SPECIAL ANALYSIS

The great challenge for Massachusetts is to keep the Commonwealth's workforce and talent pipeline adaptable to the jobs and industries of the future. Disruptive technologies are already having an impact on how employers think about their hiring needs, with an increasing level of convergence between the talent needs of both tech and non-tech companies (Chamberlain, 2018). While Massachusetts has adapted well to previous disruptions, the pace of change is now faster (McKinsey Global Institute, 2017) and the need for innovation more urgent. Efforts to address this challenge are already underway at universities, businesses, and community organizations across the Commonwealth, so better understanding and dissemination of these efforts will help ease this transition.

To that end, the *Index* has invited 4 commentators from organizations around the state to share their thoughts on how education and training programs must be improved to keep the Commonwealth's workforce globally competitive. Our commentaries fall into the following categories:

- Adult (Continuing Education/Retraining): Marybeth Campbell, Executive Director, SkillWorks
- Higher Ed (Universities, Colleges, and Community Colleges): Robert E. Johnson, Ph.D., Chancellor, University of Massachusetts Dartmouth
- Business/Employers: John O'Leary, Manager, Deloitte Services LP, and State and Local Government Research Leader, Deloitte Center for Government Insights
- Youth (K-12 Education): Cari Perchase, Principal, Marshall Simonds Middle School, Burlington, Massachusetts

Previous editions of the Special Analysis have looked toward the past to gain insights into our current economy, looking at data analysis trends or each region's innovation strengths. However, this is the second year in a row where the *Index* is taking a forward-looking approach, following on last year's look at the issue of technologic convergence. While the strength of the *Index* has been on gleaning insights from past data and historic trends, this section will continue to be a space where we will tackle emerging issues and engage the Massachusetts innovation community at-large on predictions, responses, and insights on the advances that the quickening pace of innovation and advancement is having on the Commonwealth's economy and its workforce.



## SPECIAL ANALYSIS: Commentary

### ADULT (CONTINUING EDUCATION/RETRAINING)

**Marybeth Campbell, Executive Director, SkillWorks**



There has been much talk lately about the ‘future of work’ and what we need to do to prepare for the changing nature of work. The future is now. Today’s unprecedented tight labor market, anticipated attrition due to baby boomer retirements and historic economic growth has created a never before seen tension between the demand to fill jobs and the lack of supply ready to fill those jobs.

What we require today is a next generation solution that can launch our untapped talent into new opportunities at a much faster, more direct rate while also supporting and leveraging the long term success of both workers and their employers via advancement, retention, and strong employment practices. The good news is we don’t have to create that solution from scratch.

The opportunity and challenge to deepen and diversify our talent pool is equal parts on the employer, the jobseeker and our training and education institutions if we are to support and sustain a workforce that keeps us competitive as a world-wide hub for innovation. Our training and education programs must keep pace with our changing economy by building strong employer relationships and deeper internal business acumen. We need more access to internships for students from high school through post-secondary to expose young people to careers, develop job skills and create connections with potential employers. Employers should consider opportunities to improve employment practices not just through higher wages and benefits that may attract talent, but by also tapping talent from sources that have been traditionally overlooked, such as young adults, immigrants and persons with disabilities.

Lastly, we need to support a more seamless, effective means for employers to find talent from traditional and nontraditional pipelines and there are many examples of how to build those effective practices right here in Massachusetts. The Boston Foundation and SkillWorks, a local workforce funder collaborative, are working together to make investments in our training and education infrastructure, especially in the nonprofits that have expertise in working with diverse but untapped talent sources. They have invested in programs like Year Up, Resilient Coders and Hack.Diversity that offer internships and job opportunities for young adults who might otherwise fall outside traditional hiring pipelines in our 4-year institutions. The Boston Private Industry Council and SkillWorks also launched TechHire Boston, an employer-led consortium of IT/Tech companies working together to increase the supply and diversify our talent pipeline for the IT/Tech sectors.

Statewide there are nonprofit programs such as UTEC in Lowell and ROCA in Chelsea working with youth and young adults, and robust career technical high schools across our state working on programs like healthcare and advanced manufacturing and much more. Adult-based programs such as Jewish Vocational Services and BEST Hospitality Training Center in Boston work directly with employers to tap immigrant and refugee pipelines for the hospitality and other sectors. In Western, MA the Hampden County Sheriff’s Department has a strong program focused on re-entry pipelines. There are many nonprofit programs across the Commonwealth that have evidence based and impactful programs that, with greater more sustained resources, can elevate new streams of talent into employment.

The response to the call for the future of work is to invest and expand now in programs that are responsive to employers, build capacity to meet labor needs and prepare a diverse set of jobseekers for jobs so we best position ourselves proactively against any and all opportunities presented to us today, tomorrow and for the future.

*Marybeth Campbell is the Executive Director of SkillWorks and can be found at [skill-works.org](http://skill-works.org).*

## SPECIAL ANALYSIS: Commentary

### HIGHER ED (UNIVERSITIES, COLLEGES, AND COMMUNITY COLLEGES)

**Robert E. Johnson, Ph.D., Chancellor, University of Massachusetts Dartmouth**



Today's graduates will face a hyper-connected, rapidly changing economy and looming global challenges. Over the course of their lives, college graduates will hold nearly 20 jobs in five different industries, including industries that do not yet exist. Within 15 years, nearly half of today's jobs will be lost—not to overseas labor markets or immigrants, but to machines.

The agile university **rewards value creation**. The primary objective of higher education is to impart knowledge and to teach students to think critically and solve problems. At Morehouse College, I received a wonderful liberal arts education, but I was not intentionally taught to create new value for my future employer or my community. At UMass Dartmouth, we are developing a “boot camp” that will guarantee our students graduate with a value creation mindset that they will take with them from job to job, from industry to industry.

So, as we consider the well-deserved innovation ranking of Massachusetts, we must be ever-vigilant. Retaining our enviable standing will require that our higher education institutions, and those who govern them, strive every day to unleash the creative talent within them.

*Robert E. Johnson is the Chancellor of the University of Massachusetts Dartmouth and can be found at [umassd.edu](http://umassd.edu).*



If Massachusetts is to retain its leadership position in innovation, it is no longer good enough for higher education institutions, both public and private, to meet the needs of present-day people and their employers. We must anticipate future needs; failure to do so is educational malpractice.

We must equip college students to thrive and compete for jobs that do not yet exist, using technologies not yet invented, to solve problems not yet identified. That means giving them more than a skillset. We need to give them an agile mindset underpinned by a sense of resilience and optimism. These will drive learners to be entrepreneurial and innovative, constantly adding value in the workplace and strengthening the civic fabric of their community.

Most of our colleges and universities are not prepared to meet this challenge. In order to prepare students, they must begin by transforming themselves into agile universities.

The agile university **creates cultures that embrace and reward risk taking**. They value their students' future more than their old traditions. At UMass Dartmouth, we recently set aside our traditional teacher training program to work with Fall River Public schools to develop a teaching corps equipped to add value in a challenging urban setting. We structured the financial aid program to incentivize graduates to stay in Fall River schools for four years, confronting the teacher retention problem facing urban schools across the state and country.

The agile university **accelerates faculty creativity and innovation**. Today, both in the private and public sector, development of academic programs to meet emerging demands of students and the needs of employers can take years. The economy is moving too fast for that. We will soon confront this challenge at UMass Dartmouth by identifying people in our region who began but never finished college, and then offering them a new “academy” that helps them complete their program and start adding new value to the communities.

## SPECIAL ANALYSIS: Commentary

### BUSINESS/EMPLOYERS

#### John O'Leary, Head of State and Local Government research for the Deloitte Center for Government Insights



**Deloitte.**

The concern of many is that robots will take away our jobs. The reality is that if we can embrace a new vision of the Future of Work, we will create a future made brighter by technology. Our region is particularly well positioned to benefit from the tech revolution, but to do so will mean rethinking how firms – from start-ups to Fortune 500 companies—source and manage human talent.

Technologies such as artificial intelligence, 3-D printing, and virtual reality are enabling machines to do more of the work in producing services and products. The aspect of this change that gets the big headlines, of course, is the question of headcount. While technology will replace some jobs that largely encompass repetitive tasks, technology also is creating new opportunities for workers.

Consider the case of ATM machines. In 1980, as ATMs were just being introduced in earnest, there were roughly 500,000 bank tellers in America. Twenty years later, after 400,000 ATMs had been installed, there weren't fewer bank tellers—there were more, as banks opened more branches and introduced more services. This "automation paradox" helps explain why we experience very low unemployment despite increasing technology.

Critically, the Future of Work should prompt companies to rethink how they manage their human talent. With machines doing the mundane work, humans increasingly will do the tasks that require creativity, collaboration, and the tapping of specialized skills. There will be a critical need to not only secure, develop and continuously re-educate internal talent, but also the ability to find, in quick-strike fashion, the discrete capability needed to move a project forward, whether related to algorithms, data analytics, blockchain, and so forth. Technology will also enable remote work, allowing this talent to come from anywhere. As noted by a recent Capital H Blog by Deloitte's human capital practice, "the best talent may no longer be where companies exist, meaning that managing a more broadly dispersed workforce will be a competitive differentiator."

This may be good news for Massachusetts' high-tech community. While it will certainly face its share of challenges, they nevertheless may be ahead of other types of companies in developing a more collaborative and virtual workforce. With a rich history in education and tech innovation, Massachusetts may have fewer cultural barriers in how workers share knowledge, and how ideas flow up, down and across the organization.

Whether formally or informally, many Massachusetts companies—tech companies in particular—are already in a mode of continuous learning and quite adept at tapping into "gig" workers with specialized skills. In the year ahead, look for Massachusetts' companies to continue to innovate their management strategies, especially around how they integrate the human workforce with new cognitive technologies. As our machines grow smarter, the people who use them must grow smarter as well—which means investing in people. Such strategies could feature the use of people analytics, career path development, learning and development, even community involvement. New approaches that encourage an entrepreneurial thinking way of how things get done while adding the structure, protocols and documentation that ready organizations for new levels of maturity.

As Future of Work takes hold in the broader economy, there may be a distinct opportunity for Massachusetts' technology companies to not only be known for creating amazing new products and services, but also for how to work with people.

Innovation, after all, doesn't just involve technology. It means unleashing human talent to take advantage of the amazing new tools that are being developed here in Massachusetts every day.

*John O'Leary heads up State and Local Government research for the Deloitte Center for Government Insights. John has served in several senior leadership roles for the Commonwealth of Massachusetts, including Chief Human Resource Officer. He was a distinguished research fellow with the Kennedy School of Government at Harvard University and is the co-author of the best-selling book "If We Can Put a Man on the Moon: Getting Big Things Done in Government." John can be found at [deloitte.com](http://deloitte.com).*

## SPECIAL ANALYSIS: Commentary

### YOUTH (K-12 EDUCATION)

#### Cari Perchase, Principal, Marshall Simonds Middle School, Burlington Public Schools



I can remember the first time I saw a computer in school as a child. I was in middle school. It was the mid 1980s, and we were in an art class.

In high school, instead of the traditional typing class (which was still being offered), I chose to take a basic programming class, where I copied pre-written programs into the computer. In 1991, I brought a word processor with me to college to type my papers. When I first started teaching, there were two computer labs in the building and students would go once or twice a week to learn how to word process and how to do internet searches. In a few short years, two computer labs multiplied to having two to three computers in every classroom. Technology was at a premium; there was much enthusiasm, from teachers and administrators, to use technology to support learning. The limited access to the technology was often the barrier to integrating technology on a daily basis. If we could reserve the portable projector, then we could use a PowerPoint to convey information to students.

In 2010, I became a public school administrator. As I reflect back on my experience, it is amazing at how much the access to technology has changed in a relatively short time. We, students and adults alike, hold the world in the palm of our hand, by the way of a smartphone. The convergence of a sequence of events, improved infrastructures, advancements in mobile devices (Chromebooks and iPads), and a technology integration support model, resulted in our students having more access to technology throughout the school day. The traditional "Computer Class" or "Technology Class", where students learned Microsoft Word, Excel, and PowerPoint, became outdated. As more devices became available, more students became proficient users due to access in and out of school, and more teachers integrated technology into their daily lessons, the skills once learned in isolation became a part of every class.

At Medway Middle School, we were fortunate to receive a grant, which kickstarted the transition of our technology education program. We started by offering students in grades 7 and 8 the opportunity to take one of two Project Lead the Way (PLTW) offerings, Automation and Robotics or Design and Modeling, instead of the traditional technology education course. Each year, we saw an increase in enrollment and many students elected to take the two-year sequence. We observed students who were more engaged and learning different skills than in the past; they were collaborating, problem-solving, and taking risks. Students who struggled in the traditional classroom, excelled in tasks that were hands-on, with real-world applications. Although we saw an increase in the number of students, we did see a disparity in the number of female students electing the PLTW courses. This helped us see the need to provide all students, not just the ones who may have an interest or a family who knew the value of the a less traditional technology class, the opportunity to participate in a pre-engineering program. Once the 7th and 8th grade course sequence was implemented, the App Creator course was implemented in 6th grade.

This year, I transitioned to a different district and I am the proud principal of Marshall Simonds Middle School in Burlington. Burlington Public Schools have been leaders in technology in education and was the first public school district to implement a 1:1 iPad initiative in kindergarten through grade 12. This year, our school is reviewing the master schedule and developing a program of studies. As we continue to explore different schedule models, making sure our students have opportunities to learn 21st century skills, including coding, problem-solving, using the design process, and engineering is a priority. It is our intention to have a coordinated 3-year course sequence that will include computer science, technology, and engineering. We do not yet have all the answers and we are always looking to the future, which is undetermined.

*Cari Perchase is the Principal of the Marshall Simonds Middle School and can be found at [burlingtonpublicschools.org/schools/marshall-simonds-middle-school](http://burlingtonpublicschools.org/schools/marshall-simonds-middle-school).*

## SPECIAL ANALYSIS: Training Organization Profiles

Organizations around the state are already working on ways to prepare people for success for a future of work alongside increasingly capable and intelligent machines. On the following pages we have highlighted several examples addressing this issue from Western Massachusetts to Boston as well as for K-12 students and adults looking for a career change.

### YOUTH/K-12 EDUCATION PROGRAMS

#### Advanced Functional Fabrics of America (AFFOA) High School Curriculum



Recent breakthroughs in fiber materials and manufacturing processes have allowed design and production of advanced functional fabrics that see, hear, sense, communicate, store, and convert energy, regulate temperature, monitor health, and change color. These technologies are positioned to create high-value products which can revitalize domestic textile manufacturing and generate high-quality jobs. However, manufacturing fabrics with advanced capabilities requires a workforce with new skill sets.

AFFOA established a partnership between Greater Lawrence Technical School (GLTS), MIT – Edgerton Center, and AFFOA HQ to develop technical high school curriculum of Advanced Functional Fabrics. This program is aimed at developing the next generation of multi-skilled manufacturers by exposing students to a myriad of technical skills in the context of manufacturing advanced functional fabrics.

The objective of the partnership is to develop an introductory Advanced Functional Fabrics (AFF) Career Pathway curricula at the technical high school level within GLTS' Machine Technology and STEAM Innovation Program that can be replicated in other venues. The curricula develops and brings together skill-sets that crosscuts many industries inside and outside of advanced functional fabrics, therefore providing students with multiple industry career pathways. The initial curriculum was rolled out to students in October 2018. The curricula continues to be developed, and by the end of 2019 will include all of the following elements:

- How Advanced Functional Fabrics are made (e.g. equipment, processes, materials).
- Introduction to product and market applications and design of fiber, textile and products.
- Project-based coursework that enables students to design and prototype new product and market applications that lead to better lives for our citizens and society.
- Build capacity in students to go from an idea phase, to prototyping and communicating ideas in production improvement, to physical production and testing of the product.

AFFOA has leveraged funding from the Commonwealth to secure equipment for Advanced Functional Fabrics necessary equipment needed to be placed at GLTS. By equipping GLTS with additional equipment and expertise they become an extension trainer for technical high school students.

Midway through 2019, AFFOA, MIT, and GLTS will begin the process of expanding the reach of the AFF curricula to other interested parties, including and not limited to: technical high schools, general education K-12, community colleges, and Fabric Discovery Centers needing training and development for their staff. In addition to GLTS curricula development, AFFOA will also partner with program providers such as NuVu Studios, and MIT and Fashion Institute of Technology (FIT), to scale the reach of the AFF curriculum to take different shapes and forms such as: two week intensives, open studio sprint models, entrepreneurial boot camps, etc.<sup>2</sup>

<sup>2</sup><http://go.affoa.org/>

## SPECIAL ANALYSIS: Training Organization Profiles

### YOUTH/K-12 EDUCATION PROGRAMS

#### The Latino STEM Alliance



The Latino STEM Alliance is a program focused on expanding access to STEM education and promoting STEM career interest in Boston and Gateway Cities across Massachusetts through education integrated with technology. It partners with inner-city schools and local community organizations to provide both in-class and after-school STEM learning, along with partnerships with universities and employers to bolster the program and provide examples of STEM careers.

The Latino STEM Alliance starts by showing how technology can be integrated into the standard classroom curriculums in elementary school. For middle school, it offers supplies, teacher training, and a robotics curriculum to expand upon the foundation established earlier. The program includes lessons on how to design, build, program, and debug robots with a parallel focus on developing important skills like critical thinking and teamwork. At the end of the year there is a robotics competition for students, giving them a chance to display what they've learned and be inspired by others.

While the focus has been entirely on elementary schools and middle schools, there is a pilot high school program during the 2018-2019 school year. The program, which currently exists in Boston, Lawrence, Haverhill, and Chelsea, is estimated to reach 1,200 elementary and middle school students.<sup>3</sup>

#### Science from Scientists

Founded in 2002, Science from Scientists (SfS) helps bolster interest and proficiency in STEM fields for elementary through middle school students. Originally founded in Boston, the program expanded to the Bay Area in California in 2014, Central Massachusetts in 2015, and to Bloomington, MN, in 2016.

SfS runs in-school hands-on STEM lessons by partnering with schools serving grades 3 through 8. A pair of scientists then goes to each school every other week for the entire school year, working with the teachers each visit to select from over 90 modular lessons to run. In 2018 they worked with over 70 schools to impact over 9,000 students, with 92% of teachers surveyed saying they saw real passion for science developing in their classrooms, and 82% of students surveyed reporting increased interest in science. They also cited real impact on both science quizzes and tests, including the MCAS. In addition to their in-class lessons they also offer assistance to teachers and students from grades 3-12 in running science fairs, offering help in everything from administration, to tutoring students, and even judging the fair.

SfS also offers the Scientist-Teacher Partnerships (STP) program, helping teachers be more comfortable with STEM classes and activities. STP is broken into three parts: workshops for the teachers, modeling and practice of the lessons, and time to assimilate and integrate the lessons into their unit plans.<sup>4</sup>

<sup>3</sup><https://www.latinostem.org/>

<sup>4</sup><https://www.sciencefromscientists.org/>

## SPECIAL ANALYSIS: Training Organization Profiles

### ADULT/CAREER CHANGE PROGRAMS

#### Tech Foundry



Tech Foundry is a Western Massachusetts IT training program that runs for 14 weeks during which participants meet five days a week totaling 20 hours per week. The Springfield-based program generally meets 12:30-5PM and has four different technological focuses: networking, data analysis, programming, and computer troubleshooting.

The program started to come together in April 2013 and the first class began in July 2014, where it was at first a six-week full-time program for high-school seniors. In September of 2014 it changed to a nine month afterschool program of five hours per week, and by 2016 more than 100 students had been served. In 2015 it then switched to the current form of the program targeting students who have already graduated high school.

Students in the program earn badges after completing three components for each, broken into learn, demonstrate, and application. They start with learning the basics in a hands-on environment, then once finished, move on to a project or assignment to demonstrate their understanding. Finally the application section involves their ability to pass on the knowledge, with options from creating a video tutorial to teaching fellow students.<sup>5</sup>

#### Apprenti Massachusetts



Apprenti, in partnership with the One8 Foundation and the Massachusetts Executive Office of Labor and Workforce Development (EOLWD), has launched its Registered Apprenticeship program in the Commonwealth and is accepting applications for positions in software development and cybersecurity, with more positions to follow.

Unlike many traditional job-training options, Apprenti combines paid on-the-job training and education for placement in a high-skill occupation. Apprenti has worked with the tech industry to identify mid-tier jobs ready to be filled by highly competent people — regardless of educational background (43% of accepted apprentices lack a 4-year degree). The program is open to anyone over the age of 18 with a high school diploma or equivalent certificate.

Apprenti utilizes an online testing platform to identify promising talent who might not have traditional industry credentials and uses a scoring system to match apprentices with employers. Accepted apprentices enter a 2-5 month period of technical training with third party providers, after which they begin a year of paid on-the-job training. During this period, employers have the option of hiring the apprentice into a permanent position before the end of the apprenticeship.

Results so far indicate the program has a successful track record of boosting the skills and earning potential of participants while also meeting employer needs. 73% of apprentices are hired into permanent positions by their employer. The median salary during apprenticeship is \$21,000 more than the median salary for previously employed apprentices. Of those apprentices retained by a company, the median salary increase is +\$42,500. 22% of apprentices were unemployed before entering the program.

For its first cohort of apprentices, Apprenti has secured partnerships with several of the area's top employers, including Wayfair, PTC, Carbon Black, Cengage, and Harvard University IT. These Massachusetts partnerships build on a growing network of national partnerships with companies like Amazon and Microsoft. Apprenti has partnered with two leading organizations supporting the tech industry in the state, the Massachusetts Technology Collaborative (MassTech) and the Massachusetts Technology Leadership Council (MassTLC) in order to ensure tech apprenticeship becomes a foundational part of the Massachusetts tech talent ecosystem.<sup>6</sup>

<sup>5</sup><https://www.thetechfoundry.org/>

<sup>6</sup><https://apprenticareers.org/>

## SPECIAL ANALYSIS: Training Organization Profiles

### ADULT/CAREER CHANGE PROGRAMS

#### SkillWorks



SkillWorks, a public/private partnership between the Boston Foundation and the City of Boston, launched in 2003 to improve workforce development in Massachusetts. The program has four key focus areas: driving demand, deepening capacity, increasing employability, and targeting impact. Since inception, SkillWorks has helped advocate for \$100 million in local, state, and national funding for workforce development and resources. While SkillWorks doesn't have an explicit sector focus, it has targeted several awards at helping people enter Greater Boston's large healthcare and IT industries.

The program has run in three phases so far, with phase I running from 2003-2008, phase II running from 2009-2013, and phase III running 2014-2018. Since the start of the program, SkillWorks has helped over 6,000 job seekers and incumbent workers, 1,700 of them in phase III. In phase III, 68% of job seekers who completed the program found employment, 95% of those are still employed, and 21% saw either wage increases or got a second job after finishing. Of incumbent workers, 68% of those who completed the training got a raise or second job and 98% are still employed.

SkillWorks is currently entering phase IV, running 2018-2021. It outlined goals for the next phase include a 75% rate of completed training for enrolled job seekers and an 85% rate of people earning wages higher than the Boston living wage.<sup>7</sup>

#### Resilient Coders



Resilient Coders recruits young people of color from Boston and the surrounding area to train in software engineering, website development, and app design with a 14-week tech Bootcamp. Resilient Coders strives for social justice through economic empowerment, and in the opportunity for meritocracy in tech by training people of color for high-growth careers and connecting them with jobs. It provides this training free through the support of its Bootcamp Partners: Cambridge Innovation Center (CIC), Microsoft, Google, the Boston Foundation, the Amelia Peabody Foundation, John Hancock, The Lenny Zakim Fund, BNY Mellon, Bank of America, State Street, the Philanthropy Connection, and the Wellington Management Foundation.

Before each Bootcamp, Resilient Coders runs two hackathons, from which it recruits its students; for 14 weeks, daily, this select cohort of early-career individuals meet to receive direct instruction and begin building their own games and applications. By the end of their time with Resilient Coders, they have solid proficiency in HTML, well-crafted and responsive CSS, JavaScript, jQuery, React, Node, and Mongo DB. By the time they graduate, students will have demonstrated proficiency in semantically structured markup, inheritance and specificity, accessibility, progressive enhancement, responsive design, and effective use of functions, methods, and variables. They will have built, and pushed to GitHub, work that showcases these skills, including a game or application in vanilla JavaScript. Besides preparing students for full-time work as engineers, every student must also procure, service, and invoice their own freelance client to be able to self-employ.

After graduation, some students join Resilient Lab, and others go right into an Apprenticeship leveraging their new skills. Resilient Lab is a digital design and development agency that employs recent graduates to build websites and applications for clients. Engineers at Resilient Lab have worked on products for companies like Wanderu, City Awake, and HelpScout.

Graduates have gone on to work for companies including Wellington, Fidelity, DigitasLBI, SapientRazorfish, the City of Boston's Department of Innovation and Technology, Boston University, the Boston Globe, and tech startups such as RStudio, Veson Nautical, Gravyty, Bison, and many others.<sup>8</sup>

<sup>7</sup><http://www.skill-works.org/>

<sup>8</sup><http://www.resilientcoders.org/>

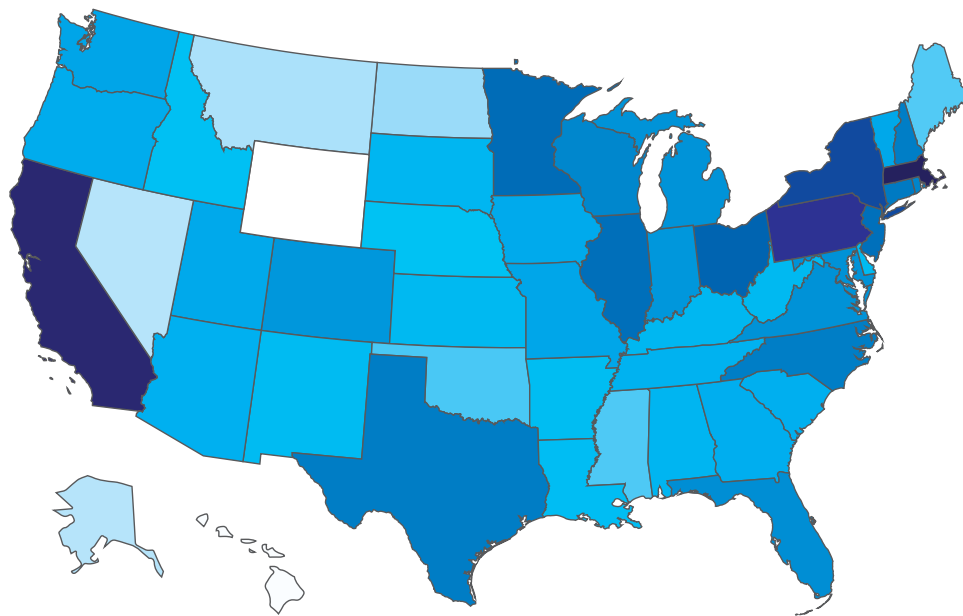


## LEADING TECHNOLOGY STATES (LTS)

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 compose the **Innovation Economy (IE)** 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.

### ELEVEN KEY INNOVATION ECONOMY SECTORS

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



| 2018 Leading Technology States (LTS) |                     |
|--------------------------------------|---------------------|
| State                                | LTS Selection Score |
| Massachusetts                        | 2.27                |
| California                           | 2.16                |
| Pennsylvania                         | 1.99                |
| New York                             | 1.83                |
| Ohio                                 | 1.62                |
| Minnesota                            | 1.55                |
| Illinois                             | 1.52                |
| New Jersey                           | 1.51                |
| Connecticut                          | 1.43                |
| Texas                                | 1.40                |
| North Carolina                       | 1.39                |
| New Hampshire                        | 1.39                |
| Rhode Island                         | 1.34                |
| Wisconsin                            | 1.32                |
| Florida                              | 1.26                |

### THE METRICS USED TO SELECT THE 2018 LTS

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

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

Defined as the percent of a state’s workers who are employed in the Innovation Economy relative to the national percentage and is a measure of the overall intensity of a state’s Innovation Economy.

#### Total Innovation Economy employment

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 15.

To learn more about the selection methodology for the LTS, see page 63.

# ECONOMIC IMPACT - Indicators 1-5

## Why are these Indicators Significant?

### **Indicator 1: Industry Sector Employment and Wages - pp. 19-20**

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

### **Indicator 2: Occupations and Wages - pp. 21-22**

The Innovation Economy supports 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 has tripled as a percentage of the workforce in the last century, so anything but continued employment growth would indicate a shift away from the norm. An important difference between this indicator and the previous one is that Industry Sector Employment and Wages tracks total employment in an industry for all job types found within it, while Occupations and Wages tracks employment by job type across all industries.

### **Indicator 3: Household Income - p. 23**

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 increased purchasing power and higher living standards. The distribution of income also provides an indication of which Massachusetts economic groups are benefiting.

### **Indicator 4: Output - p. 24**

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.

### **Indicator 5: Exports - pp. 25-26**

Nearly all of Massachusetts' top 25 exports are produced within the Innovation Economy. Manufacturing exports are an indicator of global competitiveness and selling into global markets can bolster growth in sales and employment. In addition, diversity in export markets and products can offset domestic economic downturns. Manufacturing represents approximately ten percent of all private sector jobs in the state and approximately 20% of manufacturing jobs in Massachusetts are tied to exports. In Massachusetts, 111,000 jobs are supported by manufacturing exports, compared to 6.2 million nationwide.

**For more information visit: [masstech.org/index](https://masstech.org/index)**

## INDICATOR 1: Industry Sector Employment and Wages

### How Does Massachusetts Perform?

Innovation economy employment grew faster than overall employment in 10 of the 15 LTS from 2016-2017. The fastest rates of growth were in Florida, where innovation economy and overall employment grew by 2.4% and 2.2% respectively. In Massachusetts, innovation economy employment grew 1.5%, while the state employment as a whole grew 1.3%. Scientific, Technical & Management Services and Business Services performed the best in terms of employment, growing 5.3% and 2.8% respectively. Overall, there has been a growing trend of jobs shifting from manufacturing sectors to service-oriented sectors. Multiple factors contribute to this, including outsourcing manufacturing to places with cheaper labor, as well as automation and the rising tech industry.

The Computer & Communications Hardware Sector experienced employment decline from 2016-2017 in 9 of the 15 LTS, including Massachusetts. Massachusetts saw three other sectors decline in employment from 2016-2017: Defense Manufacturing & Instrumentation, Advanced Materials, and Finance. Defense Manufacturing & Instrumentation has struggled with reduced federal funding, resulting from Department of Defense cost-cutting measures, and the winding down of major overseas deployments. Of the three sectors where Massachusetts saw declines, two of them also had declines nationally: Computer & Communications Hardware (-0.34%) and Defense Manufacturing & Instrumentation (-0.38%).

### MASSACHUSETTS & ... INDUSTRY SECTOR EMPLOYMENT & WAGES

- **Scientific, Technical & Management Services; Biopharma & Medical Devices; and Software & Communication Services were the three fastest growing sectors in employment from 2012-2017, all over 10%**
- **The three fastest growing sectors in employment also were the #1, #2, and #4 fastest growing sectors for wages as well**

### Employment Change by Key Sector Massachusetts & LTS, 2016-2017

|   | LTS with At Least 2% Growth |            |            |            |            |            |            |            |            | MA Employment | LTS With At Least 2% Decline |             |             |             |              |
|---|-----------------------------|------------|------------|------------|------------|------------|------------|------------|------------|---------------|------------------------------|-------------|-------------|-------------|--------------|
| Advanced Materials                          |                             |            |            |            |            |            |            |            |            | -0.8%         |                              |             |             |             |              |
| Biopharma & Medical Devices                 | CA<br>6.2%                  | NH<br>4.4% | NY<br>4.2% | TX<br>3.2% | MA<br>2.0% |            |            |            |            | 2.0%          |                              |             |             |             | OH<br>-3.7%  |
| Business Services                           | NJ<br>4.6%                  | MA<br>2.8% | TX<br>2.6% | RI<br>2.5% |            |            |            |            |            | 2.8%          |                              |             |             |             |              |
| Computers & Communications Hardware         | RI<br>5.0%                  | NJ<br>4.1% |            |            |            |            |            |            |            | -2.1%         | MA<br>-2.1%                  | OH<br>-2.2% | NY<br>-2.2% | MN<br>-3.0% | CT<br>-5.4%  |
| Defense Manufacturing & Instrumentation     | NH<br>4.5%                  | FL<br>4.2% | IL<br>4.1% | MN<br>2.0% |            |            |            |            |            | -1.6%         |                              |             |             |             |              |
| Diversified Industrial Manufacturing        |                             |            |            |            |            |            |            |            |            | 0.2%          |                              |             |             | RI<br>-2.6% | NY<br>-3.6%  |
| Finance                                     | RI<br>8.6%                  | FL<br>3.6% | MN<br>3.3% | NC<br>2.5% | TX<br>2.1% |            |            |            |            | 0.0%          |                              |             |             |             | NH<br>-10.4% |
| Healthcare Delivery                         | WI<br>4.7%                  | NY<br>3.7% | CA<br>3.1% | MN<br>2.9% | FL<br>2.7% | NH<br>2.2% | TX<br>2.2% | NJ<br>2.0% | PA<br>2.0% | 1.4%          |                              |             |             |             |              |
| Postsecondary Education                     | NC<br>5.8%                  | CA<br>2.2% | TX<br>2.1% |            |            |            |            |            |            | 1.3%          |                              |             |             |             |              |
| Scientific, Technical & Management Services | RI<br>7.1%                  | MN<br>5.8% | MA<br>5.3% | WI<br>4.7% | NC<br>4.4% | CT<br>4.2% | FL<br>4.1% | NH<br>2.5% | PA<br>2.3% | 5.3%          |                              |             |             |             | CA<br>-4.3%  |
| Software & Communications Services          | NH<br>12.5%                 | CA<br>5.3% | FL<br>3.6% | TX<br>2.5% | NC<br>2.2% | MA<br>2.0% |            |            |            | 2.0%          |                              |             | CT<br>-3.8% | NJ<br>-4.0% | RI<br>-14.4% |
| Innovation Economy                          | FL<br>2.4%                  | MN<br>2.2% | TX<br>2.0% | NC<br>2.0% | WI<br>2.0% |            |            |            |            | 1.5%          |                              |             |             |             |              |
| Total Jobs                                  | FL<br>2.2%                  |            |            |            |            |            |            |            |            | 1.3%          |                              |             |             |             |              |

Additional charts for select indicators can be viewed at [masstech.org/index](https://masstech.org/index)

**INDICATOR 1: Industry Sector Employment and Wages**

Wage growth has been particularly strong in Massachusetts Innovation Economy sectors since 2012. Three sectors had double digit wage growth over the period: Scientific, Technical & Management Services (16.9%), Biopharmaceuticals & Medical Devices (16.0%), and Financial Services (12.4%). Scientific, Technical & Management Services had the fastest wage growth and fastest employment growth, while Biopharmaceuticals & Medical Devices had the second fastest employment growth and second fastest wage growth.

**Employment and Annual Average Wage in Key Sectors**  
Massachusetts, 2012-2017

| Sectors                                     | 2012 Employment Total | 2017 Employment Total | % Change in Employment 2012-2017 | 2012 Average Wage | 2017 Average Wage | 2012-2017 % Wage Change |
|---|-----------------------|-----------------------|----------------------------------|-------------------|-------------------|-------------------------|
| Advanced Materials                          | 29,904                | 28,399                | -5.3%                            | \$67,907          | \$70,667          | 3.9%                    |
| Biopharma & Medical Devices                 | 55,030                | 64,757                | 15.0%                            | \$126,433         | \$150,504         | 16.0%                   |
| Business Services                           | 146,298               | 156,487               | 6.5%                             | \$107,207         | \$113,932         | 5.9%                    |
| Computer & Communications Hardware          | 37,097                | 33,494                | -10.8%                           | \$123,052         | \$129,397         | 4.9%                    |
| Defense Manufacturing & Instrumentation     | 37,443                | 35,740                | -4.8%                            | \$111,015         | \$115,057         | 3.5%                    |
| Diversified Industrial Manufacturing        | 39,675                | 38,041                | -4.3%                            | \$80,957          | \$81,436          | 0.6%                    |
| Financial Services                          | 155,038               | 160,157               | 3.2%                             | \$134,546         | \$153,644         | 12.4%                   |
| Healthcare Delivery                         | 351,473               | 390,697               | 10.0%                            | \$69,474          | \$70,362          | 1.3%                    |
| Postsecondary Education                     | 144,681               | 158,667               | 8.8%                             | \$64,511          | \$68,198          | 5.4%                    |
| Scientific, Technical & Management Services | 76,985                | 90,873                | 15.3%                            | \$100,628         | \$121,036         | 16.9%                   |
| Software & Communications Services          | 141,730               | 162,252               | 12.6%                            | \$121,958         | \$134,122         | 9.1%                    |

## INDICATOR 2: Occupations and Wages

### How Does Massachusetts Perform?

Massachusetts had higher average wages than the LTS and the U.S. overall in all occupational categories tracked by the *Index*, with the exception of Social Services, where average wages in Massachusetts were 2.8% lower than the LTS average. The gap between Massachusetts and the LTS in overall wages is even larger than in any specific category. This indicates that Massachusetts has a larger percentage of its employment in high paying occupational categories. Below we highlight certain key occupational categories:

- Business, Financial, and Legal Occupations earn an average wage of \$112,544 in Massachusetts, higher than any other occupational category. This is 8.8% and 14.3% higher than their counterparts in the LTS and U.S. respectively. More than 500,000 workers in Massachusetts hold such an occupation.
- Healthcare wages have continued to grow in Massachusetts and remain higher than the LTS and U.S. as a whole, and is the category that the difference is most similar between the LTS (17.2%) and U.S. averages (20%) and is the only category to be stable in employment numbers.
- Wages for Production in Massachusetts are higher than in the LTS by 8.5%, and 9.2% higher than the U.S. as a whole. However, at an average of \$41,750 in Massachusetts, this is the second lowest wage category tracked by the *Index*.

### MASSACHUSETTS & ... OCCUPATIONS & WAGES

- Higher than average wages in all occupational categories aside from Social Services in the LTS

### Average Wages by Occupation

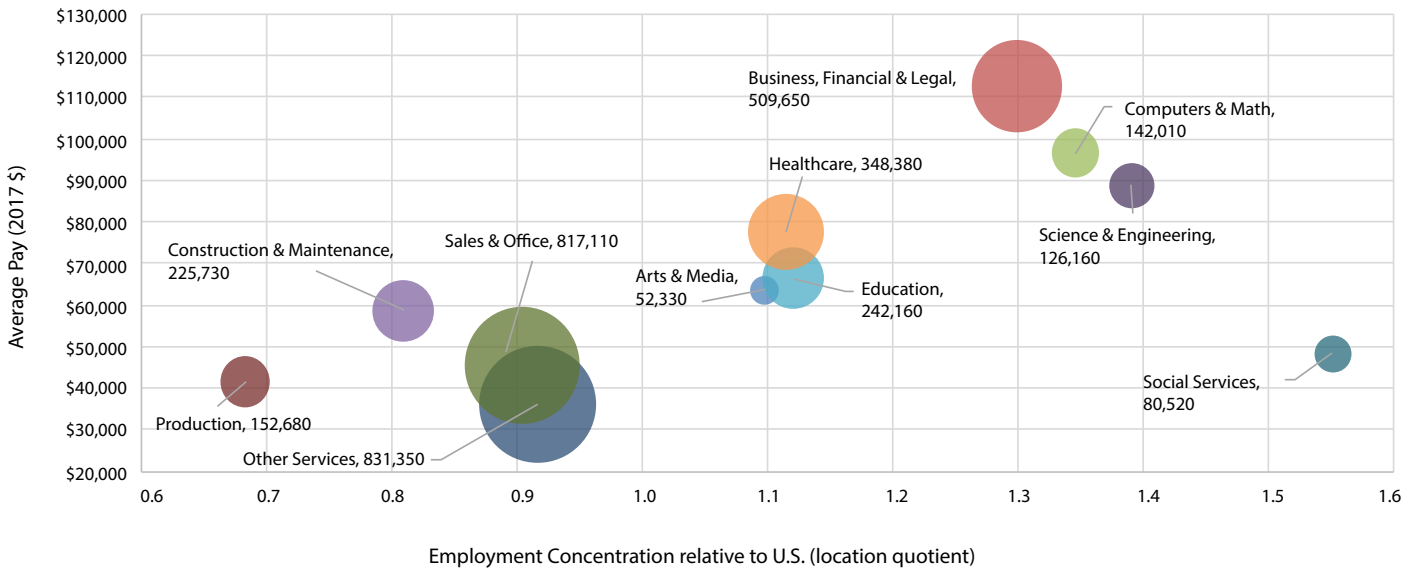
Massachusetts, LTS, & U.S., 2017

| Occupation                 | Average Wage  |           |          |
|----------------------------|---------------|-----------|----------|
|                            | Massachusetts | LTS       | U.S.     |
| Arts & Media               | \$63,640      | \$62,699  | \$58,950 |
| Business, Financial, Legal | \$112,544     | \$103,464 | \$98,495 |
| Computers & Math           | \$96,470      | \$91,953  | \$89,810 |
| Construction & Maintenance | \$58,723      | \$50,476  | \$48,918 |
| Education                  | \$66,430      | \$58,365  | \$55,470 |
| Healthcare                 | \$77,545      | \$66,187  | \$64,642 |
| Other Services             | \$35,887      | \$31,886  | \$31,091 |
| Production                 | \$41,570      | \$38,310  | \$38,070 |
| Sales & Office             | \$45,392      | \$40,544  | \$39,037 |
| Science & Engineering      | \$88,839      | \$84,763  | \$82,487 |
| Social Services            | \$48,360      | \$49,749  | \$48,050 |
| All Occupations            | \$62,107      | \$52,567  | \$50,634 |

Additional charts for select indicators can be viewed at [masstech.org/index](https://masstech.org/index)

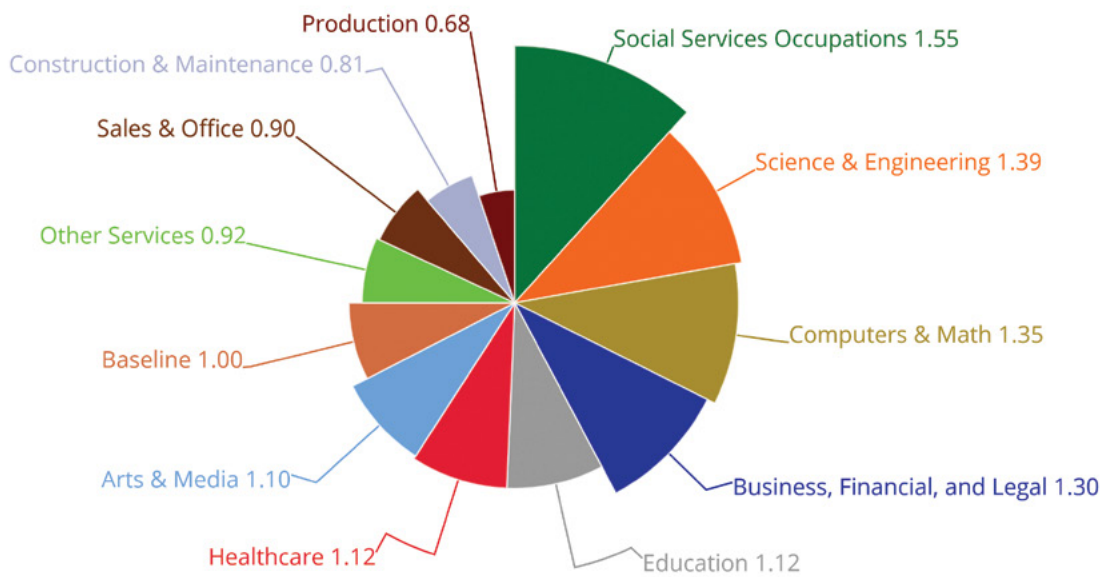
## INDICATOR 2: Occupations and Wages

### Occupations by Total Employment Concentration and Annual Pay Massachusetts, 2017



### Occupations Concentration

#### Massachusetts Location Quotients by Occupation Group, 2017



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

### INDICATOR 3: Household Income

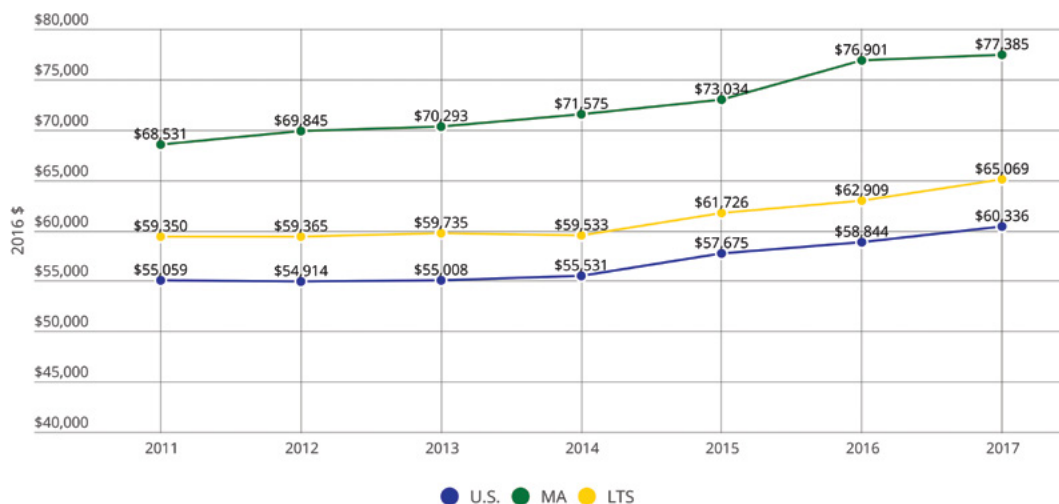
#### How Does Massachusetts Perform?

Massachusetts had the 5th highest median household income in the U.S. in 2017 and a higher median income than the average LTS. Massachusetts has seen growth in median household income in every year since 2012, and has recorded 10.8% median household income growth over the 2012-2017 period, during which the U.S. on average grew 9.9%, and the LTS 9.6%. While median household income in Massachusetts has historically grown faster than the U.S. or LTS on average, from 2016-2017 median household income growth was lowest in Massachusetts at 0.6% while the U.S. average grew 2.5% and the LTS grew 3.4%.

#### MASSACHUSETTS & ... HOUSEHOLD INCOME

- Higher median household income in 2017 (\$77,000) than either the LTS or U.S. average
- Median household income rising faster than either the LTS or U.S. averages since 2012

Median Household Income  
MA, LTS, & U.S., 2011-2017



| Region | 2012     | 2013     | % Change 2012-2013 | 2014     | % Change 2013-2014 | 2015     | % Change 2014-2015 | 2016     | % Change 2015-2016 | 2017     | % Change 2016-2017 | % Change 2012-2017 |
|--------|----------|----------|--------------------|----------|--------------------|----------|--------------------|----------|--------------------|----------|--------------------|--------------------|
| U.S.   | \$54,914 | \$55,008 | 0.2%               | \$55,531 | 0.9%               | \$57,675 | 3.9%               | \$58,844 | 2.0%               | \$60,336 | 2.5%               | 9.9%               |
| MA     | \$69,845 | \$70,293 | 0.6%               | \$71,575 | 1.8%               | \$73,034 | 2.0%               | \$76,901 | 5.3%               | \$77,385 | 0.6%               | 10.8%              |
| LTS    | \$59,365 | \$59,735 | 0.6%               | \$59,533 | -0.3%              | \$61,726 | 3.7%               | \$62,909 | 1.9%               | \$65,069 | 3.4%               | 9.6%               |

Massachusetts has proportionally many more households with incomes above \$100,000 than both the LTS and U.S., and less households with incomes below \$35,000. This could partly explain why incomes have recovered at a faster rate in Massachusetts than elsewhere, since over the last several decades higher level income households have seen larger gains in household income than the population as a whole. This is largely due to increasing returns to college education and Massachusetts having a high relative proportion of degree holders. As such, the state should see larger income gains than would be experienced elsewhere. New Jersey, another highly educated state, is the only state among the LTS to have a higher median household income than Massachusetts.

Percentage of Households by Income Level  
Massachusetts, LTS, & U.S., 2017

| Household Income   | MA     | LTS Average | US     |
|--------------------|--------|-------------|--------|
| Under \$35,000     | 24.50% | 27.69%      | 29.40% |
| \$35,000- \$99,999 | 35.90% | 41.84%      | 42.80% |
| Above \$100,000    | 39.40% | 30.47%      | 27.80% |

Additional charts for select indicators can be viewed at [masstech.org/index](http://masstech.org/index)

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

## INDICATOR 4: Output

### How Does Massachusetts Perform?

Between 2012 and 2017 output increased in most of the Commonwealth's Key Sectors with the exceptions of Defense Manufacturing & Instrumentation, Diversified Industrial Manufacturing, and Advanced Materials. Three Key Sectors experienced output growth above 20% from 2012-2017: Software & Communication Services (24.3%), Biopharmaceuticals, Medical Devices & Hardware (25.5%), and Scientific, Technical & Management Services (21.7%). In absolute terms, Software & Communication Services, the largest of the Key Sectors in terms of output, is a clear driver of growth in the economy as its output increased \$7.9 billion from 2012-2017.

Massachusetts' position as a leader in Biopharmaceuticals & Medical Devices has been further strengthened by the relocation of headquarters or major facilities of pharmaceutical companies to the Boston area. There are now over 2,000 establishments in the Biopharmaceuticals, Medical Devices & Hardware industry in Massachusetts.

In per capita output Massachusetts outperforms the LTS average in all Key Sectors except for Advanced Materials. Advanced Materials is the Commonwealth's smallest sector in terms of output and made up only 2.2% of innovation economy employment in 2017. The largest difference in absolute terms of per capita output is in the Software & Communication Services sector where the state is \$2,377 per capita or 168.2% ahead of the LTS average. Financial Services, Healthcare Delivery, and Biopharmaceuticals, Medical Devices & Hardware all are more than \$1,500 per capita above the LTS average. Postsecondary Education is 188% higher than the LTS average, the largest difference in percentage terms. Massachusetts ranks highest in per capita output among the LTS in: Biopharmaceuticals & Medical Devices & Hardware; Healthcare Delivery; Postsecondary Education; Scientific, Technical & Management Services; and Software & Communication Services.

### MASSACHUSETTS & ... OUTPUT

- Output increased in 8 of 11 sectors from 2012-2017, accounting for 90.5% of all innovation output
- Higher per capita output than LTS average in all but Advanced Materials

### Output in Key Sectors

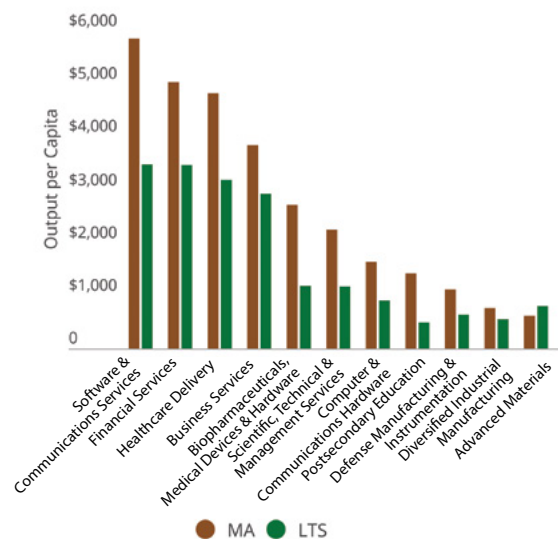
Massachusetts, 2012 & 2017

\$ Millions

| Key Sectors                                    | 2012 Output (\$ M) | 2017 Output (\$ M) | 2012-2017 Output Growth (\$ M) | 2012-2017 % Change |
|--|--------------------|--------------------|--------------------------------|--------------------|
| Software & Communications Services             | \$32,336           | \$40,199           | \$7,863                        | 24.3%              |
| Financial Services                             | \$33,274           | \$34,547           | \$1,273                        | 3.8%               |
| Healthcare Delivery                            | \$29,923           | \$33,103           | \$3,179                        | 10.6%              |
| Business Services                              | \$24,187           | \$26,392           | \$2,206                        | 9.1%               |
| Biopharmaceuticals, Medical Devices & Hardware | \$14,849           | \$18,628           | \$3,779                        | 25.5%              |
| Scientific, Technical & Management Services    | \$12,679           | \$15,437           | \$2,757                        | 21.7%              |
| Computer & Communications Hardware             | \$11,145           | \$11,251           | \$106                          | 1.0%               |
| PostSecondary Education                        | \$9,447            | \$9,763            | \$316                          | 3.3%               |
| Defense Manufacturing & Instrumentation        | \$7,943            | \$7,665            | -\$279                         | -3.5%              |
| Diversified Industrial Manufacturing           | \$5,393            | \$5,261            | -\$132                         | -2.4%              |
| Advanced Materials                             | \$4,355            | \$4,248            | -\$108                         | -2.5%              |

### Output per Capita in Key Industry Sectors

Massachusetts & LTS, 2017



| Key Sectors                                    | MA      | LTS     |
|--|---------|---------|
| Software & Communication Services              | \$5,860 | \$3,483 |
| Financial Services                             | \$5,036 | \$3,471 |
| Healthcare Delivery                            | \$4,826 | \$3,189 |
| Business Services                              | \$3,847 | \$2,927 |
| Biopharmaceuticals, Medical Devices & Hardware | \$2,716 | \$1,183 |
| Scientific, Technical & Management Services    | \$2,250 | \$1,172 |
| Computer & Communication Hardware              | \$1,640 | \$909   |
| Postsecondary Education                        | \$1,423 | \$494   |
| Defense Manufacturing & Instrumentation        | \$1,117 | \$641   |
| Diversified Industrial Manufacturing           | \$767   | \$555   |
| Advanced Materials                             | \$619   | \$805   |

Additional charts for select indicators can be viewed at [masstech.org/index](http://masstech.org/index)

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



## INDICATOR 5: Exports

### How Does Massachusetts Perform?

Massachusetts has seen some variability in the destination of its exports between 2012-2017, with historically important trading partners such as the United Kingdom and Canada purchasing fewer goods from Massachusetts businesses. Canada was the largest export destination for Massachusetts in 2017, even though exports to that country have declined 18.8% since 2012. Exports to Mexico (#2), Hong Kong (#6), and Switzerland (#10) have all experienced tremendous growth. Except for Canada (#1), the United Kingdom (#4), and Germany (#5) all other countries within the top ten export destinations have seen increases in trade from 2012-2017. Massachusetts is 12th among the LTS in exports as a percentage of GDP in 2017, moving up from 13th in 2016.

### MASSACHUSETTS & ... EXPORTS

- 12th among LTS in Exports as a % of GDP in 2017
- Canada was the largest trading partner in 2017 - \$3B
- \$27.8B in exports in 2017

**Massachusetts Exports: Top Ten Destinations and Value**  
(\$ Millions), 2012-2017

| Country        | 2012 Exports (\$ Mill) | 2017 Exports (\$ Mill) | % Change 2012-2017 |
|----------------|------------------------|------------------------|--------------------|
| Canada         | \$3,708                | \$3,012                | -18.8%             |
| Mexico         | \$1,715                | \$2,562                | 49.3%              |
| China          | \$2,003                | \$2,304                | 15.0%              |
| United Kingdom | \$2,721                | \$2,116                | -22.3%             |
| Germany        | \$1,925                | \$1,820                | -5.4%              |
| Hong Kong      | \$757                  | \$1,321                | 74.5%              |
| Japan          | \$1,149                | \$1,279                | 11.3%              |
| Netherlands    | \$1,149                | \$1,255                | 9.2%               |
| South Korea    | \$1,099                | \$1,219                | 10.9%              |
| Switzerland    | \$464                  | \$1,119                | 141.2%             |

Additional charts for select indicators can be viewed at [masstech.org/index](https://masstech.org/index)

### INDICATOR 5: Exports

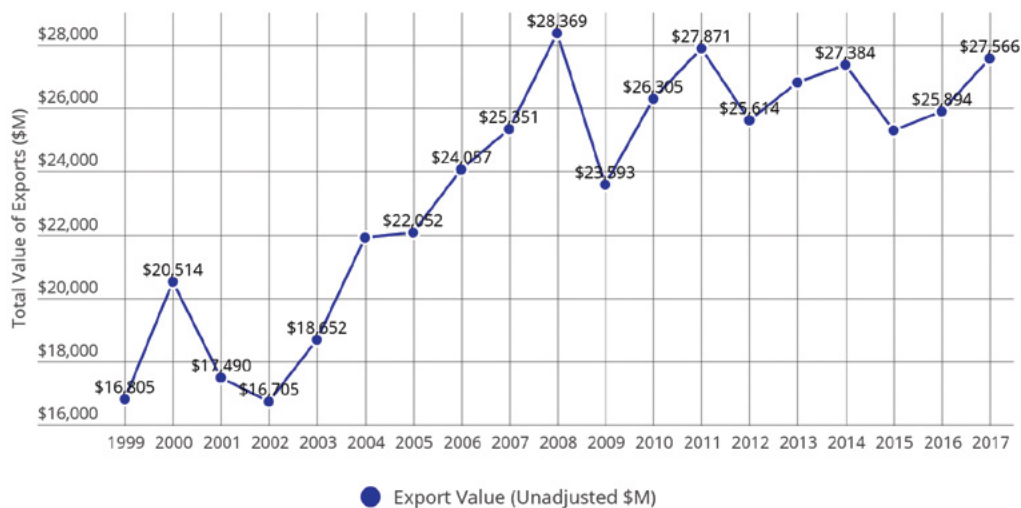
U.S. exports increased by approximately \$95B from 2016-2017, and Massachusetts’ reached \$27.7B, its highest peak since the post-recession peak of \$27.8B in 2011. Massachusetts’ 2017 exports were \$1.7B higher than in 2016 and higher than the 10-year average, which includes the record peak of \$28.4B in 2008, by \$1.1B.

The Commonwealth’s top three export commodities in 2017 have all increased in trade value from 2016. They consisted of Medical Instruments and Appliances (up \$37.6M), Machines & Apparatus for the Manufacture of Semiconductors (up \$97.8M), and Electronic Integrated Circuits, Processors and Controllers (up \$103.6M).

**Exports as a Percentage (%) of GDP**  
Massachusetts & LTS, 2012 & 2017

| State          | Exp as % of GDP 2012 | Exp as % of GDP 2017 |
|----------------|----------------------|----------------------|
| Texas          | 20.2%                | 17.4% ↓              |
| Illinois       | 10.2%                | 9.2% ↓               |
| Ohio           | 9.4%                 | 8.9% ↓               |
| Wisconsin      | 8.9%                 | 7.9% ↓               |
| New Hampshire  | 5.4%                 | 7.3% ↑               |
| California     | 8.0%                 | 7.2% ↓               |
| North Carolina | 3.3%                 | 7.1% ↑               |
| Minnesota      | 7.0%                 | 6.8% ↓               |
| New Jersey     | 7.6%                 | 6.7% ↓               |
| Connecticut    | 7.0%                 | 6.6% ↓               |
| Florida        | 8.7%                 | 6.6% ↓               |
| Massachusetts  | 6.2%                 | 6.0% ↓               |
| New York       | 6.6%                 | 6.0% ↓               |
| Pennsylvania   | 6.4%                 | 5.8% ↓               |
| Rhode Island   | 4.9%                 | 4.7% ↓               |

**Total Value of Exports**  
Massachusetts, 1999-2017  
Unadjusted (\$ Millions)



Data Source for Indicator 5: U.S. Census Bureau Foreign Trade Division, Staying Power II Report, xe.com

# RESEARCH - Indicators 6-9

## Why are these Indicators Significant?

### **Indicator 6: Research & Development (R&D) - p. 28**

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, these data provide a basis for estimating a region's general capacity for knowledge creation. The distribution of R&D expenditures by type of performer illustrates the relationship that states have with the different types of R&D performers and how a differentiated list of performers can help produce an innovative and diverse ecosystem.

### **Indicator 7: Academic Article Output - p. 29**

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.

### **Indicator 8: Utility Patents - p. 30**

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-protecting 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. Utility Patents are those for unique and novel inventions that have some practical purpose, as opposed to purely aesthetic Design Patents.

### **Indicator 9: Technology Patents - p. 31**

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

**For more information visit: [masstech.org/index](https://masstech.org/index)**

## INDICATOR 6: Research and Development

### How Does Massachusetts Perform?

Massachusetts had the second highest overall level of R&D funding in the country in 2015 at \$28.7B, ahead of Texas (\$23.7B). R&D as a percentage of GDP in Massachusetts remained the highest among the LTS, at 5.86% in 2015, the same as 2014. While Massachusetts is the leader in R&D as a percentage of GDP, California still maintains a significant lead in total R&D funding (\$125.06B in 2015).

The majority of R&D in 2015 was performed by private industry throughout the LTS. In 2015, 74.95% of R&D expenditures in Massachusetts were made by private industry, placing Massachusetts eighth in the LTS. Massachusetts ranks fourth among the LTS in terms of R&D performed by universities, colleges, and other non-profit organizations with \$5.2B, a 4.49% increase from 2010-2015. Massachusetts also has the second highest percentage of R&D performed at Federally Funded Research and Development Centers (4.79%) in the LTS, following Illinois.

### MASSACHUSETTS & ... RESEARCH & DEVELOPMENT

- **\$28.7B in R&D expenditures in 2015, 2nd nationally**
- **First among LTS in R&D expenditures as a % of GDP (5.86%)**
- **Business performs 75% of R&D in Massachusetts**

**Total R&D Expenditures**  
Massachusetts & LTS, 2010 & 2015  
Millions of 2015 \$

| State          | 2010 Total R&D Expenditure | 2015 Total R&D Expenditure | % Change 2010-2015 | 2015 R&D Spending as a % of GDP By State |
|----------------|----------------------------|----------------------------|--------------------|--|
| California     | \$87,958                   | \$125,056                  | 42.18%             | 4.99%                                    |
| Massachusetts  | \$21,928                   | \$28,665                   | 30.72%             | 5.86%                                    |
| Texas          | \$21,178                   | \$23,668                   | 11.76%             | 1.47%                                    |
| New York       | \$18,612                   | \$22,401                   | 20.36%             | 1.53%                                    |
| Illinois       | \$17,178                   | \$16,502                   | -3.93%             | 2.12%                                    |
| New Jersey     | \$19,410                   | \$15,865                   | -18.27%            | 2.82%                                    |
| Pennsylvania   | \$14,196                   | \$14,839                   | 4.53%              | 2.10%                                    |
| Ohio           | \$10,910                   | \$12,233                   | 12.12%             | 2.00%                                    |
| North Carolina | \$9,497                    | \$11,823                   | 24.50%             | 2.36%                                    |
| Connecticut    | \$8,073                    | \$9,918                    | 22.85%             | 3.88%                                    |
| Florida        | \$8,635                    | \$9,456                    | 9.51%              | 1.06%                                    |
| Minnesota      | \$8,028                    | \$8,053                    | 0.32%              | 2.45%                                    |
| Wisconsin      | \$5,805                    | \$6,132                    | 5.64%              | 2.01%                                    |
| New Hampshire  | \$2,344                    | \$2,333                    | -0.48%             | 3.12%                                    |
| Rhode Island   | \$1,563                    | \$1,427                    | -8.67%             | 2.54%                                    |

Additional charts for select indicators can be viewed at [masstech.org/index](http://masstech.org/index)

## INDICATOR 7: Academic Article Output

### How Does Massachusetts Perform?

Massachusetts has maintained a high rate of Science and Engineering (S&E) Academic Article Output relative to its population in 2015, the most recent year for which data are available. In 2015, S&E Academic Article Output climbed to 3,411 academic articles per million residents, more than three times the U.S. average (1,005).

Massachusetts also ranked first internationally in 2015, outperforming second-place Switzerland by roughly 29.1%, or 768 articles per million residents.

Massachusetts also performs well in terms of academic productivity per dollar. It continues to lead the LTS in article output per million dollars of academic R&D funding. In 2005, 2010, and 2015, Massachusetts produced more S&E Academic Articles per R&D dollar than all other LTS and the nation overall. In 2015, the state reported 6.8 articles per million academic R&D dollar spent. Massachusetts also led in a second measure of research productivity, articles per 1,000 S&E Doctorate Holders. The median of the rest of the LTS (996) is 28.2% lower than Massachusetts' 1,388 figure.

Articles per researcher and articles per dollar both decreased from 2013-2015 in both the U.S. and Massachusetts, along with almost every LTS. Rhode Island is the only state in which both increased.

### MASSACHUSETTS & ... ACADEMIC ARTICLE OUTPUT

- **23,172 Academic Science & Engineering Articles (S&E) produced in 2015 (3rd nationally)**
- **#1 in U.S. and globally for Academic S&E Articles produced per-capita in 2015**
- **Since 2004, Mass. had the highest output per \$1M nationally six times and was 2nd seven times**

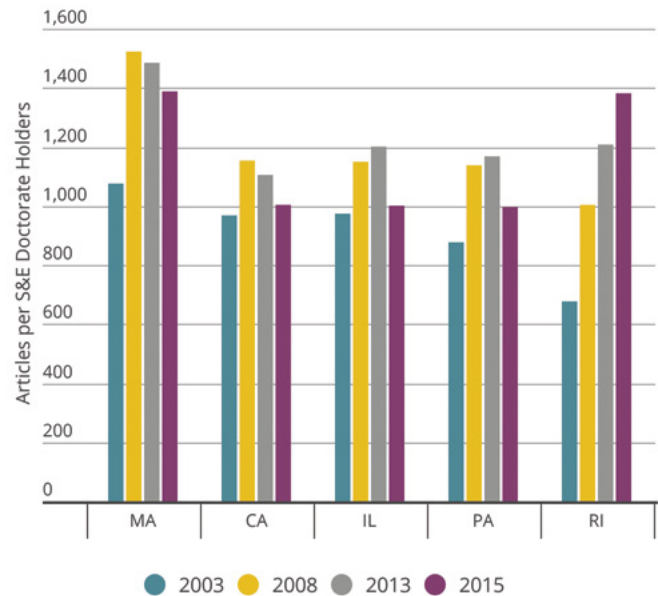
### Science and Engineering (S&E) Academic Article Output per Million Residents

Massachusetts, Top LTS and Top International, 2015

| Location      | S&E Article Output per million residents |
|---------------|--|
| Massachusetts | 3,411                                    |
| Switzerland   | 2,642                                    |
| Denmark       | 2,473                                    |
| Australia     | 2,186                                    |
| Sweden        | 2,109                                    |
| Rhode Island  | 2,029                                    |
| Singapore     | 2,027                                    |
| Connecticut   | 1,615                                    |
| Pennsylvania  | 1,473                                    |
| New York      | 1,323                                    |

### Science and Engineering (S&E) Academic Article Output per 1,000 S&E Doctorate Holders

Massachusetts & Top 5 LTS, 2003, 2008, 2013, 2015



|    | 2003  | 2008  | 2013  | 2015  |
|----|-------|-------|-------|-------|
| MA | 1,076 | 1,523 | 1,485 | 1,388 |
| CA | 968   | 1,154 | 1,105 | 1,004 |
| IL | 974   | 1,150 | 1,201 | 1,001 |
| PA | 877   | 1,138 | 1,168 | 997   |
| RI | 677   | 1,004 | 1,208 | 1,382 |

Additional charts for select indicators can be viewed at [masstech.org/index](http://masstech.org/index)

## INDICATOR 8: Utility Patents

### How Does Massachusetts Perform?

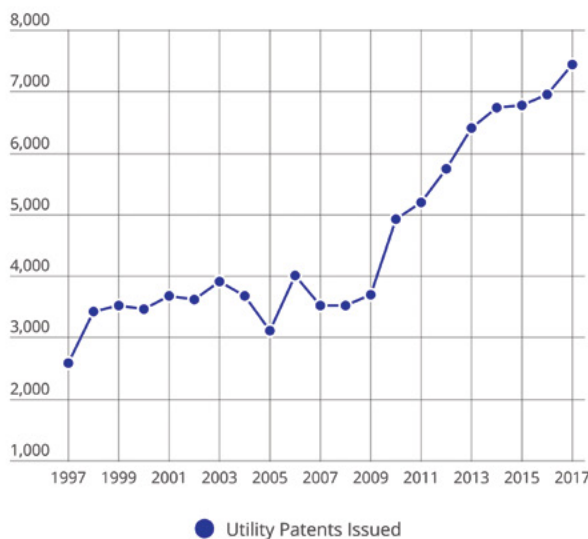
In 2017 Massachusetts again saw record numbers of utility patents granted, reaching 7,430. Its share of U.S. utility patents was 4.9%, an increase from last year and evidence that Massachusetts is a key state for translating research into products meant for commercialization. The Commonwealth's growth rate in patents granted per million residents from 2012-2017 was 25.8%, tied for second with California, with New Hampshire placing first at 37.9%, all of which were above the national growth rate of 14.5%. In 2017, Massachusetts ranks fourth among the LTS in total number of utility patents granted, behind California, Texas, and New York. Nationally, it ranks first in utility patents granted per million residents.

**MASSACHUSETTS & ...  
UTILITY PATENTS**

- **7,430 utility patents granted in 2017, a new record**
- **4th among LTS in utility patents granted**
- **1st nationally in utility patents granted per capita**

### Utility Patents Issued

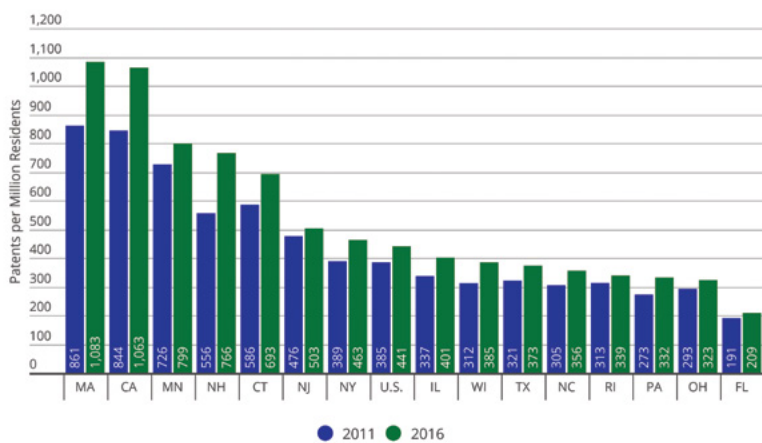
Massachusetts, 1997-2017



| Year | Utility Patents Issued in MA |
|------|------------------------------|
| 1997 | 2,575                        |
| 1998 | 3,413                        |
| 1999 | 3,521                        |
| 2000 | 3,458                        |
| 2001 | 3,668                        |
| 2002 | 3,608                        |
| 2003 | 3,908                        |
| 2004 | 3,672                        |
| 2005 | 3,114                        |
| 2006 | 4,011                        |
| 2007 | 3,510                        |
| 2008 | 3,516                        |
| 2009 | 3,696                        |
| 2010 | 4,923                        |
| 2011 | 5,191                        |
| 2012 | 5,734                        |
| 2013 | 6,409                        |
| 2014 | 6,725                        |
| 2015 | 6,777                        |
| 2016 | 6,946                        |
| 2017 | 7,430                        |

### Utility Patents per Million Residents

Massachusetts, LTS & U.S., 2012 & 2017



| State               | 2012       | 2017       |
|---------------------|------------|------------|
| MA                  | 861        | 1,083      |
| CA                  | 844        | 1,063      |
| MN                  | 726        | 799        |
| NH                  | 556        | 766        |
| CT                  | 586        | 693        |
| NJ                  | 476        | 503        |
| NY                  | 389        | 463        |
| <b>U.S. Average</b> | <b>385</b> | <b>441</b> |
| IL                  | 337        | 401        |
| WI                  | 312        | 385        |
| TX                  | 321        | 373        |
| NC                  | 305        | 356        |
| RI                  | 313        | 339        |
| PA                  | 273        | 332        |
| OH                  | 293        | 323        |
| FL                  | 191        | 209        |

Additional charts for select indicators can be viewed at [masstech.org/index](http://masstech.org/index)

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

## INDICATOR 9: Technology Patents

### How Does Massachusetts Perform?

In 2017 Massachusetts was the per-capita leader among the LTS in total technology patents within the six categories tracked by the *Index*. Massachusetts led in Drugs & Healthcare and Analytical Instruments & Research Methods patents at 274 and 135 patents per million residents respectively. It placed second in Software (271), Advanced Materials patents (71); third in Electric & Advanced Hardware (133); and 5th in Manufacturing and Manufacturing Processes (19). Looking at the categories where Massachusetts either led or placed second in, they account for 83.2% of all Massachusetts patents. Technology patents have continued to steadily increase in the Commonwealth over the last decade and represent the majority of all patents issued (83.4% in 2017).

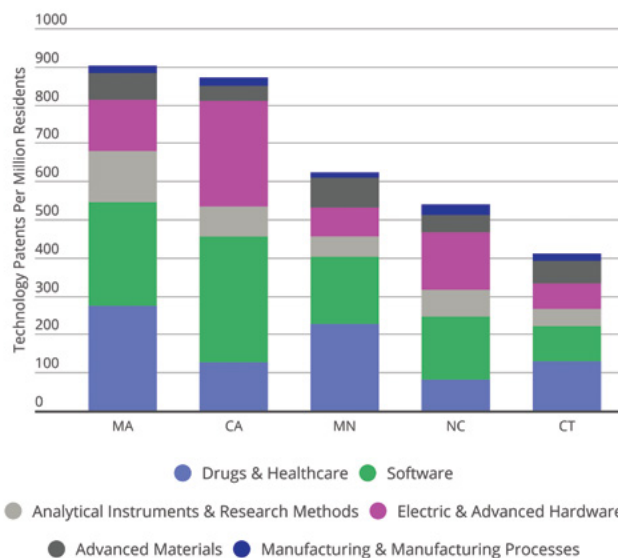
### MASSACHUSETTS & ... TECHNOLOGY PATENTS

- 6,197 Tech Patents in 2017
- 1st nationally in Tech Patents per capita
- 1st among LTS in Drugs & Healthcare and Analytical Instruments & Research Methods patents per capita

**Technology Patents by Category**  
Massachusetts, 2017

| Category                                  | Percent of Patents | # of Patents |
|---|--------------------|--------------|
| Drugs & Healthcare                        | 30.3%              | 1,878        |
| Software                                  | 30.0%              | 1,862        |
| Analytical Instruments & Research Methods | 14.9%              | 924          |
| Electric & Advanced Hardware              | 14.7%              | 914          |
| Advanced Materials                        | 7.9%               | 490          |
| Manufacturing & Manufacturing Processes   | 2.1%               | 129          |

**Technology Patents**  
per Million Residents by Field  
Massachusetts & Top 5 LTS, 2017



| State | Drugs & Healthcare | Software | Analytical Instruments & Research Methods | Electric & Advanced Hardware | Advanced Materials | Manufacturing & Manufacturing Processes |
|-------|--------------------|----------|---|------------------------------|--------------------|---|
| MA    | 274                | 271      | 135                                       | 133                          | 71                 | 19                                      |
| CA    | 126                | 329      | 79  | 276                          | 40                 | 22                                      |
| MN    | 226                | 175      | 54  | 75                           | 79                 | 15                                      |
| NC    | 81                 | 165      | 69  | 152                          | 45                 | 26                                      |
| CT    | 128                | 93       | 45  | 66                           | 60                 | 20                                      |

Additional charts for select indicators can be viewed at [masstech.org/index](http://masstech.org/index)

Data Source for Indicator 9: USPTO, Census Bureau

## Why are these Indicators Significant?

### **Indicator 10: Technology Licensing - p. 33**

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.

### **Indicator 11: SBIR/STTR - p. 34**

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) that builds 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.



## INDICATOR 10: Technology Licensing

### How Does Massachusetts Perform?

Massachusetts is essentially tied with California in the number of technology licenses and options executed in 2017, leading the LTS. Massachusetts was the leader in this category in 2012. LTS newcomer Florida had a significant increase from 2007 to 2012 (78.2%) and 2012 to 2017 (99.6%), growing from what would have been 9th place in 2007 to 5th in 2017.

There has been a shift among the types of institutions in Massachusetts that comprise a majority of licenses and options executed. In 2006, Universities had the most technology licenses and options executed; from 2008 through 2014 Research Institutions & Hospitals had the most; and then in 2015 it shifted back to Universities. In 2017, Universities accounted for 57% of all licenses and options executed, accounting for 43% and 57% respectively of all licenses and options executed.

University revenues are down 19% since 2007. Hospitals saw a more dramatic, although artificially inflated drop of 67.5% over the same time frame, due to a large legal settlement for Massachusetts General Hospital which inflated the 2007 totals. However since 2012, Research Institutions & Hospital revenues are actually up 5.5%, while University revenues are down 47.6%.

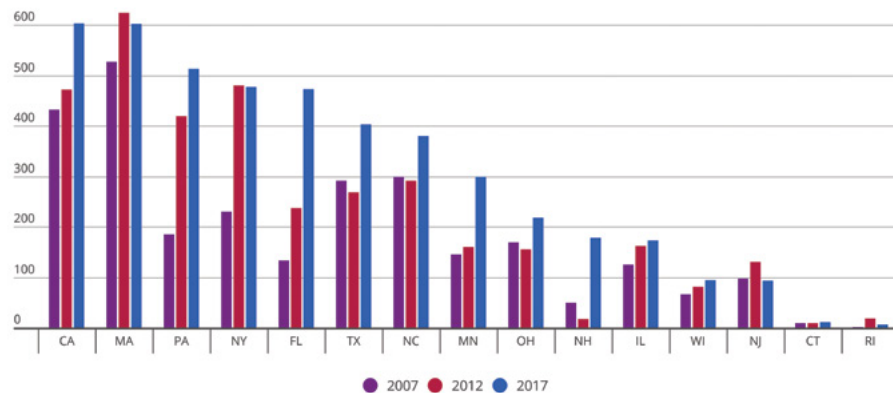
### MASSACHUSETTS & ... TECHNOLOGY LICENSING

- 602 Technology Licenses/Options Executed in 2017 (2nd in LTS)
- \$264M in Licensing Revenue in 2017

### Technology Licenses and Options Executed Research Institutions, Hospitals & Universities Massachusetts, 2007-2017

| Year | Tech Licensing and Options Executed<br>Research Institutions & Hospitals | Tech Licensing and Options Executed<br>Universities |
|------|--|---|
| 2007 | 245  | 282   |
| 2008 | 242  | 234   |
| 2009 | 303  | 238   |
| 2010 | 286  | 228   |
| 2011 | 294  | 251   |
| 2012 | 376  | 248   |
| 2013 | 264  | 237   |
| 2014 | 292  | 254   |
| 2015 | 272  | 276   |
| 2016 | 237  | 276   |
| 2017 | 259  | 343   |

### Technology Licenses and Options Executed Massachusetts & LTS, 2007, 2012 & 2017



| State | CA  | MA  | PA  | NY  | FL  | TX  | NC  | MN  | OH  | NH  | IL  | WI | NJ  | CT | RI |
|-------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|----|-----|----|----|
| 2007  | 432 | 527 | 185 | 230 | 133 | 291 | 299 | 145 | 169 | 49  | 125 | 66 | 97  | 9  | 1  |
| 2012  | 472 | 624 | 419 | 480 | 237 | 268 | 291 | 160 | 155 | 17  | 162 | 81 | 130 | 9  | 18 |
| 2017  | 603 | 602 | 513 | 477 | 473 | 403 | 380 | 299 | 218 | 178 | 173 | 94 | 93  | 11 | 6  |

Additional charts for select indicators can be viewed at [masstech.org/index](http://masstech.org/index)

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

## INDICATOR 11: SBIR/STTR Awards

### How Does Massachusetts Perform?

There was an increase in the number of Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) awards in Massachusetts, from 532 to 604 between 2016 to 2017. However, the total SBIR and STTR award funding decreased by \$30 million during that same timeframe. Since the 2010 post-recession peak, the number of awards has fallen 30.0%. Total funding has fallen 24.8%. Massachusetts received approximately \$89.6 million less in 2017 than it did in 2010 when adjusted for inflation. This reflects the overall decline in awards which have decreased by 1,561, and award funding which has decreased by \$407.5 million nationally since 2010 to 2017. Massachusetts is first in SBIR/STTR Award funding per \$1 million GDP among the LTS and second in total funding amount, behind California. Among the SBIR and STTR awards in Massachusetts in 2017, the U.S. Department of Health & Human Services accounted for most of the funding (41.1%), while the Department of Defense accounted for over half of total awards (50.3%).

### MASSACHUSETTS & ... SBIR/STTR

- **\$271M in 2017 SBIR/STTR funding**
- **2nd in total funding among LTS**
- **1st in SBIR/STTR funding as a % of GDP**

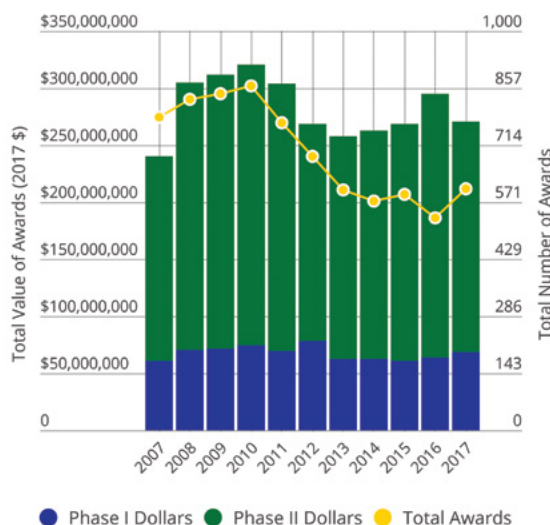
**SBIR/STTR Awards Funding**  
Massachusetts & LTS, 2017

| State          | SBIR/ STTR Awards Total Funding Amount | Award Funding per \$1 Million GDP |
|----------------|--|-----------------------------------|
| Massachusetts  | \$270,969,255                          | \$594                             |
| New Hampshire  | \$32,988,172                           | \$468                             |
| New York       | \$113,888,090                          | \$248                             |
| California     | \$543,751,384                          | \$228                             |
| North Carolina | \$83,663,144                           | \$164                             |
| Ohio           | \$86,973,502                           | \$155                             |
| Pennsylvania   | \$97,800,606                           | \$147                             |
| Minnesota      | \$44,362,323                           | \$145                             |
| Rhode Island   | \$6,839,597                            | \$134                             |
| Connecticut    | \$26,629,271                           | \$119                             |
| Illinois       | \$52,865,649                           | \$75                              |
| Florida        | \$61,985,448                           | \$74                              |
| Wisconsin      | \$20,517,370                           | \$73                              |
| Texas          | \$107,532,688                          | \$71                              |
| New Jersey     | \$51,662,827                           | \$40                              |

**SBIR & STTR Awards by Agency**  
Massachusetts, 2017

| SBIR & STTR Awards by Agency                  | Funding       | # of Awards |
|---|---------------|-------------|
| Health and Human Services                     | \$111,439,672 | 157         |
| Department of Defense                         | \$99,100,667  | 304         |
| Department of Energy                          | \$26,873,900  | 53          |
| National Science Foundation                   | \$12,664,610  | 24          |
| National Aeronautics and Space Administration | \$9,268,185   | 33          |

**SBIR & STTR Awards**  
Total Number of Awards and Value (by Phase) of Awards Granted  
Massachusetts, 2007-2017



| Year | Phase I Dollars | Phase II Dollars | Total Awards |
|------|-----------------|------------------|--------------|
| 2007 | \$60,908,609    | \$179,419,421    | 784          |
| 2008 | \$70,926,327    | \$234,362,758    | 830          |
| 2009 | \$71,480,522    | \$240,242,715    | 844          |
| 2010 | \$74,103,415    | \$246,629,563    | 863          |
| 2011 | \$69,250,113    | \$234,839,741    | 769          |
| 2012 | \$78,421,129    | \$190,033,418    | 686          |
| 2013 | \$62,590,503    | \$195,103,045    | 603          |
| 2014 | \$62,599,552    | \$199,838,538    | 573          |
| 2015 | \$60,708,712    | \$208,268,073    | 591          |
| 2016 | \$63,310,319    | \$231,503,316    | 532          |
| 2017 | \$68,354,307    | \$202,614,948    | 604          |

Phase 1 = Proof of Concept;  
Phase 2 = R&D; <https://sbir.nih.gov/about/three-phase-program>

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

## Why are these Indicators Significant?

### **Indicator 12: Business Formation - p. 36**

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.

### **Indicator 13: Initial Public Offerings (IPO) & Mergers and Acquisitions (M&A) - p. 37**

Initial Public Offerings (IPOs) and Mergers and 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. Overall figures are relatively low so it is expected that year-over-year figures will fluctuate, which is why it is important to review trends over multiple years.

## INDICATOR 12: Business Formation

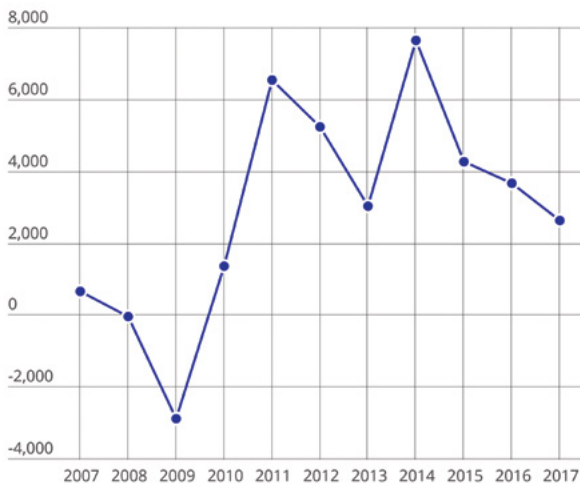
### How Does Massachusetts Perform?

In 2017 Massachusetts experienced its 8th consecutive year of business establishment growth, with a net gain of 2,620 business establishments. While close to the average annual gain over this period (+2,907 establishments), it represents a 66% decline from the peak of 7,630 net new establishments in 2014.

**MASSACHUSETTS & ...  
BUSINESS FORMATION**

- Net gain of 2,620 business establishments in 2017
- 97 Start-ups initiated from universities, hospitals, research institutions, and technology investment firms in 2017 (2nd in LTS)

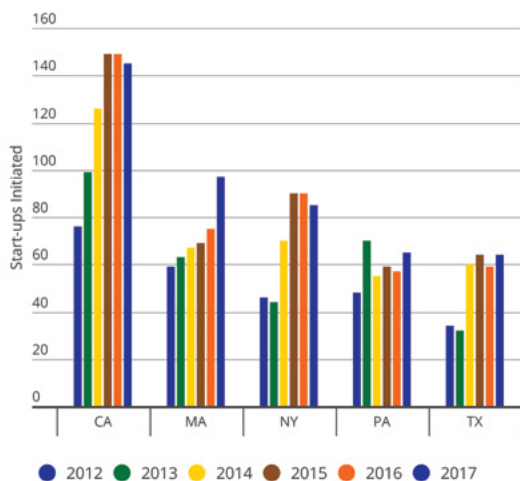
**Net Change in Number of Business Establishments**  
Massachusetts, 2007 -2017



| Year | Net Change in Number of Business Establishments |
|------|---|
| 2007 | 639   |
| 2008 | -47   |
| 2009 | -2,909  |
| 2010 | 1,363   |
| 2011 | 6,538   |
| 2012 | 5,213   |
| 2013 | 3,033   |
| 2014 | 7,630   |
| 2015 | 4,248   |
| 2016 | 3,653   |
| 2017 | 2,620   |

In 2017, start-up formations from universities, hospitals, and research institutions in Massachusetts increased to 97. From 2012-2017, Massachusetts has averaged 75 start-ups initiated per year from universities, hospitals, research institutions, and technology investment firms. Of the LTS, only California leads Massachusetts in start-up formation, with 145 in 2017 and an average of 124 over the 2012-2017 period, while New York rounds out the top three with 85 in 2017. Both California and New York had declines in growth rate from 2016-2017, -2.7% and -5.6% respectively, while Massachusetts had an increase of 29.3%.

**Start-up Companies Initiated**  
From Universities, Hospitals, Research Institutions, and Technology Investment Firms  
Massachusetts & Top 5 LTS, 2012-2017



| State | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
|-------|------|------|------|------|------|------|
| CA    | 76   | 99   | 126  | 149  | 149  | 145  |
| MA    | 59   | 63   | 67   | 69   | 75   | 97   |
| NY    | 46   | 44   | 70   | 90   | 90   | 85   |
| PA    | 48   | 70   | 55   | 59   | 57   | 65   |
| TX    | 34   | 32   | 60   | 64   | 59   | 64   |

Additional charts for select indicators can be viewed at [masstech.org/index](http://masstech.org/index)

## INDICATOR 13: Initial Public Offerings (IPO) & Mergers and Acquisitions (M&A)

### How Does Massachusetts Perform?

California and Massachusetts were the major generators of IPOs with each state's focus on advanced technology cluster development and large innovation economies. Massachusetts recorded more than a 50% increase in IPOs in 2018 (20) than in 2013 (13). Massachusetts IPOs were dominated by biotech and pharmaceutical companies in 2018 with 15 of the 20 IPOs. The average dollar amount raised in the IPO by these Massachusetts biotech companies was \$145.2M.

Massachusetts had the same number of companies acquired in 2018 as in 2017 (168), while the number increased in 11 of the LTS. Every state save for New Jersey had an increase in the number of companies based there acquiring other firms.

### MASSACHUSETTS & ... IPO AND M&A

- 20 IPO's in 2018
- Average amount raised; \$145.2M
- 168 Massachusetts companies acquired in 2018 (4th in LTS)
- 223 Massachusetts companies acquired another company in 2018 (4th in LTS)

### Number of Initial Public Offerings (IPOs) Massachusetts & LTS, 2013-2018

| No. of IPOs by State | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2018 IPO Total \$ |
|----------------------|------|------|------|------|------|------|-------------------|
| CA                   | 39   | 47   | 35   | 14   | 27   | 48   | \$6,928,937,892   |
| CT                   | 1    | 5    | 0    | 0    | 1    | 2    | \$180,000,000     |
| FL                   | 6    | 3    | 2    | 2    | 0    | 2    | \$1,477,971,296   |
| IL                   | 6    | 4    | 2    | 0    | 2    | 2    | \$187,900,000     |
| MA                   | 10   | 21   | 10   | 13   | 17   | 20   | \$2,904,147,222   |
| MN                   | 1    | 1    | 0    | 1    | 2    | 4    | \$1,202,037,814   |
| NC                   | 0    | 0    | 0    | 0    | 0    | 3    | \$454,207,921     |
| NH                   | 7    | 7    | 2    | 0    | 3    | 0    | \$0               |
| NJ                   | 8    | 12   | 6    | 2    | 12   | 3    | \$209,400,000     |
| NY                   | 6    | 3    | 3    | 2    | 3    | 9    | \$3,940,200,000   |
| OH                   | 0    | 0    | 0    | 0    | 0    | 4    | \$802,000,000     |
| PA                   | 3    | 5    | 4    | 0    | 4    | 3    | \$228,500,000     |
| RI                   | 0    | 1    | 1    | 0    | 0    | 0    | \$0               |
| TX                   | 7    | 7    | 4    | 4    | 12   | 4    | \$695,400,000     |
| WI                   | 2    | 0    | 0    | 0    | 1    | 0    | \$0               |

\*IPOs with verified dollars raised

### Number of Companies Being Acquired Massachusetts & LTS, 2013-2018

| No. of Companies being Acquired by State | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
|--|------|------|------|------|------|------|
| CA                                       | 427  | 536  | 534  | 721  | 651  | 730  |
| TX                                       | 73   | 93   | 109  | 169  | 190  | 216  |
| NY                                       | 93   | 106  | 112  | 179  | 143  | 186  |
| MA                                       | 69   | 132  | 101  | 176  | 168  | 168  |
| IL                                       | 41   | 65   | 73   | 101  | 96   | 141  |
| FL                                       | 53   | 65   | 67   | 117  | 134  | 137  |
| NJ                                       | 43   | 41   | 53   | 78   | 76   | 92   |
| PA                                       | 48   | 43   | 67   | 99   | 94   | 91   |
| OH                                       | 26   | 32   | 35   | 67   | 67   | 81   |
| NC                                       | 23   | 41   | 45   | 57   | 55   | 78   |
| MN                                       | 19   | 26   | 24   | 61   | 63   | 59   |
| WI                                       | 11   | 22   | 14   | 40   | 36   | 57   |
| CT                                       | 13   | 25   | 21   | 34   | 37   | 47   |
| NH                                       | 5    | 5    | 7    | 17   | 17   | 15   |
| RI                                       | 1    | 6    | 3    | 7    | 4    | 5    |

### Number of Companies Acquiring Others Massachusetts & LTS, 2013-2018

| No. of Companies Acquiring Others by State | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
|--|------|------|------|------|------|------|
| CA   | 484  | 542  | 503  | 698  | 648  | 748  |
| NY   | 110  | 181  | 189  | 310  | 301  | 338  |
| TX   | 81   | 118  | 109  | 182  | 204  | 261  |
| MA   | 79   | 127  | 120  | 170  | 171  | 223  |
| IL   | 78   | 117  | 129  | 183  | 157  | 190  |
| FL   | 44   | 71   | 95   | 120  | 120  | 154  |
| PA   | 41   | 63   | 43   | 115  | 105  | 120  |
| NJ   | 36   | 73   | 58   | 114  | 108  | 107  |
| OH   | 34   | 33   | 32   | 70   | 88   | 93   |
| MN   | 29   | 37   | 40   | 62   | 67   | 76   |
| NC   | 15   | 32   | 26   | 46   | 52   | 76   |
| CT   | 26   | 35   | 52   | 69   | 49   | 64   |
| WI   | 14   | 13   | 13   | 48   | 43   | 51   |
| NH   | 6    | 13   | 5    | 9    | 5    | 13   |
| RI   | 5    | 7    | 6    | 12   | 7    | 10   |

Data Source for Indicator 13: Renaissance Capital, IPO Home, National Venture Capital Association (NVCA), Ipomonitor.com, Crunchbase.com

# CAPITAL - Indicators 14-16

## Why are these Indicators Significant?

### **Indicator 14: Federal Funding for Academic and Health R&D - pp. 39-40**

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 that make up 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.

### **Indicator 15: Industry Funding for Academic Research - pp. 41-42**

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 promoting 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.

### **Indicator 16: Venture Capital - pp. 43-44**

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 and recruiting opportunities in the Innovation Economy. Empirical research suggests that the amount of VC in a region has a positive effect on economic growth.

## INDICATOR 14: Federal Funding for Academic and Health R&D

### How Does Massachusetts Perform?

Due to federal budget cuts, federal funding for academic R&D declined in all the LTS except Florida and New Hampshire in 2016, with every other state falling below its 2011 level. Massachusetts remains second among the LTS in federal R&D funding awarded to universities and non-profit institutions. Massachusetts received \$3.2 billion in federal R&D funding in 2016, roughly 1/3rd less than California's total (\$4.8 billion), an impressive statistic considering the Commonwealth's population, which is roughly 1/6th that of the Golden State.

Massachusetts continues to maintain a lead in federal funding for Academic R&D per \$1,000 GDP at \$6.40. This is more than twice as much as second ranked Rhode Island, which also benefits from a large concentration of research hospitals and medical schools, as well as a small population base. Despite leading the LTS, Massachusetts has suffered a 14% decrease in federal funding for Academic R&D per \$1,000 GDP since 2011. This is reflective of a long term decrease in the percentage of the federal budget spent on R&D, which has been declining since 1966.

### MASSACHUSETTS & ... FEDERAL FUNDING FOR ACADEMIC & HEALTH R&D

- **\$3.2B in federal funding for academic and health R&D in 2016, 2nd nationally**
- **Also 2nd nationally in NIH funding in 2017 with \$2.7B**
- **11 Research Organizations received more than \$100M in NIH funding in 2017**

**Federal Funding for R&D**  
Universities, Colleges and Non-Profit Organizations  
Massachusetts & LTS, 2006, 2011, 2016

| State          | 2006 Absolute Funding (Millions \$) | 2011 Absolute Funding (Millions \$) | 2016 Absolute Funding (Millions \$) | 2006 Funding per \$1000 GDP | 2011 Funding per \$1000 GDP | 2016 Funding per \$1000 GDP |
|----------------|-------------------------------------|-------------------------------------|-------------------------------------|-----------------------------|-----------------------------|-----------------------------|
| California     | \$5,089                             | \$5,114                             | \$4,823                             | \$2.30                      | \$2.33                      | \$1.86                      |
| Connecticut    | \$736                               | \$611                               | \$581                               | \$2.77                      | \$2.39                      | \$2.31                      |
| Florida        | \$738                               | \$837                               | \$845                               | \$0.83                      | \$1.03                      | \$0.92                      |
| Illinois       | \$1,205                             | \$1,403                             | \$1,213                             | \$1.62                      | \$1.91                      | \$1.56                      |
| Massachusetts  | \$3,187                             | \$3,387                             | \$3,185                             | \$7.44                      | \$7.41                      | \$6.40                      |
| Minnesota      | \$619                               | \$663                               | \$652                               | \$2.08                      | \$2.18                      | \$1.94                      |
| New Hampshire  | \$167                               | \$148                               | \$166                               | \$2.34                      | \$2.07                      | \$2.15                      |
| New Jersey     | \$498                               | \$474                               | \$439                               | \$0.89                      | \$0.88                      | \$0.77                      |
| New York       | \$2,800                             | \$2,732                             | \$2,641                             | \$2.19                      | \$2.04                      | \$1.84                      |
| North Carolina | \$1,389                             | \$1,552                             | \$1,353                             | \$3.00                      | \$3.33                      | \$2.70                      |
| Ohio           | \$1,055                             | \$1,018                             | \$946                               | \$1.84                      | \$1.78                      | \$1.53                      |
| Pennsylvania   | \$2,300                             | \$2,135                             | \$2,042                             | \$3.65                      | \$3.19                      | \$2.80                      |
| Rhode Island   | \$204                               | \$227                               | \$221                               | \$3.55                      | \$4.20                      | \$3.92                      |
| Texas          | \$1,929                             | \$1,705                             | \$1,589                             | \$1.55                      | \$1.23                      | \$0.96                      |
| Wisconsin      | \$594                               | \$635                               | \$584                               | \$2.09                      | \$2.21                      | \$1.88                      |
| United States  | \$35,813                            | \$36,107                            | \$34,197                            | \$2.19                      | \$2.18                      | \$1.87                      |

Of the 54,194 awards from the National Institutes of Health (NIH) in the U.S. in 2017, Massachusetts accounts for 5,185 or 9.6% of total awards and a 10.4% share of NIH funding. Eleven Massachusetts research organizations attracted more than \$100 million in NIH funding in 2017, totaling 3,739 awards and \$2.1 billion in funding. Boston, Cambridge, and Worcester together combined for a total of 4,693 awards with 2.5 billion in NIH funding due to the high density of hospitals, universities, and pharmaceutical companies in those cities.

**Additional charts for select indicators can be viewed at [masstech.org/index](https://masstech.org/index)**

Data Source for Indicator 14: NSF, BEA, National Institutes of Health (NIH), Census Bureau, <https://www.aas.org/programs/r-d-budget-and-policy/historical-trends-federal-rd>

**INDICATOR 14: Federal Funding for Academic and Health R&D**

Massachusetts continues to attract the largest share of NIH funding per \$1 million GDP among the LTS and nationally. Massachusetts' amount of NIH funding per \$1M GDP (\$5,347) is unparalleled in the LTS, reaching more than 3 times the median share for the LTS. Massachusetts received the second highest number of NIH awards (5,185 in 2017) following only California (8,013). In terms of absolute amount of NIH funding, Massachusetts ranked second (\$2.7B) to California (\$4B).

**National Institutes of Health (NIH) R&D Funding**  
per \$1 million GDP  
Massachusetts & LTS, 2017

| NIH R&D Funding by State | Number of Awards | Absolute Funding (Millions \$) | Funding per \$1 Million GDP |
|--------------------------|------------------|--------------------------------|-----------------------------|
| Massachusetts            | 5,185            | \$2,717                        | \$5,347                     |
| Rhode Island             | 486              | \$171                          | \$2,962                     |
| North Carolina           | 2,330            | \$1,246                        | \$2,429                     |
| Pennsylvania             | 3,582            | \$1,673                        | \$2,246                     |
| Connecticut              | 1,191            | \$524                          | \$2,037                     |
| New York                 | 5,056            | \$2,386                        | \$1,632                     |
| Minnesota                | 1,121            | \$557                          | \$1,625                     |
| California               | 8,013            | \$3,946                        | \$1,490                     |
| U.S.                     | 54,194           | \$26,150                       | \$1,397                     |
| New Hampshire            | 234              | \$109                          | \$1,377                     |
| Wisconsin                | 915              | \$425                          | \$1,340                     |
| Ohio                     | 1,758            | \$754                          | \$1,198                     |
| Illinois                 | 2,009            | \$806                          | \$1,011                     |
| Florida                  | 1,294            | \$650                          | \$695                       |
| Texas                    | 2,764            | \$1,161                        | \$685                       |
| New Jersey               | 572              | \$241                          | \$416                       |

**Massachusetts Research Organizations Receiving \$100M+ in NIH Funding**  
2017

| Organizations Receiving \$100M+ in NIH Funding | Awards | Funding       |
|--|--------|---------------|
| Massachusetts General Hospital                 | 812    | \$394,465,880 |
| Brigham and Women's Hospital                   | 571    | \$390,450,002 |
| Harvard Medical School                         | 415    | \$213,715,633 |
| Boston Children's Hospital                     | 345    | \$157,591,678 |
| University of Mass. Medical School Worcester   | 332    | \$154,428,281 |
| Dana-Farber Cancer Institute                   | 219    | \$144,653,313 |
| Boston University Medical Campus               | 265    | \$134,198,969 |
| Beth Israel Deaconess Medical Center           | 240    | \$130,821,684 |
| Harvard School of Public Health                | 192    | \$127,640,164 |
| Broad Institute, Inc.                          | 88     | \$125,297,044 |
| Massachusetts Institute of Technology          | 260    | \$110,825,963 |

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



## INDICATOR 15: Industry Funding for Academic Research

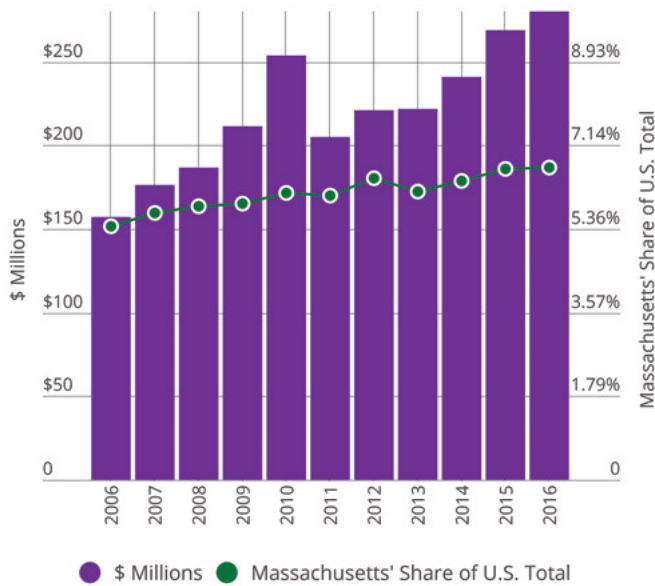
### How Does Massachusetts Perform?

After a decline in 2013, industry funding for academic research and development in science and engineering (S&E) in Massachusetts reached \$292M in 2017, a \$67M increase over 2012. Over the last five years, Massachusetts' share of the U.S. total has remained relatively steady, averaging 6.4% a year. Massachusetts' share of the U.S. total in 2017 was 6.61%.

### MASSACHUSETTS & ... INDUSTRY FUNDING FOR ACADEMIC RESEARCH

- **\$292M in 2017 Industry Funding for Academic Science & Engineering Research (5th nationally)**
- **Second highest level of Industry Funding for Academic and Science Research as a % of GDP**

**Industry Funding for Academic Research in Science & Engineering**  
Massachusetts, 2006-2016



| Year | \$ Millions | Massachusetts' Share of U.S. Total |
|------|-------------|------------------------------------|
| 2006 | \$157       | 5.42%                              |
| 2007 | \$176       | 5.69%                              |
| 2008 | \$187       | 5.84%                              |
| 2009 | \$211       | 5.90%                              |
| 2010 | \$254       | 6.13%                              |
| 2011 | \$205       | 6.07%                              |
| 2012 | \$221       | 6.45%                              |
| 2013 | \$222       | 6.16%                              |
| 2014 | \$241       | 6.37%                              |
| 2015 | \$269       | 6.65%                              |
| 2016 | \$280       | 6.66%                              |

Additional charts for select indicators can be viewed at [masstech.org/index](http://masstech.org/index)

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

### INDICATOR 15: Industry Funding for Academic Research

Since 2013 the majority of the LTS have experienced considerable growth in industry-funded academic research in S&E as a percentage of GDP, reversing the decline experienced from 2009-2013. Thirteen LTS have experienced double digit growth rates. In 2017, Massachusetts experienced an increase of \$6M of industry-funded academic research from the previous year. North Carolina leads the LTS in industry funding for academic research in S&E per \$100,000 GDP with \$76.55; MA is in second (\$64.12); the remaining LTS are substantially behind the two leaders.

In 2017, industry funding as a share of total academic S&E research funding increased to 7.45% in Massachusetts, a slight increase from 2016 (7.38%), which placed it in 3rd place among the LTS, following North Carolina (11.41%) and Ohio (8.72%).

Industry funding for academic research in S&E for each of the LTS is relatively small compared with the total research enterprise in each state, thus funding amount percentages can change dramatically from year to year.

**Industry Share of States' Total Academic R&D Funding in Science & Engineering**  
Massachusetts & LTS, 2016

| State          | Industry Share of States' Total Academic R&D Funding in S&E |
|----------------|---|
| North Carolina | 12.10%  |
| Ohio           | 8.68%   |
| New York       | 7.55%   |
| Massachusetts  | 7.38%   |
| Texas          | 6.46%   |
| California     | 6.41%   |
| Connecticut    | 6.25%   |
| Illinois       | 5.90%   |
| Pennsylvania   | 5.51%   |
| Florida        | 4.45%   |
| New Hampshire  | 3.94%   |
| New Jersey     | 3.71%   |
| Minnesota      | 3.58%   |
| Wisconsin      | 2.97%   |
| Rhode Island   | 1.76%   |

**Amount in 2016 and Growth Rate in Industry Funding for Academic Research in Science & Engineering per \$100,000 GDP**  
Massachusetts & LTS, 2011-2016

| State          | Industry Funding for Academic Research in S&E per \$100,000 GDP in 2016 | Growth Rate 2011-2016 |
|----------------|---|-----------------------|
| North Carolina | \$70.81   | 3.00%                 |
| Massachusetts  | \$56.33   | 25.64%                |
| New York       | \$32.09   | 49.36%                |
| Ohio           | \$30.88   | 9.67%                 |
| Pennsylvania   | \$29.85   | 17.68%                |
| Connecticut    | \$29.17   | 253.72%               |
| California     | \$21.98   | -5.06%                |
| Texas          | \$20.50   | -6.37%                |
| New Hampshire  | \$19.36   | -34.97%               |
| Illinois       | \$18.17   | 26.68%                |
| Rhode Island   | \$14.42   | 1.27%                 |
| Wisconsin      | \$13.97   | -12.62%               |
| Florida        | \$12.28   | 4.51%                 |
| Minnesota      | \$10.25   | -12.16%               |
| New Jersey     | \$7.57  | -28.38%               |

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

## INDICATOR 16: Venture Capital (VC)

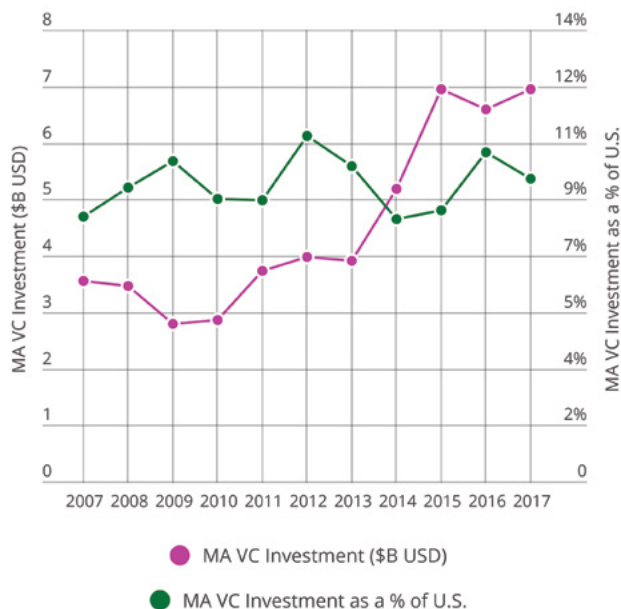
### How Does Massachusetts Perform?

Massachusetts' average share of annual VC investment from 2007 to 2017 was 9.2%, ranging from around 8% to 11% annually. The Commonwealth's VC investment fell to 9.4% of the U.S. total in 2017 down from 10.21% in 2016. California continued as the number one destination for VC investment, growing 5% from 2016. The largest gain from 2016-2017 was in Rhode Island, which had an 81% increase in VC investment from \$35 million to \$193 million. Massachusetts had the highest VC investment per \$1,000 GDP at \$15.20, with California in second at \$14.87.

### MASSACHUSETTS & ... VENTURE CAPITAL

- **\$6.9B in VC investment in 2016 (3rd Nationally)**
- **Trailed only California (\$35.9B) and New York (\$11.3B)**
- **The top 3 states for VC investment (CA, NY, MA) account for 72.8% of VC investment in the U.S.**
- **Massachusetts has the Highest VC funding per \$1,000 GDP**

**Venture Capital Investment**  
Total (\$ Billions) & as a % of U.S.  
Massachusetts, 2007-2017



| Year | MA VC Investment (\$B USD) | MA VC Investment as a % of U.S. |
|------|----------------------------|---------------------------------|
| 2007 | \$3.56                     | 8.23%                           |
| 2008 | \$3.46                     | 9.13%                           |
| 2009 | \$2.80                     | 9.94%                           |
| 2010 | \$2.86                     | 8.75%                           |
| 2011 | \$3.73                     | 8.72%                           |
| 2012 | \$3.97                     | 10.72%                          |
| 2013 | \$3.92                     | 9.79%                           |
| 2014 | \$5.18                     | 8.13%                           |
| 2015 | \$6.94                     | 8.41%                           |
| 2016 | \$6.60                     | 10.21%                          |
| 2017 | \$6.94                     | 9.40%                           |

Healthcare and Internet were by far the largest target industries for VC funding in Massachusetts in 2016, representing 53.7% and 21.0% respectively of total VC funding for the state. This reflects the Commonwealth's strength in these sectors as well as their broader appeal to investors. Venture Capital investment in Massachusetts rose 4.8% (\$6.6B to \$6.9B) from 2016-2017, with Healthcare growing 5%. Massachusetts is also home to eight 'unicorn' companies (private companies with valuation above \$1B) with seven additional national unicorn companies having presence in Boston.

The majority of total VC funding in Massachusetts went to Healthcare (53.7%) and Internet (21.0%), with other categories ranging from 5.9% in Mobile & Telecommunications to 1.9% in Automotive. The 11 specifically tracked categories represent 98.9% of all VC funding, with "Other" making up the remaining 1.1%. The fastest growth came from Automotive, going from \$1.5M to \$132M 2016-2017 (8,516%), followed by Industrial which grew \$185M (149%).

**Additional charts for select indicators can be viewed at [masstech.org/index](http://masstech.org/index)**

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

## INDICATOR 16: Venture Capital

## Venture Capital Investment by Sector

Massachusetts  
Millions of 2017 \$

| Sector                            | VC Investment (Millions of 2017 \$) |
|-----------------------------------|-------------------------------------|
| Healthcare                        | \$3,727                             |
| Internet                          | \$1,457                             |
| Mobile & Telecommunications       | \$409                               |
| Computer Hardware & Services      | \$390                               |
| Industrial                        | \$308                               |
| Software (non-internet or mobile) | \$255                               |
| Automotive                        | \$132                               |
| Electronics                       | \$96                                |
| Consumer Products & Services      | \$89                                |
| Other                             | \$73                                |

Seed funding from VC in Massachusetts decreased from 2016-2017 by \$57M (24%), but overall has increased by \$167M from 2007 to 2017, rising to \$180M. Early stage financing has increased every year since 2012, increasing by \$87M in 2017. Expansion financing increased 54% since 2007, the lowest amount compared to the other stages, and a similar amount to the 2016-2017 growth of 47%. Late stage financing fell \$205M (9%) from 2016-2017, becoming the 2nd largest category of financing, having grown 315% since 2007. Every stage of VC peaked in 2016, with the exception of Expansion, which peaked in 2015 and then fell 33% in 2016, increasing in 2017 to within 1% of that peak.

## Venture Capital Investment

Massachusetts & LTS, 2012-2017  
Millions of 2017 \$

| State | VC Investment 2017 (Mill \$) | 2016-2017 % Change | 2012-2017 % Change | 2017 VC Investment per \$1000 GDP |
|-------|------------------------------|--------------------|--------------------|-----------------------------------|
| MA    | \$6,935                      | 5%                 | 95%                | \$15.20                           |
| CA    | \$35,490                     | 5%                 | 115%               | \$14.87                           |
| NY    | \$11,274                     | 41%                | 753%               | \$8.71                            |
| RI    | \$193                        | 437%               | 1471%              | \$3.77                            |
| IL    | \$1,925                      | 61%                | 403%               | \$2.73                            |
| FL    | \$2,150                      | 70%                | 338%               | \$2.57                            |
| NC    | \$912                        | 40%                | 25%                | \$1.98                            |
| MN    | \$537                        | 34%                | 21%                | \$1.76                            |
| PA    | \$1,017                      | 43%                | -24%               | \$1.53                            |
| NJ    | \$626                        | 33%                | -60%               | \$1.23                            |
| TX    | \$1,631                      | 11%                | -6%                | \$1.07                            |
| CN    | \$231                        | 18%                | -72%               | \$1.03                            |
| NH    | \$52                         | -52%               | -75%               | \$0.73                            |
| OH    | \$299                        | 11%                | 50%                | \$0.53                            |
| WI    | \$82                         | -32%               | -29%               | \$0.29                            |

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

# TALENT - Indicators 17-22

## Why are these Indicators Significant?

### **Indicator 17: Educational Attainment - pp. 46-47**

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, businesses 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 the 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 in 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.

### **Indicator 18: Public Investment in Education - p. 48**

Investments in elementary, middle, and high schools are important for preparing a broadly educated and innovation-capable workforce. Investments in public, post-secondary 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.

### **Indicator 19: STEM Career Choices and Degrees - p. 49**

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 work in non-STEM occupations.

### **Indicator 20: Talent Flow and Attraction - pp. 50-51**

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.

### **Indicator 21: Housing Affordability - pp. 52-53**

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 both essential service providers (i.e. teachers, emergency services, etc) 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. One measure for housing affordability is the Housing Price Index which is a weighted index measuring the movement of housing prices.

### **Indicator 22: Infrastructure - pp. 54-55**

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 and affecting the overall quality of life. The more productive workers become, the more the cost of this lost time increases.

**For more information visit: [masstech.org/index](https://www.masstech.org/index)**

## INDICATOR 17: Educational Attainment

### How Does Massachusetts Perform?

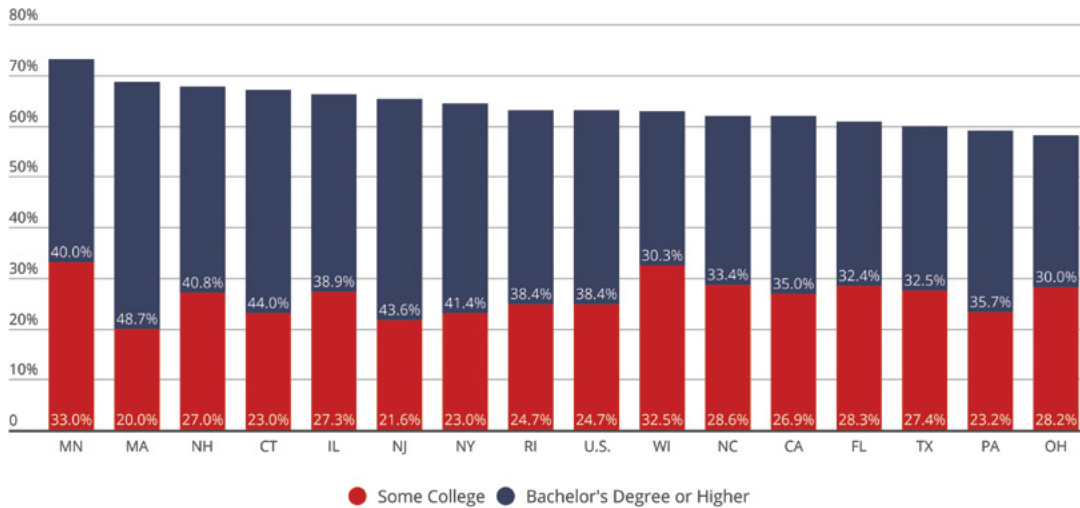
Massachusetts continues to be the 'best in class' when it comes to the percentage of adults with a bachelor's degree or higher (48.7%) when compared to the LTS (35.3%) or that of the U.S. overall (38.4%) during the 2015-2017 timeframe. Massachusetts remains competitive among the LTS in workforce educational attainment, with 68.7% of its working age population having completed at least some college, 2nd in the LTS behind Minnesota but just a percentage point ahead of 3rd place New Hampshire. Minnesota leads in overall college attainment, due largely to its strong performance with students having less than a four-year degree.

**MASSACHUSETTS & ...  
EDUCATIONAL  
ATTAINMENT**

- **48.7% of workforce with at least a bachelor's degree**
- **17.74 Postsecondary Degrees conferred per 1,000 people, 1st nationally\***

### Educational Attainment of Working Age Population

Massachusetts, LTS & U.S., Three-Year Rolling Average, 2015-2017

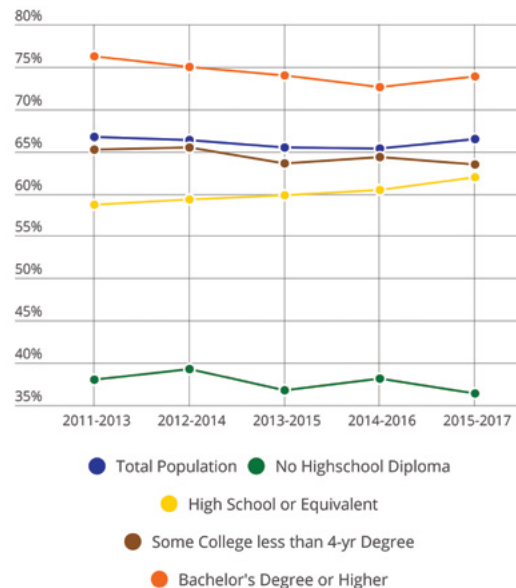


Since 2007 the percentage of adults with a Bachelor's Degree or Higher in Massachusetts has increased 7.9 percentage points, placing fourth among the LTS in this measure behind New York (14.7), New Jersey (11.2), and Illinois (8.4). The Commonwealth's overall number of college educated workers has increased by 6.8% due to a fall of 1.1% in individuals in the Some College category, which has occurred in 8 of the LTS over this period. North Carolina is the only LTS to have a decline in the percentage of individuals with a Bachelor's Degree or Higher since 2007, and the only LTS to have a decline in total college educated adults in the workforce.

### Employment Rate by Educational Attainment

Massachusetts, Three-Year Rolling Average, 2011-2017

| Categories                         | 2011-2013 | 2012-2014 | 2013-2015 | 2014-2016 | 2015-2017 |
|------------------------------------|-----------|-----------|-----------|-----------|-----------|
| Total Population                   | 66.7%     | 66.3%     | 65.5%     | 65.3%     | 66.4%     |
| No Highschool Diploma              | 38.0%     | 39.3%     | 36.7%     | 38.1%     | 36.4%     |
| High School or Equivalent          | 58.7%     | 59.3%     | 59.8%     | 60.4%     | 61.9%     |
| Some College less than 4-yr Degree | 65.2%     | 65.4%     | 63.6%     | 64.3%     | 63.4%     |
| Bachelor's Degree or Higher        | 76.3%     | 75.0%     | 74.0%     | 72.6%     | 73.8%     |



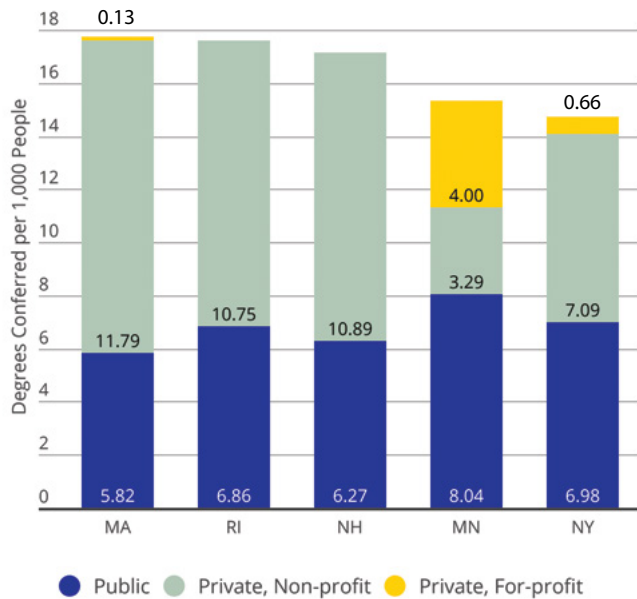
\*With non-Utah based students of online Western Governor's University calculated out.

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

## INDICATOR 17: Educational Attainment

Massachusetts (17.74) and Rhode Island (17.61) are essentially tied for first among LTS in post-secondary degrees conferred per 1,000 people with Massachusetts being 0.13 ahead due to the For-profit schools. Massachusetts is 0.13 ahead of Rhode Island in Private, Non-Profit while Rhode Island is 1.04 ahead in Public. New Hampshire placed third among the LTS (17.15), followed by Minnesota (14.86), and New York (14.73). Massachusetts also led the LTS in high school attainment of young adults, with an average of 95% of such individuals holding a diploma or equivalent from 2015-2017.

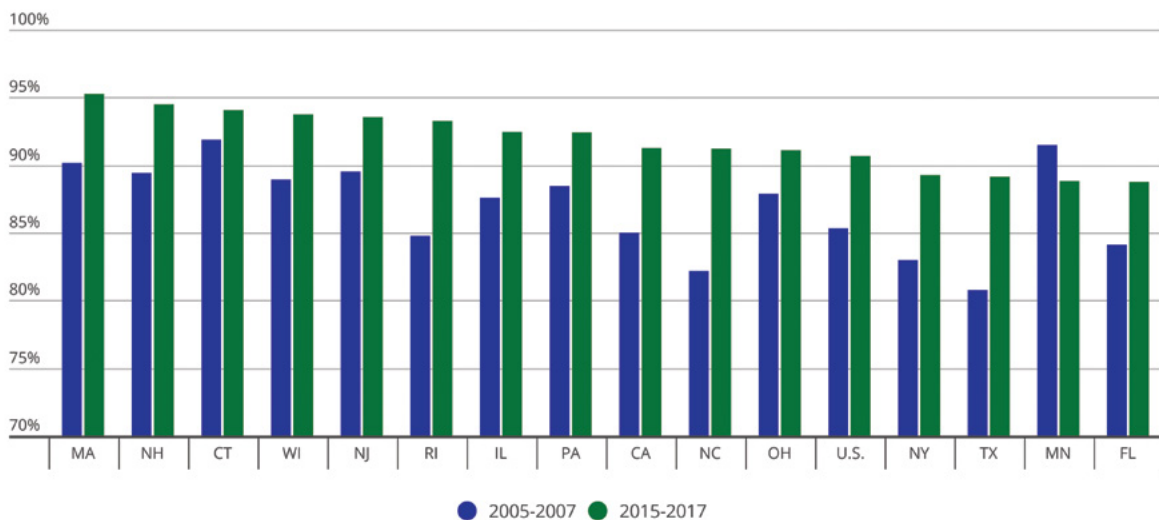
**Post-Secondary Degrees Conferred per 1,000 People**  
Massachusetts & Top 5 LTS, 2015-2016



| State | Public | Private, Non-profit | Private, For-profit |
|-------|--------|---------------------|---------------------|
| MA    | 5.82   | 11.79               | 0.13                |
| RI    | 6.86   | 10.75               | 0.00                |
| NH    | 6.27   | 10.89               | 0.00                |
| MN    | 8.04   | 3.29                | 4.00                |
| NY    | 6.98   | 7.09                | 0.66                |

### High School Attainment of Persons aged 19-24

Massachusetts, LTS & U.S., 2007 & 2017, Three-Year Rolling Average



|           | MA     | NH     | CT     | WI     | NJ     | RI     | IL     | PA     | CA     | NC     | OH     | U.S.   | NY     | TX     | MN     | FL     |
|-----------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| 2005-2007 | 90.17% | 89.42% | 91.88% | 88.94% | 89.53% | 84.78% | 87.59% | 88.46% | 85.00% | 82.19% | 87.88% | 85.34% | 82.98% | 80.76% | 91.48% | 84.11% |
| 2015-2017 | 95.26% | 94.50% | 94.07% | 93.75% | 93.56% | 93.26% | 92.46% | 92.42% | 91.26% | 91.22% | 91.10% | 90.68% | 89.27% | 89.15% | 88.83% | 88.76% |

Additional charts for select indicators can be viewed at [masstech.org/index](http://masstech.org/index)

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

## INDICATOR 18: Public Investment in Education

### How Does Massachusetts Perform?

Massachusetts continues its above-average spending per pupil on public elementary and secondary school systems (\$15,593). Of the LTS, only New York, Connecticut, and New Jersey spend more per student than Massachusetts, which spends approximately \$4,000 more per student than the national average.

In terms of higher education, appropriations per full-time-equivalent (FTE) student in Massachusetts (\$8,741) is slightly above the LTS average (\$8,165) and more significantly above the U.S. average (\$7,642). In this measure Massachusetts places 6th among the LTS but is 9th amongst LTS in student share (43.6%). This reflects the relatively high cost of education in Massachusetts compared to other LTS. Of the five LTS ahead of Massachusetts in appropriations, four of them have lower student shares.

Massachusetts' state higher education appropriations per student (\$8,741) have increased by 20.6% since 2012. Illinois had the highest level of state higher education appropriations per student in 2017, leading the LTS at \$15,468, 30.4% more than in 2012, with a student share of 32.1%.

*MASSACHUSETTS & ...*  
**PUBLIC INVESTMENT IN EDUCATION**

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- **\$15,593 in 2016 public school spending per student (8th nationally)**
- **6th in Educational Appropriations per student among LTS**

**Per Pupil Spending**  
Public Elementary/Secondary School Systems  
Massachusetts, LTS, & U.S., 2016

| State                | Per Pupil Spending |
|----------------------|--------------------|
| New York             | \$22,366           |
| Connecticut          | \$18,958           |
| New Jersey           | \$18,402           |
| Massachusetts        | \$15,593           |
| Rhode Island         | \$15,532           |
| Pennsylvania         | \$15,418           |
| New Hampshire        | \$15,340           |
| Illinois             | \$14,180           |
| Minnesota            | \$12,382           |
| Ohio                 | \$12,102           |
| <b>United States</b> | <b>\$11,762</b>    |
| California           | \$11,495           |
| Wisconsin            | \$11,456           |
| Texas                | \$9,016            |
| Florida              | \$8,920            |
| North Carolina       | \$8,792            |

**State Higher Education Appropriations per Full Time Equivalent Student**  
Massachusetts, LTS, & U.S., 2012-2017

| State               | State Higher Education Appropriations per Student 2017 | 2012-2017 % Change |
|---------------------|--|--------------------|
| Illinois            | \$15,468   | 30.42%             |
| New York            | \$10,636   | -4.91%             |
| Connecticut         | \$10,281   | 3.71%              |
| California          | \$10,157   | 41.13%             |
| North Carolina      | \$8,778  | 16.84%             |
| Massachusetts       | \$8,741  | 20.64%             |
| <b>U.S. Average</b> | <b>\$7,642</b>   | <b>7.51%</b>       |
| Texas               | \$7,356  | 0.74%              |
| New Jersey          | \$7,062  | 46.68%             |
| Minnesota           | \$6,775  | 26.29%             |
| Florida             | \$6,484  | 22.97%             |
| Rhode Island        | \$6,104  | 2.52%              |
| Wisconsin           | \$5,953  | -5.17%             |
| Ohio                | \$5,592  | 6.91%              |
| Pennsylvania        | \$4,431  | 19.24%             |
| New Hampshire       | \$2,959  | -1.30%             |

Adjusted for Inflation, Enrollment Mix, and Cost of Living

Additional charts for select indicators can be viewed at [masstech.org/index](http://masstech.org/index)

Data Source for Indicator 18: State Higher Education Office, Census Bureau, ACS



## INDICATOR 19: STEM Career Choices and Degrees

### How Does Massachusetts Perform?

Massachusetts leads the LTS in degrees (graduate & undergraduate) granted in STEM fields per one million residents at 3,292, a figure 24.7% higher than the second state, New Hampshire. Among STEM fields, engineering and biological & biomedical science are the most popular majors, together comprising 61.6% of STEM degrees granted in Massachusetts, while the LTS average is 56.6%. Computer and Information Sciences was the third most popular degree granted in STEM, accounting for 23.1% in Massachusetts and 27.4% on average in the LTS. Degrees granted in STEM fields to non-permanent residents in Massachusetts rose in all fields from 2012-2017 and total STEM degrees granted from 2012 to 2017 in Massachusetts rose 44.5%.

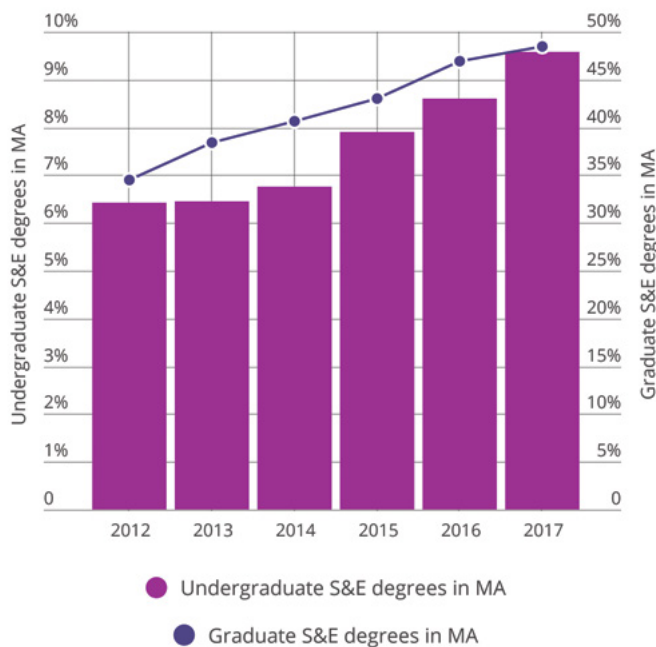
Foreign students attracted to the Commonwealth's high-quality universities and colleges are an important source of STEM talent for Massachusetts' companies and research institutions. Graduate degrees granted in Science and Engineering (S&E) to temporary, non-permanent residents reached a peak in 2017 at 48.5%. Undergraduate S&E degrees conferred to temporary, non-permanent residents also reached a new peak share at 9.6% of total undergraduate S&E degrees in 2017. However, these are comparably small numbers with Massachusetts' institutions granting 200 additional undergraduate degrees to foreign students in S&E in 2017, for a total of 1,295. This is in comparison to the 3,929 degrees granted to foreign students in 2017, which increased by 360 between 2016 and 2017.

It is expected that the number of non-permanent residents completing degrees may slow, stagnate, or decline in 2018 due to observed declining enrollments of international students.\*

### MASSACHUSETTS & ... STEM CAREER CHOICES AND DEGREES

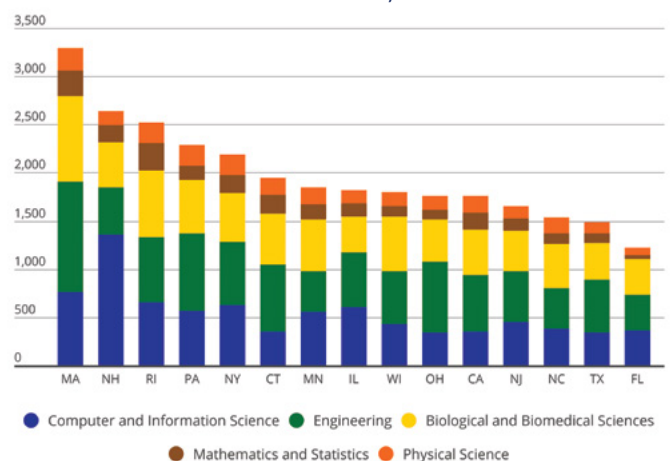
- **22,583 graduates in STEM fields in 2017 (7th in LTS)**
- **Highest number of 2017 STEM graduates per capita nationally**

**S&E Degrees Conferred to Temporary Non-permanent Residents**  
Universities in Massachusetts, 2012-2017



| Year | Undergraduate S&E degrees in MA | Graduate S&E degrees in MA |
|------|---------------------------------|----------------------------|
| 2012 | 6.42%                           | 34.51%                     |
| 2013 | 6.44%                           | 38.42%                     |
| 2014 | 6.76%                           | 40.67%                     |
| 2015 | 7.90%                           | 42.99%                     |
| 2016 | 8.60%                           | 46.89%                     |
| 2017 | 9.58%                           | 48.45%                     |

**Degrees Granted in STEM Fields All Degree Levels**  
per 1 Million Residents  
Massachusetts & LTS, 2016-2017



| State | Computer and Information Science | Engineering | Biological and Biomedical Sciences | Mathematics and Statistics | Physical Science |
|-------|----------------------------------|-------------|------------------------------------|----------------------------|------------------|
| MA    | 762                              | 1,149       | 881                                | 264                        | 237              |
| NH    | 1,358                            | 485         | 471                                | 182                        | 143              |
| RI    | 655                              | 674         | 697                                | 285                        | 212              |
| PA    | 568                              | 797         | 565                                | 147                        | 212              |
| NY    | 624                              | 656         | 508                                | 187                        | 212              |
| CT    | 356                              | 690         | 528                                | 196                        | 178              |
| MN    | 562                              | 417         | 538                                | 150                        | 177              |
| IL    | 605                              | 568         | 371                                | 138                        | 138              |
| WI    | 429                              | 546         | 566                                | 114                        | 148              |
| OH    | 344                              | 731         | 444                                | 94                         | 150              |
| CA    | 352                              | 590         | 463                                | 183                        | 173              |
| NJ    | 446                              | 533         | 420                                | 123                        | 129              |
| NC    | 380                              | 420         | 464                                | 109                        | 159              |
| TX    | 347                              | 542         | 383                                | 95                         | 115              |
| FL    | 362                              | 371         | 371                                | 44                         | 73               |

\*<https://www.bostonglobe.com/metro/2018/11/09/mba-programs-see-fewer-foreign-students/3hkvAKYQRLWAAM0ejfbv9I/story.html>  
Data Source for Indicator 19: College Board, ACS, NCES, IPEDS

## INDICATOR 20: Talent Flow and Attraction

### How Does Massachusetts Perform?

In recent years net migration in the LTS has been concentrated in the so-called “Sun Belt” states with Florida, Texas, North Carolina, and California having the highest net migration, with Massachusetts at fifth. Those four LTS with the highest net migration also had the highest total population growth from 2012-2017, and the only LTS to have population growth higher than the U.S. average. Florida’s net migration is equal to 98% of the total population growth for the state, while North Carolina’s is 78%. Massachusetts ranks 6th amongst the LTS in total population growth, 0.7% lower than the U.S. average.

Massachusetts has a strong record of attracting college educated adults, ranking first among the LTS in the percentage of net migration consisting of college educated members of the workforce. Massachusetts placed first in this measure in both 2012 and 2017.

In 2017 Massachusetts’ net migrations levels were around 22,000, the first increase since the 2013 peak of 32,251. International migration increased 10.8% from 2016-2017, reaching 45,298, while the domestic migration loss decreased from -25,606 to -23,089, an improvement of 9.8%. Overall net migration grew 45.2%.

Massachusetts has had positive net migration every year since 2008, representing a strong rebound from the early-to mid-2000’s when the state experienced six consecutive years of negative net migration.

MASSACHUSETTS & ...  
TALENT FLOW &  
ATTRACTION

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- **+22,000 in Net Migration in 2017, up 45% from 2016**
- **Positive Net Migration every year since 2008**
- **61.1% of members of the work force migrating to Massachusetts had a bachelor’s degree or higher**

### Relocation by College-Educated Adults To the LTS from Out-of-State or Abroad Massachusetts & LTS, 2012-2017

| Location    | 2012 Bachelor's Migration | 2012 Graduate or Professional Migration | College Educated % of Net Migration | 2017 Bachelor's Migration | 2017 Graduate or Professional Migration | College Educated % of Net Migration <sup>2</sup> | 2012-2017 Difference |
|-------------|---------------------------|---|-------------------------------------|---------------------------|---|--|----------------------|
| MA          | 34,398                    | 28,795                                  | 57.8%                               | 37,837                    | 38,215                                  | 61.1%  | 20.4%                |
| CA          | 141,091                   | 95,041                                  | 52.9%                               | 168,493                   | 131,032                                 | 56.1%  | 26.8%                |
| NY          | 70,878                    | 55,459                                  | 52.7%                               | 75,463                    | 69,928                                  | 55.4%  | 15.1%                |
| CN          | 14,600                    | 15,085                                  | 50.3%                               | 17,081                    | 16,802                                  | 52.3%  | 14.1%                |
| IL          | 48,846                    | 32,736                                  | 50.2%                               | 47,577                    | 38,541                                  | 54.9%  | 5.6%                 |
| NH          | 11,503                    | 5,108                                   | 50.2%                               | 9,971                     | 7,406                                   | 45.3%  | 4.6%                 |
| RI          | 5,316                     | 4,542                                   | 47.7%                               | 6,287                     | 6,390                                   | 57.3%  | 28.6%                |
| NJ          | 31,271                    | 25,810                                  | 47.2%                               | 46,714                    | 39,762                                  | 55.5%  | 51.5%                |
| MN          | 20,191                    | 12,795                                  | 45.8%                               | 23,111                    | 15,144                                  | 48.2%  | 16.0%                |
| PA          | 37,108                    | 27,586                                  | 43.5%                               | 45,830                    | 40,314                                  | 48.1%  | 33.2%                |
| WI          | 15,136                    | 11,461                                  | 43.1%                               | 19,567                    | 15,954                                  | 47.2%  | 33.6%                |
| NC          | 50,312                    | 29,684                                  | 42.5%                               | 60,490                    | 41,549                                  | 45.6%  | 27.6%                |
| <b>U.S.</b> | <b>1,290,949</b>          | <b>888,164</b>                          | <b>41.8%</b>                        | <b>1,569,061</b>          | <b>1,141,597</b>                        | <b>45.4%</b>                                     | <b>24.4%</b>         |
| OH          | 32,259                    | 24,499                                  | 40.6%                               | 35,930                    | 25,482                                  | 42.7%  | 8.2%                 |
| TX          | 92,905                    | 65,155                                  | 38.6%                               | 126,371                   | 78,169                                  | 43.3%  | 29.4%                |
| FL          | 95,527                    | 56,898                                  | 33.2%                               | 136,296                   | 87,210                                  | 39.2%  | 46.6%                |

Additional charts for select indicators can be viewed at [masstech.org/index](http://masstech.org/index)

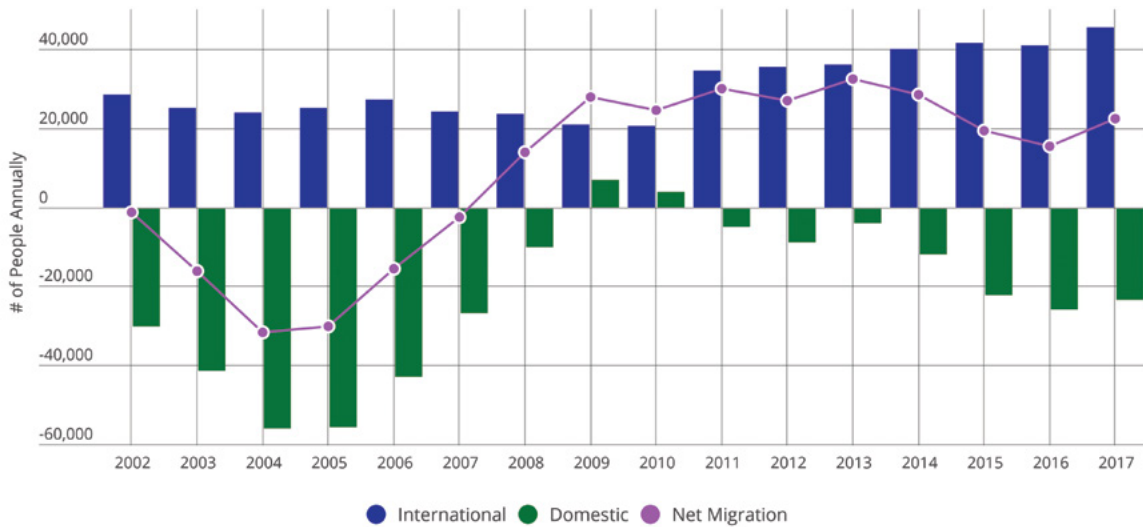
Data Source for Indicator 20: Census Bureau, ACS

## INDICATOR 20: Talent Flow and Attraction

### Population Change & Net Migration Massachusetts, U.S. & LTS, 2012 & 2017

|                | 2012 Population | 2017 Population | Total Population Change 2012-2017 | Total Population % Change 2012-2017 | Total Net Migration 2012-2017 | Net Migration % of Total Population Change |
|----------------|-----------------|-----------------|-----------------------------------|-------------------------------------|-------------------------------|--|
| United States  | 313,993,272     | 325,719,178     | 11,725,906                        | 3.7%                                | 5,985,867                     | 51%  |
| California     | 38,019,006      | 39,536,653      | 1,517,647                         | 4.0%                                | 454,943                       | 30%  |
| Connecticut    | 3,597,705       | 3,588,184       | -9,521                            | -0.3%                               | -40,524                       | 426%                                       |
| Florida        | 19,341,327      | 20,984,400      | 1,643,073                         | 8.5%                                | 1,605,627                     | 98%  |
| Illinois       | 12,878,494      | 12,802,023      | -76,471                           | -0.6%                               | -378,211                      | 495%                                       |
| Massachusetts  | 6,659,627       | 6,859,819       | 200,192                           | 3.0%                                | 129,454                       | 65%  |
| Minnesota      | 5,377,695       | 5,576,606       | 198,911                           | 3.7%                                | 62,243                        | 31%  |
| New Hampshire  | 1,320,923       | 1,342,795       | 21,872                            | 1.7%                                | 15,803                        | 72%  |
| New Jersey     | 8,882,095       | 9,005,644       | 123,549                           | 1.4%                                | -30,403                       | -25%                                       |
| New York       | 19,625,409      | 19,849,399      | 223,990                           | 1.1%                                | -213,647                      | -95%                                       |
| North Carolina | 9,755,299       | 10,273,419      | 518,120                           | 5.3%                                | 404,890                       | 78%  |
| Ohio           | 11,546,969      | 11,658,609      | 111,640                           | 1.0%                                | -34,886                       | -31%                                       |
| Pennsylvania   | 12,768,034      | 12,805,537      | 37,503                            | 0.3%                                | -6,775                        | -18%                                       |
| Rhode Island   | 1,052,761       | 1,059,639       | 6,878                             | 0.7%                                | 279                           | 4%   |
| Texas          | 26,078,327      | 28,304,596      | 2,226,269                         | 8.5%                                | 1,306,192                     | 59%  |
| Wisconsin      | 5,721,075       | 5,795,483       | 74,408                            | 1.3%                                | -14,825                       | -20%                                       |

### Domestic & International Migration Massachusetts, 2002-2017



|               | 2002    | 2003    | 2004    | 2005    | 2006    | 2007    | 2008   | 2009   | 2010   | 2011   | 2012   | 2013   | 2014    | 2015    | 2016    | 2017    |
|---------------|---------|---------|---------|---------|---------|---------|--------|--------|--------|--------|--------|--------|---------|---------|---------|---------|
| International | 28,517  | 24,961  | 23,944  | 25,220  | 27,123  | 24,226  | 23,643 | 20,866 | 20,659 | 34,572 | 35,460 | 35,960 | 40,091  | 41,526  | 40,898  | 45,298  |
| Domestic      | -29,936 | -41,300 | -55,788 | -55,426 | -42,821 | -26,666 | -9,799 | 6,843  | 3,720  | -4,679 | -8,675 | -3,709 | -11,569 | -22,087 | -25,606 | -23,089 |
| Net Migration | -1,419  | -16,339 | -31,844 | -30,206 | -15,698 | -2,440  | 13,844 | 27,709 | 24,379 | 29,893 | 26,785 | 32,251 | 28,522  | 19,439  | 15,292  | 22,209  |

Data Source for Indicator 20: Census Bureau, ACS

## INDICATOR 21: Housing Affordability

### How Does Massachusetts Perform?

The percentage of Massachusetts’ renters qualifying as “burdened” by housing costs (spending more than 30% of their income on housing) increased by 0.4% from 2016-2017. Massachusetts ranks 6th in the LTS for burdened renters after California, Florida, New York, New Jersey, and Connecticut. Massachusetts and the U.S. as a whole have seen slight declines in the percentage of burdened renters over the last five years. In every LTS, over 40% of renters spend more than 30% of their income on housing. The percentage of burdened homeowners in Massachusetts went up slightly from 2016-2017, increasing from 26.4% to 26.5%, still down 4.8% from 31.3% in 2012.

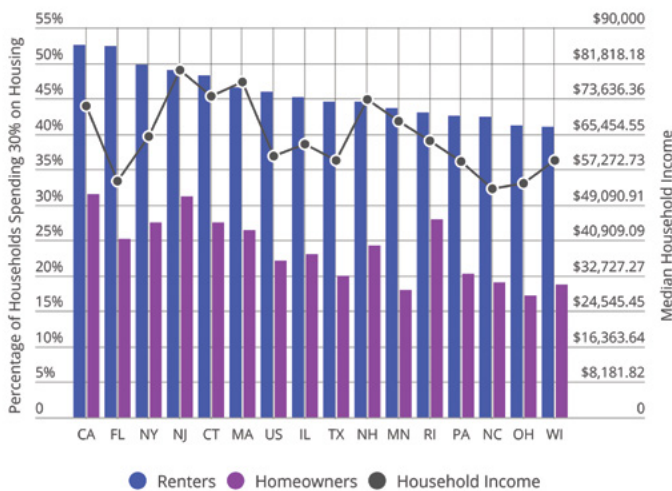
Overall, homeowners are significantly less likely to be burdened by housing costs than renters. Homeowners face differing rates of housing cost burden with over 30% of homeowners in California and New Jersey spending more than 30% of their income on housing, and fewer than 20% doing so in Minnesota, North Carolina, Ohio, and Wisconsin. On the surface, the situation seems to be improving in Massachusetts, yet home prices and rents are increasing. Demand for more housing is, however, having a positive effect on the Commonwealth’s economic growth and driving a boom in construction jobs. Around 9,800 construction jobs were created from 2016 to 2017 in Massachusetts, a 4.8% increase in construction employment.

Rising housing costs could potentially be a setback for the Massachusetts economy in the future, as the lack of affordable housing and increasing commuting times may result in losses to regions with more affordable housing stock. Over the last decade, housing prices have risen dramatically in Massachusetts, which currently ranks third highest on the Federal Housing Finance Authority Housing Price Index (HPI) among the LTS, behind Florida and Texas. While HPI in the state has just recovered past the mid-2000s levels, it has risen 34.2% from Q4 2012 (when the market bottomed out) to Q2 2018. Florida (65.6%) and California (63.9%) have both experienced especially sharp rises in prices over the same time period, though both had much lower starting points. Texas had the third highest rate of increase (45.0%) and the highest starting HPI among the three LTS with the fastest growing HPI.

**MASSACHUSETTS & ...  
HOUSING AFFORDABILITY**

- **3rd highest FHA Housing Price Index among LTS as of Q2 2018**
- **46.5% of MA renters are housing cost burdened in 2017 (6th in the LTS, 12th nationally)**

**Households Spending 30% or more of Income on Housing Costs**  
Massachusetts, LTS & U.S., 2017



|                     | Renters | Homeowners | Household Income |
|---------------------|---------|------------|------------------|
| CA                  | 52.5%   | 31.5%      | \$71,805         |
| FL                  | 52.4%   | 25.2%      | \$54,594         |
| NY                  | 49.7%   | 27.5%      | \$64,894         |
| NJ                  | 49.0%   | 31.2%      | \$80,088         |
| CT                  | 48.3%   | 27.5%      | \$74,168         |
| MA                  | 46.5%   | 26.5%      | \$77,385         |
| <b>U.S. Average</b> | 46.0%   | 22.1%      | \$60,336         |
| IL                  | 45.2%   | 23.0%      | \$62,992         |
| TX                  | 44.5%   | 20.0%      | \$59,206         |
| NH                  | 44.5%   | 24.2%      | \$73,381         |
| MN                  | 43.7%   | 18.0%      | \$68,388         |
| RI                  | 43.0%   | 28.0%      | \$63,870         |
| PA                  | 42.5%   | 20.3%      | \$59,195         |
| NC                  | 42.4%   | 19.1%      | \$52,752         |
| OH                  | 41.1%   | 17.2%      | \$54,012         |

Additional charts for select indicators can be viewed at [masstech.org/index](https://masstech.org/index)

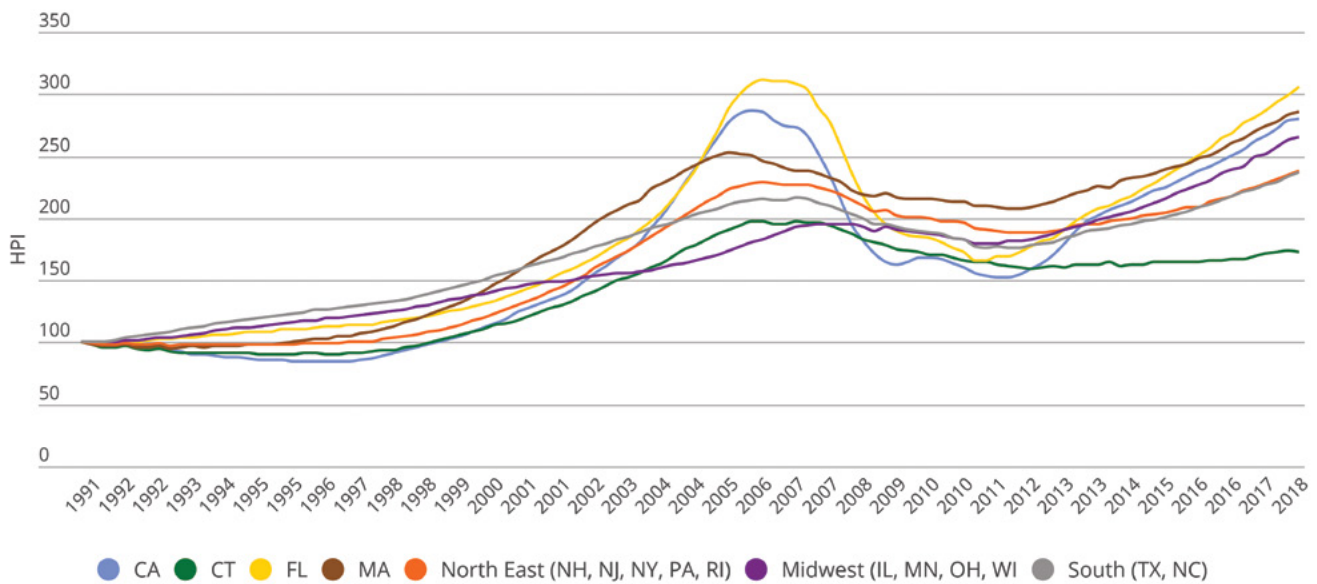
Data Source for Indicator 21: Federal Housing Finance Agency, Census Bureau, The Boston Globe, U.S. Department of Labor, Corelogic

## INDICATOR 21: Housing Affordability

**Percent of Households Spending at least 30% of Income on Housing**  
Massachusetts & U.S., 2012-2017

| Location | 2012 Homeowners | 2012 Renters | 2017 Homeowners | 2017 Renters | 2012-2017 Homeowners % Change | 2012-2017 Homeowners % Change |
|----------|-----------------|--------------|-----------------|--------------|-------------------------------|-------------------------------|
| U.S.     | 27.2%           | 48.1%        | 22.1%           | 46.0%        | -5.1%                         | -2.1%                         |
| CA       | 37.6%           | 54.6%        | 31.5%           | 52.5%        | -6.1%                         | -2.1%                         |
| CT       | 34.3%           | 49.6%        | 27.5%           | 48.3%        | -6.8%                         | -1.3%                         |
| FL       | 32.8%           | 54.2%        | 25.2%           | 52.4%        | -7.6%                         | -1.8%                         |
| IL       | 29.0%           | 47.0%        | 23.0%           | 45.2%        | -6.1%                         | -1.8%                         |
| MA       | 31.3%           | 46.8%        | 26.5%           | 46.5%        | -4.8%                         | -0.3%                         |
| MN       | 22.6%           | 45.3%        | 18.0%           | 43.7%        | -4.5%                         | -1.7%                         |
| NH       | 32.9%           | 46.1%        | 24.2%           | 44.5%        | -8.7%                         | -1.6%                         |
| NJ       | 39.0%           | 51.3%        | 31.2%           | 49.0%        | -7.9%                         | -2.3%                         |
| NY       | 33.2%           | 50.4%        | 27.5%           | 49.7%        | -5.7%                         | -0.7%                         |
| NC       | 24.5%           | 44.8%        | 19.1%           | 42.4%        | -5.4%                         | -2.5%                         |
| OH       | 22.2%           | 45.4%        | 17.2%           | 41.1%        | -5.0%                         | -4.3%                         |
| PA       | 24.8%           | 45.9%        | 20.3%           | 42.5%        | -4.4%                         | -3.4%                         |
| RI       | 33.1%           | 47.8%        | 28.0%           | 43.0%        | -5.1%                         | -4.8%                         |
| TX       | 22.8%           | 44.5%        | 20.0%           | 44.5%        | -2.8%                         | 0.1%                          |
| WI       | 25.0%           | 45.9%        | 18.8%           | 41.0%        | -6.2%                         | -5.0%                         |

**Housing Price Index**  
CA, CT, FL, MA, North East, Midwest, South  
Q1 1991-Q2 2018



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

## INDICATOR 22: Infrastructure

### How Does Massachusetts Perform?

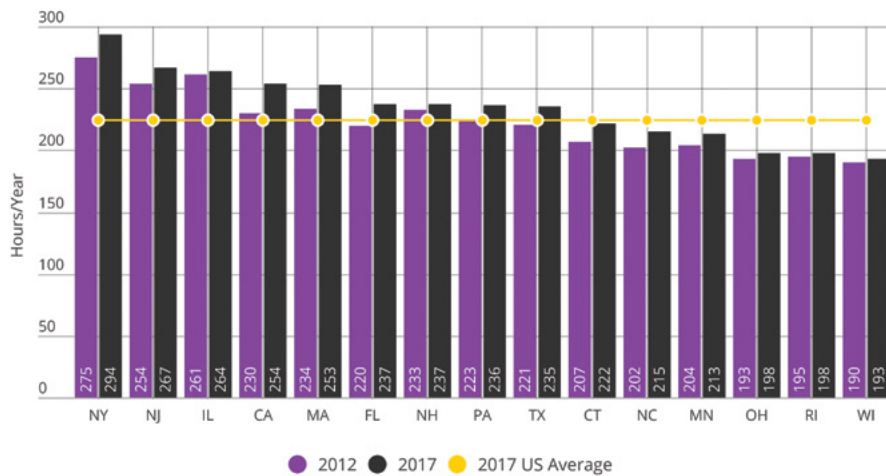
In metropolitan areas of more than 250,000 commuters (“large metros”), MA commuters spend 253 hours each year commuting on average, an increase of 19 hours since 2012. Massachusetts ranks fifth highest in this measure, nearly tied for fourth with California at 254. New York (294), New Jersey (267), and Illinois (264) all spend even more time commuting. California large metros have experienced the largest increase in commuting time, a rise of 23 hours annually. New York has experienced a similar increase in commuting time as Massachusetts, largely driven by New York City, which has experienced increasing problems with the Metropolitan Transit Authority. Illinois and Rhode Island have had the smallest increases in commuting times with 3 hour increases, the same amount as the U.S. average.

Since 1990, Massachusetts has consistently sustained higher industrial electricity prices than either the LTS or the U.S. as a whole. After a trend of declining prices from 1990 to 2006, Massachusetts has experienced a relatively large increase in industrial electricity prices compared to the LTS and the U.S. The difference in prices between Massachusetts and much of the country is due to a number of persistent factors, including a relative lack of generating capacity in New England, a lack of interconnection with other regions, and a mix of energy sources with higher input costs. The other New England states also have higher industrial electricity prices than the LTS average.

**MASSACHUSETTS & ...  
INFRASTRUCTURE**

- **Fifth highest commute times (253 hours/year) in large metros among LTS**
- **Largest percentage decrease in people driving to work**
- **97.4% of the population have access to 25/3 Mbps+ (5th among LTS), 87.8% have access to 100/10+ (11th among LTS), and 36.6% have access to 250/25+ (11th among LTS)**

**Average Metropolitan Commute Time  
Large Metros (above 250K commuters)  
Hours/Year - Massachusetts & LTS, 2012 & 2017**



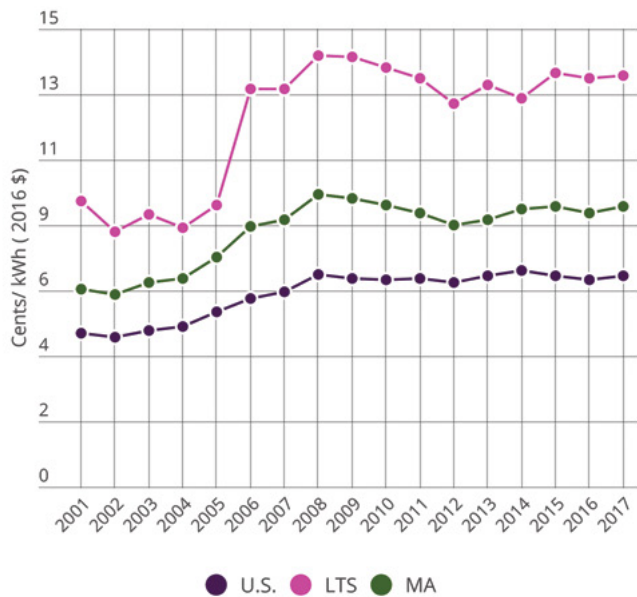
| State        | 2012 Hours/Year | 2017 Hours/year |
|--------------|-----------------|-----------------|
| NY           | 275             | 294             |
| NJ           | 254             | 267             |
| IL           | 261             | 264             |
| CA           | 230             | 254             |
| MA           | 234             | 253             |
| FL           | 220             | 237             |
| NH           | 233             | 237             |
| PA           | 223             | 236             |
| TX           | 221             | 235             |
| U.S. Average | 212             | 224             |
| CT           | 207             | 222             |
| NC           | 202             | 215             |
| MN           | 204             | 213             |
| OH           | 193             | 198             |
| RI           | 195             | 198             |
| WI           | 190             | 193             |

Additional charts for select indicators can be viewed at [masstech.org/index](http://masstech.org/index)

Data Source for Indicator 22: Census Bureau, ACS, FCC, Energy Information Administration

## INDICATOR 22: Infrastructure

**Industrial Electricity Prices**  
Massachusetts, LTS & U.S., 2001-2017  
Cents per Kilowatt Hour



| Year | U.S.   | LTS    | MA     |
|------|--------|--------|--------|
| 2001 | \$0.05 | \$0.06 | \$0.09 |
| 2002 | \$0.05 | \$0.06 | \$0.08 |
| 2003 | \$0.05 | \$0.07 | \$0.09 |
| 2004 | \$0.05 | \$0.07 | \$0.08 |
| 2005 | \$0.06 | \$0.08 | \$0.09 |
| 2006 | \$0.06 | \$0.09 | \$0.13 |
| 2007 | \$0.06 | \$0.09 | \$0.13 |
| 2008 | \$0.07 | \$0.10 | \$0.14 |
| 2009 | \$0.07 | \$0.09 | \$0.14 |
| 2010 | \$0.07 | \$0.09 | \$0.14 |
| 2011 | \$0.07 | \$0.09 | \$0.13 |
| 2012 | \$0.07 | \$0.09 | \$0.13 |
| 2013 | \$0.07 | \$0.09 | \$0.13 |
| 2014 | \$0.07 | \$0.09 | \$0.13 |
| 2015 | \$0.07 | \$0.09 | \$0.14 |
| 2016 | \$0.07 | \$0.09 | \$0.13 |
| 2017 | \$0.07 | \$0.09 | \$0.13 |

Measuring the percentage of population with access to at least one internet provider by speed in the categories of over 25 Mbps Download/3 Mbps Upload, over 100/10, and over 250/25, Massachusetts is 5th among LTS in 2017 at 25/3+ with 97.4%, 11th in 100/10+ at 87.8%, and 11th in 250/25+ at 36.6%. Access increased in all three categories, with the most significant growth from 2016-2017 being in 250/25+ which went from almost none at 0.06 to 36.58. Rhode Island and New Jersey, smaller highly urbanized states, both do very well with RI coming in 3rd at 25/3, 2nd in 100/10, and 1st in 250/25, while New Jersey comes in 2nd in 25/3, 1st for 100/10, and 3rd for 250/25. Nationwide, 90.99% of people have access to 25/3, 82.64% have access to 100/10, and 48.64% have access to 250/25.

**% of Population with Access to at Least One ISP by Speed**  
Nationwide, LTS & Massachusetts, 2016-2017

| Region         | 25/3+, 2016 | 25/3+, 2017 | 25/3+ % Change | 100/10+, 2016 | 100/10+, 2017 | 100/10+ % Change | 250/25+, 2016 | 250/25+, 2017 | 250/25+ % Change |
|----------------|-------------|-------------|----------------|---------------|---------------|------------------|---------------|---------------|------------------|
| New Jersey     | 98.67%      | 99.05%      | 0.38%          | 98.67%        | 99.05%        | 0.38%            | 2.21%         | 74.14%        | 71.93%           |
| Rhode Island   | 98.29%      | 98.28%      | -0.01%         | 98.29%        | 98.28%        | -0.01%           | 96.74%        | 97.89%        | 1.15%            |
| New York       | 97.74%      | 98.09%      | 0.35%          | 73.66%        | 97.89%        | 24.23%           | 0.94%         | 67.42%        | 66.48%           |
| Florida        | 93.17%      | 95.63%      | 2.46%          | 90.04%        | 93.88%        | 3.84%            | 4.37%         | 40.07%        | 35.70%           |
| Connecticut    | 98.70%      | 99.08%      | 0.38%          | 93.28%        | 93.74%        | 0.46%            | 12.33%        | 38.34%        | 26.01%           |
| New Hampshire  | 93.52%      | 94.30%      | 0.78%          | 82.62%        | 93.65%        | 11.03%           | 6.10%         | 6.70%         | 0.60%            |
| Pennsylvania   | 93.74%      | 94.93%      | 1.19%          | 87.31%        | 93.39%        | 6.08%            | 18.51%        | 48.18%        | 29.67%           |
| Ohio           | 91.69%      | 93.09%      | 1.40%          | 20.22%        | 90.99%        | 70.77%           | 14.43%        | 29.62%        | 15.19%           |
| California     | 93.45%      | 94.15%      | 0.70%          | 75.95%        | 90.74%        | 14.79%           | 37.31%        | 40.15%        | 2.84%            |
| North Carolina | 92.30%      | 94.03%      | 1.73%          | 77.64%        | 88.42%        | 10.78%           | 11.53%        | 28.42%        | 16.89%           |
| Massachusetts  | 96.89%      | 97.40%      | 0.51%          | 85.48%        | 87.77%        | 2.29%            | 0.06%         | 36.58%        | 36.52%           |
| Illinois       | 91.38%      | 91.22%      | -0.16%         | 84.97%        | 85.69%        | 0.72%            | 1.19%         | 84.78%        | 83.59%           |
| Texas          | 84.79%      | 87.33%      | 2.54%          | 46.99%        | 82.95%        | 35.96%           | 30.79%        | 42.09%        | 11.30%           |
| Nationwide     | 89.34%      | 90.99%      | 1.65%          | 67.69%        | 82.64%        | 14.95%           | 22.51%        | 48.64%        | 26.13%           |
| Minnesota      | 86.78%      | 88.93%      | 2.15%          | 68.04%        | 72.42%        | 4.38%            | 50.59%        | 62.06%        | 11.47%           |
| Wisconsin      | 84.68%      | 86.65%      | 1.97%          | 7.31%         | 63.62%        | 56.31%           | 5.70%         | 8.87%         | 3.17%            |

Data Source for Indicator 22: Census Bureau, ACS, FCC, Energy Information Administration

# APPENDIX I: PROFILES OF THE LEADING TECHNOLOGY STATES (LTS)

The following pages include short profiles of the LTS intended to provide data supporting their inclusion, including the Key Sectors MassTech uses to define the Innovation Economy (IE) where each state had a Location Quotient of 1.1 or above, as well as some contextual information such as examples of leading universities and research institutions, notable innovation economy employers, and a few examples of public, private, and non-profit initiatives underway in each state that are intended to support some aspect of the Innovation Economy.

## MASSACHUSETTS

**2017 POP: 6,859,819**  
**2017 GDP (\$M): \$456,176**  
**# of IE Jobs: 1,319,706**  
**% of IE Jobs: 37.3%**

### KEY SECTORS

- Biopharma & Medical Devices
- Computer & Communications Hardware
- Defense Manufacturing & Instrumentation
- Financial Services
- Healthcare Delivery
- Postsecondary Education
- Scientific, Technical, & Management Services
- Software & Communications Services

### EXAMPLE UNIVERSITIES & RESEARCH INSTITUTIONS

- Boston University
- Broad Institute
- Harvard University
- Mass General
- MIT
- Northeastern University
- Tufts University
- UMass System
- Worcester Polytechnic Institute

### EXAMPLE COMPANIES

- athenahealth
- Biogen
- Dell EMC
- Fidelity Investments
- General Electric (GE)
- Genzyme
- Raytheon
- State Street Bank

### EXAMPLE INITIATIVES

**MassRobotics:** An independent non-profit focused on growing robotics and connected devices. It seek to help bring together startups and established organizations through events with the goal of promoting economic growth and innovation. It has a 2,000 square foot lab and prototyping space, 8,000 square foot open workshop, and is renovating a second location which will be 25,000 square feet.<sup>1</sup>

**Lab Central:** LabCentral is a 103,000 sq. ft. facility that serves as a launching point for startup companies. Since 2014, companies and alumni from LabCentral have raised a total of \$2B in total funding.<sup>2</sup>

**MassChallenge:** A non-profit startup accelerator that runs a highly competitive program that attracts applications from all over the world. MassChallenge participants do not give up equity as winners, and share over \$1.5M of grants at the end of each annual program, made possible by public and private sector donors. Since being founded in 2010, MassChallenge has grown into the world's largest accelerator program expanding to Israel, the UK, Switzerland, Mexico, and Texas, as well as key programs focused on growing verticals/sectors such as healthcare technology and financial tech (FinTech). MassChallenge has over 1,500 alumni that have created over 80,000 jobs and raised \$3B.<sup>3</sup>

## CALIFORNIA

**2017 POP: 39,536,653**  
**2017 GDP (\$M): \$2,386,388**  
**# of IE Jobs: 4,754,674**  
**% of IE Jobs: 27.9%**

### KEY SECTORS

- Biopharma & Medical Devices
- Computer & Communications Hardware
- Defense Manufacturing & Instrumentation
- Scientific, Technical, & Management Services
- Software & Communications Services

### EXAMPLE UNIVERSITIES & RESEARCH INSTITUTIONS

- Cal Tech
- Lawrence Livermore National Lab
- Scripps Oceanographic Institute
- Stanford University
- UC Berkeley
- UCLA

### EXAMPLE COMPANIES

- Amgen
- Apple
- Cisco
- Facebook
- Google
- Intel
- Lockheed Martin
- Oracle
- Qualcomm

### EXAMPLE INITIATIVES

**California Nanotechnology Initiative:** A Northern California-based initiative to push the development of nanotechnology and the “nano-bio-IT convergence technology economy” of the area.<sup>4</sup>

**SFMade:** A non-profit organization dedicated to building and sustaining a manufacturing industry in San Francisco. It engages with entrepreneurs and small companies who are based and manufacture in San Francisco, offering education, networking, and assistance making connections to local resources. It engages directly with employers on workforce problems, seeking to connect it with local hiring resources and training programs. SFMade also engages with the larger San Francisco community, hosting educational workshops, factory tours, and other programs to highlight manufacturing and its importance to the local economy.<sup>5</sup>

**CONNECT:** A non-profit organization spun out of UC San Diego tasked with fostering the growth of San Diego's innovation ecosystem by acting as an incubator of sorts for cluster organizations, eventually spinning them off when they are able to stand on their own. Past successes include BIOCUM, San Diego Telecom Council, and CleanTECH San Diego. CONNECT's Springboard mentorship program has 465 alumni, 35 of which have been acquired and 255 of which are still in business. Participating companies have raised \$1.95B in capital and created over 6,400 jobs since inception, with 50 alumni raising \$291M in 2017.<sup>6</sup>



## APPENDIX I: PROFILES OF THE LEADING TECHNOLOGY STATES

### PENNSYLVANIA

**2017 POP: 12,805,537**  
**2017 GDP (\$M): \$663,847**  
**# of IE Jobs: 1,854,819**  
**% of IE Jobs: 32.0%**

#### KEY SECTORS

- Advanced Materials
- Biopharma & Medical Devices
- Business Services
- Diversified Industrial Manufacturing
- Financial Services
- Healthcare Delivery
- Postsecondary Education

#### EXAMPLE UNIVERSITIES & RESEARCH INSTITUTIONS

- Carnegie Mellon
- Penn State
- Temple University
- University of Pennsylvania
- University of Pittsburgh

#### EXAMPLE COMPANIES

- Allegheny Technology
- Comcast
- GE Transportation
- PNC Financial
- Uber
- Wyeth Pharmaceuticals

#### EXAMPLE INITIATIVES

**Pennsylvania Life Sciences Greenhouse Initiative:** A group nonprofit biotechnology initiative that includes BioAdvance Biotechnology Greenhouse of Southeastern PA, Life Sciences Greenhouse of Central PA, and the Pittsburgh Life Sciences Greenhouse. The overall program has invested more than \$90M, with \$245.7M in federal follow-on funding and more than \$4.7 billion private follow-on funding. The Initiative has funded 227 projects and companies, which have created 4,896 jobs and 261 new technologies.<sup>7</sup>

**Ben Franklin Technology Partners (BFTP):** BFTP has been an important seed stage capital provider for PA's technology sectors, boosting PA's economy by more than \$23.5 billion from 1989-2011 and generating 51,000 jobs in client firms with another 89,000 generated beyond those client firms. In 2014 BFTP assisted 1,125 client firms, which created 1,103 jobs, and had 130 patents and software copyrights awarded to client companies. BFTP has regional headquarters in the Lehigh Valley, Philadelphia, Pittsburgh, and State College.<sup>8</sup>

**The Science Center:** Five educational and medical institutions in Philadelphia joined together in 1963 to create the Science Center, an organization that promotes place and innovation-based economic developments in the Philadelphia region by convening entrepreneurs, investors, and academia, as well as through the creation of a large, urban science park. Since its founding in 1963 it has provided incubation services to 442 firms, 214 of which are still in business today. The Science Center has 12,000 employees, which in turn support 28,000 jobs in the region, and over its lifetime has had \$7.1 billion in direct output and \$5.8 billion in indirect output.<sup>9</sup>

### NEW YORK

**2017 POP: 19,849,399**  
**2017 GDP (\$M): \$1,294,571**  
**# of IE Jobs: 2,933,622**  
**% of IE Jobs: 31.6%**

#### KEY SECTORS

- Business Services
- Financial Services
- Postsecondary Education

#### EXAMPLE UNIVERSITIES & RESEARCH INSTITUTIONS

- Columbia University
- Cornell University
- New York University
- State University of New York System
- University of Rochester

#### EXAMPLE COMPANIES

- Bristol Myers Squibb
- IBM
- Global Foundries
- Most major banks
- Xerox

#### EXAMPLE INITIATIVES

**Cornell Tech:** In 2011, New York City created a \$100M prize paired with free land to attract a graduate engineering school. The winning proposal was submitted by Cornell University of Ithaca, NY and Technion-Israel Institute of Technology for Cornell Tech, located on Roosevelt Island. The new campus is a multi-decade endeavor, purpose built to encourage collaboration, innovation, and entrepreneurship. Since 2014 more than 41 startups have been founded by alumni, which employ 173 people and have raised more than \$32 million.<sup>10</sup>

**NYS STEM Incentive Program:** An incentive program to provide tuition awards to students who are in the top 10% of their graduating class who are pursuing a two- or four-year STEM degree and agree to live and work in a STEM field in New York State for five years after graduation.<sup>11</sup>

**NYSTAR Centers for Advanced Technology (CAT):** Created in 1983, CAT funds and facilitates a program of basic and applied R&D as well as technology transfer in collaboration with private industry. NYSTAR identifies strategically important technology fields for New York State and uses a competitive process to award 10-year CAT designations to universities, university-affiliated research institutes, or consortia of several institutions. There are currently 15 active CATs.<sup>12</sup>

## APPENDIX I: PROFILES OF THE LEADING TECHNOLOGY STATES

### ILLINOIS

**2017 POP: 12,802,023**  
**2017 GDP (\$M): \$705,414**  
**# of IE Jobs: 1,794,788**  
**% of IE Jobs: 30.3%**

#### KEY SECTORS

- Advanced Materials
- Diversified Industrial Manufacturing
- Financial Services
- Postsecondary Education
- Scientific, Technical, & Management Services

#### EXAMPLE UNIVERSITIES & RESEARCH INSTITUTIONS

- Northwestern University
- University of Chicago
- University of Illinois
- University of Illinois Urbana-Champaign

#### EXAMPLE COMPANIES

- AbbVie
- Boeing
- Caterpillar
- Chase Bank
- Chicago Mercantile Exchange
- John Deere
- Motorola

#### EXAMPLE INITIATIVES

**University Technology Park at IIT:** Opened officially in 2006, UTP is a 300,000 sq. ft. facility run by the Illinois Institute of Technology, housing both wet and dry labs. Currently has 18 companies residing there with 45 having graduated.<sup>13</sup>

**Illinois Innovation Network (IIN):** Launched in 2013, IIN serves as a platform to connect a wide ranging variety of local entities; from startups to researchers to community leaders, and many others. IIN helps to connect entrepreneurs to resources, bring together the Illinois Innovation Economy, and generally advance the goal of Illinois becoming a top destination for innovation.<sup>14</sup>

**Illinois Technology Development Account:** In 2003, the State Treasurer was authorized to invest up to 1% of the state's investment portfolio into venture capital and private equity in Illinois. The first fund launched in 2005 and accrued \$38.8 million in realized gains as well, and created an estimated 2,861 direct jobs and 3,433 indirect jobs. It is scheduled to wind down between 2016 and 2023, but was successful enough that in 2016 a second fund was announced. It is expected to create 8,500 jobs directly and another 10,300 indirectly and invest \$222 million of the State's Investment Portfolio while attracting \$400 million of additional private sector money.<sup>15</sup>

### OHIO

**2017 POP: 11,658,609**  
**2017 GDP (\$M): \$561,803**  
**# of IE Jobs: 1,636,208**  
**% of IE Jobs: 30.5%**

#### KEY SECTORS

- Advanced Materials
- Business Services
- Defense Manufacturing & Instrumentation
- Diversified Industrial Manufacturing
- Healthcare Delivery

#### EXAMPLE UNIVERSITIES & RESEARCH INSTITUTIONS

- Case Western Reserve
- Cleveland Clinic
- Kent State University
- Ohio State
- University of Cincinnati
- Wright-Patterson Air Force Base

#### EXAMPLE COMPANIES

- GE Aviation
- General Dynamics
- Jones Day
- Nationwide Insurance
- Timken Steel

#### EXAMPLE INITIATIVES

**Bioenterprise:** A public-private partnership started by the state government, several foundations, research universities, and hospitals to grow the biotech industry in the Cleveland Metropolitan Area.<sup>16</sup>

**Ohio Third Frontier:** Ohio Third Frontier is a business incubator launched by the Ohio State Development Agency with a focus on "accelerating the creation and growth of investable and scalable technology and tech-enabled companies throughout Ohio." Since creation they have created 3,074 jobs across 330 companies by investing \$85.2M in state dollars, matched by private for investments that bring the total to \$175M. This in turn has attracted \$1.6B in follow-on equity.<sup>17</sup>

**Partners for a Competitive Workforce:** A public-private partnership in the Greater Cincinnati Area that seeks to meet current and future demands for skilled workers through the creation of job matching programs, designing new training programs, and working with educational institutions to develop career pathways.<sup>18</sup>

### CONNECTICUT

**2017 POP: 3,588,184**  
**2017 GDP (\$M): \$224,739**  
**# of IE Jobs: 561,469**  
**% of IE Jobs: 33.6%**

#### KEY SECTORS

- Biopharma & Medical Devices
- Computer & Communications Hardware
- Defense Manufacturing & Instrumentation
- Diversified Industrial Manufacturing
- Financial Services
- Postsecondary Education

#### EXAMPLE UNIVERSITIES & RESEARCH INSTITUTIONS

- Hartford Hospital
- UConn
- Yale

#### EXAMPLE COMPANIES

- Accenture
- Aetna
- Apex
- Cigna
- United Technologies
- General Dynamics
- Kayak
- Priceline
- Sikorsky
- The Hartford
- Travelers

#### EXAMPLE INITIATIVES

**UConn Tech Park:** Phase one of a new university technology park, the Innovation Partnership Building was completed in 2017 and a ribbon cutting ceremony to mark its official opening was held on September 20th, 2018. The goal is to facilitate partnerships between industry and the university by providing flexible lab space and access to UConn's research resources and "Industry Centers."<sup>19</sup>

**CT Next:** Statewide network with more than 1,500 members that connects start-ups to mentors, collaborative workspaces, universities, suppliers, and other entrepreneurs. CT Next offers easy to navigate resource guides tailored to entrepreneurs and start-ups in different phases of development. It also offers a variety of grant programs to first-time entrepreneurs, start-ups, and municipalities aimed at making it easier to start a business, find talent, and attract more of each to Connecticut.<sup>20</sup>

**Connecticut Skills Challenge:** Coding and engineering contests for college students to test their skills and get noticed by employers. Challenge participants are entered into an online directory where employers can search for talent and are invited to participate in Connecticut Technology Council Job Fairs.<sup>21</sup>

## APPENDIX I: PROFILES OF THE LEADING TECHNOLOGY STATES

### MINNESOTA

**2017 POP: 5,576,606**  
**2017 GDP (\$M): \$305,627**  
**# of IE Jobs: 914,590**  
**% of IE Jobs: 32.0%**

#### KEY SECTORS

- Biopharma & Medical Devices
- Business Services
- Computer & Communications Hardware
- Diversified Industrial Manufacturing
- Financial Services

#### EXAMPLE UNIVERSITIES & RESEARCH INSTITUTIONS

- Mayo Clinic
- University of Minnesota

#### EXAMPLE COMPANIES

- 3M
- IBM
- Medtronic
- St. Jude Medical
- U.S. Bancorp
- United Health

#### EXAMPLE INITIATIVES

**Minnesota’s Discovery, Research, and Innovation Economy (MnDRIVE):** An \$18M annually recurring investment in four research areas at the University of Minnesota: Robotics, Global Food, Environment, and Brain Conditions. In 2017, a fifth area, Cancer Clinical Trials, was added and an additional \$4M per year was appropriated. To date MnDRIVE has leveraged \$167M in external funding and launched 13 start-up companies.<sup>22</sup>

**Enterprise Minnesota:** A non-profit manufacturing consulting organization that works with small-and medium-sized companies to increase efficiency and profitability. It has helped 510 Minnesota manufacturing companies gain access to strategies that increase efficiency and promote growth. Resulting from the organization’s work, clients have realized a total positive economic impact of over \$696 million in sales, reduced costs by over \$131M, invested over \$289M in capital expenditures and modernization and added or retained over 6,600 jobs. Also administers the Growth Acceleration Program through which the Minnesota state government provides matching funds to small businesses looking to invest in improving their operations.<sup>23</sup>

**University Ave Innovation District:** Townside Innovation District is a 370-acre innovation district which extends from the University of Minnesota east into St. Paul. It is the only innovation district in the Twin Cities “with the intent to mix entrepreneurs, residents, researchers, developers and businesses with a new, restorative, healthy and arts-inspired community.” The District spreads across two cities, has three light rail stations, and has over 30 community partners.<sup>24</sup>

### NORTH CAROLINA

**2017 POP: 10,273,419**  
**2017 GDP (\$M): \$459,287**  
**# of IE Jobs: 1,291,795**  
**% of IE Jobs: 29.8%**

#### KEY SECTORS

- Advanced Materials
- Biopharma & Medical Devices
- Computer & Communications Hardware
- Postsecondary Education

#### EXAMPLE UNIVERSITIES & RESEARCH INSTITUTIONS

- Duke University
- North Carolina State
- UNC Chapel Hill

#### EXAMPLE COMPANIES

- Bank of America
- Cisco Systems
- GlaxoSmithKline
- IBM
- Red Hat
- SAS Institute

#### EXAMPLE INITIATIVES

**Research Triangle Park (RTP):** An industry, university, and government partnership that leverages its proximity to Duke, UNC Chapel Hill, and NC State to create the world’s largest research park run by a non-profit that re-invests profits in improving the community. RTP is home to 250 companies and 50,000 skilled workers, and has \$300 million in annual investment by industries in the region’s universities each year.<sup>25</sup>

**NCBioImpact:** A partnership between North Carolina Biotechnology Center (NCBIO an industry group), the North Carolina Department of Commerce, and the state’s university and community college systems that created a training program to support the needs of the nascent biotech industry in the state. More than \$100 million has been invested in training facilities and programs around North Carolina.<sup>26</sup>

**NC IDEA:** NC IDEA serves as a “catalyst for young, high-growth, technology companies in North Carolina.” Its main focus is providing grant financing for companies in IT, Medical Diagnostics and Devices, Material Sciences, and Green Technology. Grantees may also utilize the extensive expertise of NC IDEA management in growing early stage companies. Since 2006, over 250 companies have been supported, 70% of which are still in business. Twelve of those companies have raised more than \$5 million in funding and 25% of them have raised more than \$250,000.<sup>27</sup>

## APPENDIX I: PROFILES OF THE LEADING TECHNOLOGY STATES

### TEXAS

**2017 POP: 28,304,596**  
**2017 GDP (\$M): \$1,521,003**  
**# of IE Jobs: 3,423,587**  
**% of IE Jobs: 28.5%**

#### KEY SECTORS

- Computer & Communications Hardware

#### EXAMPLE UNIVERSITIES & RESEARCH INSTITUTIONS

- NASA Johnson Space Center
- Rice University
- Texas Medical Center
- Texas A&M
- University of Houston
- University of Texas
- M.D. Anderson Cancer Center

#### EXAMPLE COMPANIES

- Apple
- Celanese
- Dell
- Freescale Semiconductor
- Rackspace
- Texas Instruments

#### EXAMPLE INITIATIVES

**Governor’s University Research Initiative (GURI):** Established in 2015, GURI is a matching grant program to assist eligible institutions of higher education in recruiting distinguished researchers, with the goal of bringing Nobel Laureates, winners of other prestigious awards, and members of honorific societies to Texas universities.<sup>28</sup>

**Texas Enterprise Fund (TEF):** A financial incentive program awarding cash grants to economic development projects where significant job creation and capital investment are projected, with the stipulation that a single Texas site be in competition with a viable out-of-state option. The fund is intended as a “deal closer” to push companies to choose Texas over the next closest competitor. Award amounts are determined by projected job creation and investment. As of 2017, TEF awarded 146 grants totaling nearly \$610M to projects that have committed to create over 83,000 jobs and generate more than \$27B in investment.<sup>29</sup>

**BioHouston:** A non-profit organization leading a broad-based effort to establish the Houston region as a top-tier global competitor in life science and biotechnology commercialization. Its mission is to create an environment that will stimulate technology transfer and research commercialization, thereby generating economic growth for the Houston region and making it a global competitor in the life sciences industry.<sup>30</sup>

### NEW JERSEY

**2017 POP: 9,005,644**  
**2017 GDP (\$M): \$511,302**  
**# of IE Jobs: 1,203,931**  
**% of IE Jobs: 30.0%**

#### KEY SECTORS

- Biopharma & Medical Devices
- Financial Services
- Scientific, Technical, & Management Services
- Software & Communications Services

#### EXAMPLE UNIVERSITIES & RESEARCH INSTITUTIONS

- New Jersey Institute of Technology
- Princeton University
- Rutgers University
- Stevens Institute of Technology

#### EXAMPLE COMPANIES

- Bristol Myers Squibb
- Johnson & Johnson
- Merck
- Pfizer
- Prudential

#### EXAMPLE INITIATIVES

**New Jersey Innovation Institute:** New Jersey Innovation Institute is a non-profit organization intended to match local firms with university researchers in order to accelerate R&D 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.<sup>31</sup>

**New Jersey Business Incubation Network:** A statewide network of business experts and resource facilities focused on supporting early and expansion stage entrepreneurial companies, increasing high value jobs, and assisting the state economic growth strategy. Over the past three years, companies in their incubators have created or retained on average over 1,350 higher-paying jobs, have generated \$130 million in revenue, have brought \$30 million third-party funding to NJ, and have trained more than 200 student interns.<sup>32</sup>

**Newark Innovation Acceleration Challenge:** Entrepreneurs submit ideas to be evaluated by a panel of judges for the opportunity to win \$3,000 to fund a summer fellowship to work on their idea. Open to Greater Newark college students and Greater Newark residents who are proposing to start a business in Newark.<sup>33</sup>

## APPENDIX I: PROFILES OF THE LEADING TECHNOLOGY STATES

### NEW HAMPSHIRE

**2017 POP: 1,342,795**  
**2017 GDP (\$M): \$70,509**  
**# of IE Jobs: 208,004**  
**% of IE Jobs: 31.8%**

#### KEY SECTORS

- Computer & Communications Hardware
- Defense Manufacturing & Instrumentation
- Diversified Industrial Manufacturing
- Financial Services
- Postsecondary Education

#### KEY SECTORS (cont)

- Software & Communications Services

#### EXAMPLE UNIVERSITIES & RESEARCH INSTITUTIONS

- Dartmouth College
- Dartmouth Hitchcock Medical Center
- University of New Hampshire

#### EXAMPLE COMPANIES

- BAE Systems
- Dyn
- Fidelity Investments
- Hypertherm
- Lonza Biologics
- Portsmouth Naval Shipyard

#### EXAMPLE INITIATIVES

**New Hampshire Innovation Research Center (NHIRC):** A program at the University of New Hampshire, created in 1991 by the state legislature with the goal of increasing university-industry collaboration and commercializing innovations to increase the number of high wage jobs in New Hampshire. To date, \$8M in state funds have been awarded to support research projects, resulting in at least 685 new jobs. Awardees have received \$32M in Small Business Innovation Research (SBIR) funding and \$900M in investment/acquisition capital.<sup>34</sup>

**Game Assembly:** A group of video game developers committed to advancing the digital gaming industry in New Hampshire. The group aims to achieve this by growing the number of game studios in NH, retaining the talent in-state, and creating awareness and education opportunities for local students.<sup>35</sup>

**Future Tech Women:** An initiative to increase the number of women in technology through empowerment, and programs such as mentorship, to increase awareness and success of women in technology related fields.<sup>36</sup>

### RHODE ISLAND

**2017 POP: 1,059,639**  
**2017 GDP (\$M): \$51,195**  
**# of IE Jobs: 148,704**  
**% of IE Jobs: 31.1%**

#### KEY SECTORS

- Biopharma & Medical Devices
- Business Services
- Diversified Industrial Manufacturing
- Financial Services
- Healthcare Delivery
- Postsecondary Education

#### EXAMPLE UNIVERSITIES & RESEARCH INSTITUTIONS

- Brown University
- Rhode Island School of Design
- University of Rhode Island
- U.S. Naval War College

#### EXAMPLE COMPANIES

- Amica Insurance
- Citizens Financial
- CVS Caremark
- Fidelity Investments
- General Dynamics
- Metlife
- Textron

#### EXAMPLE INITIATIVES

**UnderSea Technology Innovation Consortium (UTIC):** A consortium of private defense and marine companies, the University of Rhode Island, and the U.S. Navy intended to accelerate the development of advanced undersea and maritime technologies for academic, commercial, and defense purposes. In June 2018, the Other Transaction Authority (OTA) agreement was awarded to UTIC by the Naval Undersea Warfare Center. The three-year, potentially 10-year OTA agreement, was awarded for industry, academia, and the nonprofit sector, to prototype a wide range of undersea and maritime activities.<sup>37</sup>

**Innovation Vouchers:** The Rhode Island Commerce Corporation program lets business utilize R&D capacity in the state. Rhode Island businesses with fewer than 500 employees can receive grants of up to \$50,000 to fund R&D assistance from a Rhode Island university, research center, or medical center. Rhode Island manufacturers also have the option to use the voucher to fund an internal R&D project.<sup>38</sup>

**Innovate RI Fund:** Created in 2013 by the Rhode Island General Assembly, the Fund supports a variety of programs through which eligible Rhode Island small businesses may apply for grants to reduce the cost of applying for SBIR/STTR awards, to match SBIR/STTR Phase I and Phase II awards, and to hire interns.<sup>39</sup>

## APPENDIX I: PROFILES OF THE LEADING TECHNOLOGY STATES

### FLORIDA

**2017 POP: 20,984,400**  
**2017 GDP (\$M): \$836,056**  
**# of IE Jobs: 2,350,603**  
**% of IE Jobs: 27.7%**

#### KEY SECTORS

- Biopharma & Medical Devices
- Business Services
- Scientific, Technical, & Management Services

#### EXAMPLE UNIVERSITIES & RESEARCH INSTITUTIONS

- Florida State
- NASA Cape Canaveral
- University of Florida
- University of South Florida

#### EXAMPLE COMPANIES

- Boeing
- Electronic Arts-Tiburon
- First Data
- FIS
- Lockheed Martin
- Raymond James
- Sanofi Pasteur/Vax Design
- SRI International

#### EXAMPLE INITIATIVES

**Florida Gulf Coast University Innovation Hub:** The Emergent Technologies Institute (ETI) is a 26,000 square foot complex with research labs, classrooms, and offices situated on a 6.5-acre campus. ETI supports workforce and economic development along with education initiatives. For R&D it has 3 research labs, 2 high-bay research labs, 2 teaching labs, and a machine shop along with 2 acres fenced in for outdoor research projects. There are 2 large classrooms, 3 regular classrooms, a computer lab and 10 offices. ETI is planned to be the first part of a 240-acre development in Fort Myers called ITEC, which hopes to attract research and technology companies.<sup>40</sup>

**Innovation Florida:** A non-profit organization working to create an innovation economy in Florida through five different strategies: Academic Outreach, Connecting Business to Government, Venture Capital Outreach, Cross Border Collaboration, and Supporting Innovation.<sup>41</sup>

**Scripps Research Institute Florida:** A private nonprofit founded in 2004, Scripps was ranked as the top nonprofit scientific institute in 2017. The Jupiter (Fla) Campus, over 350,000 square feet on 30 acres, was completed in 2009. Scripps has produced nearly 1,000 U.S. patents and 70+ spinoff companies.<sup>42</sup>

### WISCONSIN

**2017 POP: 5,795,483**  
**2017 GDP (\$M): \$282,043**  
**# of IE Jobs: 862,779**  
**% of IE Jobs: 30.3%**

#### KEY SECTORS

- Advanced Materials
- Business Services
- Defense Manufacturing & Instrumentation
- Diversified Industrial Manufacturing
- Financial Services

#### EXAMPLE UNIVERSITIES & RESEARCH INSTITUTIONS

- Marquette University
- Milwaukee School of Engineering
- University of Wisconsin System

#### EXAMPLE COMPANIES

- Caterpillar
- Epic Systems
- Fiserv
- Harley Davidson
- John Deere
- Johnson Controls
- Kohler
- Oshkosh
- Rockwell Automation

#### EXAMPLE INITIATIVES

**Qualified New Business Venture Program (QNBV):** A program intended to incentivize investments in early stage businesses developing innovative products, processes, or services by angel investors, angel investment networks, and qualified venture capital funds. Investors are provided a Wisconsin income tax credit, equal to 25 percent of the value of investment made in certified companies.<sup>43</sup>

**The Water Council:** A non-profit organization led by a group of Milwaukee-area businesses, universities, and government agencies with the aim of turning the region into the global hub for the Water Industry. The Water Council pursues this goal through economic, technology, and talent development as well as convening industry leaders in Milwaukee, which is now home to over 200 water technology businesses. The Water Council also operates the Global Water Center, a 98,000 square-foot hub for industry-university collaboration and the development of new companies in Milwaukee. The Council currently consists of 191 members.<sup>44</sup>

**UW Milwaukee Innovation Campus:** A "third generation" research park that offers technology transfer and business incubation services. The campus incorporates the academic and research enterprise of the university directly into the development of the private sector park that will leverage the research and intellectual property generated by the university.<sup>45</sup>

# APPENDIX II: DATA SOURCES

The *22nd Edition of the Index* tracks a selection of 22 indicators that MassTech and its *Index* Advisory Committee (page 71) view as being the most comprehensive set of data for benchmarking the Innovation Economy. Indicators can change from year-to-year as new data sources become available and best-practices in tracking economic data are updated. MassTech and the *Index* Advisory Committee review the selection of indicators each year to determine whether to add or remove any and whether or not better sources of data are available.

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

### I. Note on 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 timeframes are not identical and cannot be compared without adjustments. This appendix provides information on the data sources for each indicator.

The *Index* always displays the most recent year of data available for each indicator at the time of writing.

### II. Note on Price Adjustment

The *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, U.S. Department of Labor ([www.bls.gov/data](http://www.bls.gov/data)).

### III. Note on Per-Capita Comparisons

The *Index* makes frequent use of per-capita metrics in order to make meaningful comparisons between states of vastly different sizes since the Leading Technology States (LTS) range from roughly 1 million people to nearly 40 million. Per-capita or "as a % of" metrics allow the *Index* to make comparisons on density in certain measures, which MassTech views as crucial to cluster formation and growth. Where performance is less tied to a state's population, the *Index* includes absolute figures as well.

### IV. Note on 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 for this year's *Index* includes the 10 states used every year since 2012: California, Connecticut, Illinois, Massachusetts, Minnesota, New Jersey, New York, Ohio, Pennsylvania, and Texas. This edition of the *Index* also includes five additional states: Florida, New Hampshire, North Carolina, Rhode Island, and Wisconsin. In 2018, 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: Advanced Materials, Biopharma & Medical Devices, Business Services, Computer & Communication Hardware, Defense Manufacturing & Instrumentation, Diversified Industrial Manufacturing, Financial Services, Healthcare Delivery, 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 U.S. 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 15 highest overall scores are then chosen for the LTS.

The Innovation Economy (IE) Score is used only to select the LTS as described above, it does not reflect performance on all 22 indicators used in the *Index*.

### <sup>1</sup>McKinsey Global Institute, 2017 Chart (from page 6)

McKinsey utilizes several scenarios for assessing the impacts of automation (including artificial intelligence) on the distribution of tasks performed by human workers in its report, *Jobs Lost, Jobs Gained: Workforce Transitions in a Time of Automation*, published in December 2017. The scenarios are modeled on the economies of several different countries and how automation will impact them and similar economies around the globe. In this case, we have selected a chart from the Germany scenario, which provides both a good visual representation of how time allocated to certain types of tasks may shift in the future and good analogue for the Massachusetts economy, which is similar to Germany in its focus on research & development, education, and advanced manufacturing as well as its older, well-educated workforce.

| 2018 Leading Technology States (LTS) |                     |
|--------------------------------------|---------------------|
| State                                | LTS Selection Score |
| Massachusetts                        | 2.27                |
| California                           | 2.16                |
| Pennsylvania                         | 1.99                |
| New York                             | 1.83                |
| Ohio                                 | 1.62                |
| Minnesota                            | 1.55                |
| Illinois                             | 1.52                |
| New Jersey                           | 1.51                |
| Connecticut                          | 1.43                |
| Texas                                | 1.40                |
| North Carolina                       | 1.39                |
| New Hampshire                        | 1.39                |
| Rhode Island                         | 1.34                |
| Wisconsin                            | 1.32                |
| Florida                              | 1.26                |

Source: BLS QCEW

## APPENDIX II: DATA SOURCES

### Sources for the LTS Initiatives from pages 56-62:

1. <https://www.massrobotics.org/project/facilities-residents/>
2. <https://labcentral.org/about/mission/>
3. <http://boston.masschallenge.org/>
4. <http://www.ncnano.org/>
5. <http://www.sfmade.org/services/about-us/>
6. <http://www.connect.org/>
7. <http://palifsciencesgreenhouseinitiative.com/>
8. <http://www.sep.benfranklin.org/>
9. <https://www.sciencecenter.org/>
10. <https://tech.cornell.edu/about>
11. <https://www.hesc.ny.gov/pay-for-college/financial-aid/types-of-financial-aid/nys-grants-scholarships-awards/nys-science-technology-engineering-and-mathematics-stem-incentive-program.html>
12. <https://esd.ny.gov/nystar/centersforadvtechnology.asp>
13. <https://universitytechnologypark.com/about-utp/>
14. <https://www.illinoisinnovation.com/>
15. [http://www.illinoistreasurer.gov/Businesses/Technology\\_Development\\_Accounts](http://www.illinoistreasurer.gov/Businesses/Technology_Development_Accounts)
16. <https://www.bioenterprise.com/>
17. [https://www.development.ohio.gov/bs\\_thirdfrontier/impact.htm](https://www.development.ohio.gov/bs_thirdfrontier/impact.htm)
18. <http://www.competitiveworkforce.com/>
19. <https://techpark.uconn.edu/>
20. <http://ctnext.com/>
21. <http://ct.org/signature-event/connecticut-skills-challenge/>
22. <https://cse.umn.edu/college/mndrive-minnesota-discovery-research-and-innovation-economy>
23. <https://www.enterpriseminnesota.org/about-us/who-we-are>
24. <http://towersidemsp.org/>
25. <https://www.rtp.org/about-us/>
26. [http://www.ncbioimpact.org/about\\_us.html](http://www.ncbioimpact.org/about_us.html)
27. <https://ncidea.org/>
28. <https://gov.texas.gov/business/page/guri>
29. <https://gov.texas.gov/business/page/texas-enterprise-fund>
30. <http://biohouston.org/about/>
31. <https://njii.com/>
32. <http://www.njbin.org/>
33. <http://centers.njit.edu/njiac/students/challenge/index.php>
34. <http://www.nhirc.unh.edu/>
35. <https://gameassembly.org/>
36. <http://www.futuretechwomen.org/>
37. <https://www.underseatech.org/about-utic-undersea-technology-innovation-consortium/>
38. <https://commerceri.com/innovation-incentives/>
39. <https://stac.ri.gov/find-funding/innovate-ri-fund/>
40. <https://www.fgcu.edu/eng/eti/>
41. <https://www.innovationflorida.co/>
42. <https://www.scripps.edu/campuses/florida/>
43. <https://wedc.org/programs-and-resources/qualified-new-business-venture/>
44. <https://thewatercouncil.com/>
45. <https://uwmref.org/innovationcampus>

### V. Note 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.

### VI. Note on Data Timeframes

The *Index* uses multiple time intervals when looking at data within the indicators, but generally shows five years or ten years of change from a base year (i.e. 2010-2015 or 2005-2015). Depending upon space and data availability, sometimes all data collected by MassTech from a series are displayed.



## APPENDIX II: DATA SOURCES

### INDICATOR 1: INDUSTRY SECTOR 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.

### 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 11 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.

### INDICATOR 3: HOUSEHOLD INCOME

#### Median Household Income

Median household income data are from the U.S. Census Bureau, American Community Survey. <https://factfinder.census.gov/faces/nav/jsf/pages/index.xhtml>

#### 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.

### 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. <https://www.economy.com/products/tools/data-buffet>

### INDICATOR 5: EXPORTS

Exports data are from the U.S. Census Bureau, Foreign Trade Division. Currency data from xe.com. <https://www.census.gov/foreign-trade/statistics/state/data/ma.html>

### 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. <https://ncesdata.nsf.gov/webcaspar/> and new ones will be at <https://ncesdata.nsf.gov/ids/>

#### 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."

#### 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](http://bea.gov)).

## APPENDIX II: DATA SOURCES

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 and Table 8-48- Academic S&E Articles per 1,000 S&E Doctorate Holders in Academia by state". International data is from the NSF. "Table 5-27 - S&E Articles in All Fields, by Region/Country/Economy". 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 U.S. 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)).

### 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 is based on the date the patents were granted. Patents in "computer and communications" and "drugs and medical" are based on categories developed 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 the Innovation Institute at MassTech. 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 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)).

#### 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)

IPO data pulled from [crunchbase.com](http://crunchbase.com), includes all listed as of January 2nd, 2018.

#### Mergers & Acquisitions (M&As)

Data on M&As are from [Crunchbase.com](http://Crunchbase.com). [Crunchbase.com](http://Crunchbase.com) data tends to focus more on innovation economy companies and is less likely to capture mergers of financial holding companies.

### 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 are from U.S. Census Bureau (<http://www.census.gov/popest/data/index.html>). GDP data are from Bureau of Economic Analysis ([bea.gov](http://bea.gov)), U.S. Department of Commerce.

## APPENDIX II: DATA SOURCES

### 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 FY1998, respondents have included all eligible institutions. Population data are 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), 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 U.S. Census Bureau (<http://www.census.gov/cps/data/cpstablecreator.html>), Current Population Survey, Annual Social and Economic Supplement. 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/cpstablecreator.html>), Annual Social and Economic Supplement. 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.

### INDICATOR 18: PUBLIC INVESTMENT EDUCATION

#### 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". Figures are presented in current dollars. Data exclude payments to other school systems and non K-12 programs.

<https://ncesdata.nsf.gov/webcaspar/> and new ones will be at <https://ncesdata.nsf.gov/ids/>

#### State Higher Education Appropriations per Full-Time Equivalent (FTE)

Data on public higher education appropriations per full-time equivalent (FTE) student are provided by the State Higher Education Executive Office (<http://www.shceo.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 State Higher Education Executive Officers (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 National Center for Education Statistics (NCES), Integrated Postsecondary Education Data System (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.

- Biological & Biomedical Sciences
- Physical Sciences
- Computer & Information Science & Support Services
- Engineering
- Mathematics & Statistics

#### STEM Degrees and International Science & Engineering

Data for STEM Degrees and Science and Engineering (S&E) Talent are provided by the Institute of Education Sciences (IES) through the Integrated Postsecondary Education Data System (IPEDS), using the National Science Foundation's (NSF) population of institutions by searching completions by non-residents and filtering for STEM classification codes.

## APPENDIX II: DATA SOURCES

### INDICATOR 20: TALENT FLOW AND ATTRACTION

#### Relocations to LTS by College Educated Adults

Data on population mobility come from the U.S. 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 U.S. 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". <https://factfinder.census.gov/faces/nav/jsf/pages/index.xhtml>

#### 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. <https://factfinder.census.gov/faces/nav/jsf/pages/index.xhtml>

### INDICATOR 22: INFRASTRUCTURE

#### Broadband Speed

Broadband Data are taken from the FCC Broadband Map. <https://broadbandmap.fcc.gov/#/area-comparison>  
Accessed October 2017

#### Industrial Electricity Rates

Data are taken from the U.S. Energy Information Administration, Average Retail Price of Electricity Annual Survey. <https://www.eia.gov/electricity/data/browser/>

#### Median Commute Time

Data are 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. Only "Large Metro Areas", defined as having more than 250,000 commuters are included. <https://factfinder.census.gov/faces/nav/jsf/pages/index.xhtml>

# APPENDIX III: DEFINITIONS

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 11 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: "Biopharmaceuticals, 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 Biopharma 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
- 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 & 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

## APPENDIX III: DEFINITIONS

- 5231 (cont.) 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
- 51913 Internet Publishing and Broadcasting and Web Search Portal

## MASSACHUSETTS TECHNOLOGY COLLABORATIVE

The Massachusetts Technology Collaborative, or MassTech, is a unique state agency working to strengthen the Commonwealth's position as the leading hub for innovation and entrepreneurship. MassTech serves as a catalyst, convener, project manager, researcher, and partner within the technology community on behalf of state government, driving job growth and statewide economic impact.

Our focus is on Cluster Development & Ecosystem Support, Talent Support & Workforce Development, and Business Assistance for Technology Firms.

**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.

### ABOUT THE INDEX

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

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