

The Annual Index of the Massachusetts Innovation Economy **2019 Edition**




THE INNOVATION INSTITUTE
at the MasTech Collaborative

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.

Massachusetts Technology Collaborative

The Massachusetts Technology Collaborative, or MasTech, is a unique state agency working to strengthen the Commonwealth's position as the leading hub for innovation and entrepreneurship. MasTech 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) - MasTech 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.

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Greetings,

Welcome to the 2019 Edition of the *"Index of the Massachusetts Innovation Economy."* The *Index* provides a critical view of the status of Massachusetts' Innovation Economy, in which nearly 40% of the Commonwealth's residents work.



The *Index* has facilitated analysis of the growth and performance of the state's Innovation Economy, as well as opportunities and potential challenges, since its first publication in 1997. These data and insights help inform our economic development approach, as we work in all regions of the Commonwealth to maintain and improve the high level of prosperity that Massachusetts is known for around the world.

The Massachusetts economy is facing clear headwinds, given the current global challenge around COVID-19, but our world-class Innovation Economy will help us address the challenges posed by this crisis and can bolster the Commonwealth's resiliency to the economic headwinds.

Over the last few years, we've seen the tech and innovation sector become increasingly affected by challenges such as housing affordability and transportation, issues which impact the wider economy as well. The Baker-Polito Administration is committed to meeting these challenges while continuing to strengthen our talent pipeline, research enterprise, and capital ecosystem in order to drive our economy forward over the next decade.

Entrepreneurship is at the heart of the innovation ecosystem in Massachusetts. Entrepreneurs and the start-ups they create are directly contributing to the revival of cities and towns across the Commonwealth. High-growth start-ups at the forefront of disruptive new technologies have kept Massachusetts competitive with global technology and innovation hubs such as Silicon Valley and New York. The 2019 *Index* includes a section highlighting the importance of entrepreneurship and begins a conversation around the unmet needs in the Commonwealth's entrepreneurship ecosystem. Fostering the health of our small businesses is a powerful economic development tool and our commitment to entrepreneurs at all levels is highlighted by our recently filed economic development bill and in our responses to the COVID-19 crisis. Continued analysis of the Commonwealth's regional entrepreneurial ecosystems is needed in order to support emerging innovation hubs, to strengthen entrepreneurial ties across regions, and to maximize the entrepreneurial potential of the Commonwealth and its people.

Thank you for your interest in the *Index* and the critical issues that are effecting the Massachusetts Innovation Economy. We invite you to dive into the data to see why Massachusetts is the best state for innovation and join the conversation around ways we can continue to support innovation, entrepreneurship, and opportunity for all across Massachusetts.

A handwritten signature in black ink, appearing to read 'Mike Kennealy', written in a cursive style.



Mike Kennealy
Secretary of Housing and Economic Development

Executive Summary

Data Gathered 2019 and Earlier, Report finalized February 2020

The 2019 Edition of the Index of the Massachusetts Innovation Economy continues to demonstrate that Massachusetts has one of the strongest innovation economies in the world. The foundation for this is laid by the combination of a strong education system with world-class universities, top quality research & development (R&D), and abundant access to capital. These three pillars form the driving force of the Innovation Economy, enabling established business to grow further and allowing entrepreneurs the chance to start their businesses and drive job creation and innovation. Massachusetts strengths include:

- **Talent:** Massachusetts students in Grades 4 and 8 scored #1 in both math and science tests from the National Science Foundation among the Leading Technology States (LTS). Massachusetts also has the most post-secondary degrees per capita in general, and the highest per capita STEM completions.
- **Research:** Massachusetts received more R&D investment (\$30.9B) as a % of GDP than any of the LTS in 2016, and received the most federal funding for R&D relative to GDP as well. Massachusetts had both the highest Technology Patents per capita and Science & Engineering academic articles per doctorate holder.
- **Capital:** Venture capitalists invested more money relative to GDP in Massachusetts than any of the LTS except California. Massachusetts received the most Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) funding relative to GDP.
- **Economic Impact:** Massachusetts continues to see job growth in both its largest key innovation sectors, led by Healthcare Delivery, and the key innovation sectors with the highest growth in wages. In every key sector except for Advanced Materials, Massachusetts had higher per capita output than the LTS average.

While Massachusetts remains a leading innovation economy it does face a number of challenges, some of which have continued to worsen year by year. There is also increasingly tough competition from other top innovation states, from well-established ones like California and New York, rising locations like Texas and North Carolina, and internationally as well. Massachusetts challenges include:

- **Commute Times:** Massachusetts commuters spent an average of 253 hours commuting in 2017, up 17 hours from 2012 and the 4th worst of the LTS.
- **Housing Costs:** Massachusetts had 27% of homeowners and 47% of renters being burdened by housing costs, spending 30% of their income or more on housing, in 2018. While these numbers are marginally improving Massachusetts remains as one of the states with the highest Federal Housing Administration Housing Price Indexes in the nation.
- **Venture Capital (VC):** While Massachusetts remains a top destination for venture capital investment, the share of all U.S. VC it receives has now shrunk two years in a row.
- **Migration:** Massachusetts had a net positive migration of 27,258 in 2018, but only because the net international migration was 53,013. Domestic out-migration increased from a net loss of 23,089 in 2017 to a net loss of 25,755 in 2018.

The *Index* also looks at the Entrepreneurship Ecosystem in Massachusetts with the goal of identifying topics that need further attention for entrepreneurship to reach its full potential as a transformative economic development tool in the Commonwealth. Entrepreneurs are already making a real difference in the economic fortunes of cities and towns around Massachusetts, but the ecosystem of programs and organizations supporting them could benefit from increased collaboration and coordination of activities. Massachusetts needs to think more broadly about supporting entrepreneurship, looking beyond physical workspaces and makerspaces to encompass programming and community building.

LEADING TECHNOLOGY STATES (LTS)

For this edition, the *Index* focuses on the top 10 LTS, identifying key sectors and quantifying the total number and percentage of jobs in the Innovation Economy (IE).

For more on the LTS turn to page 14. To learn about the LTS selection process turn to page 36.

MASSACHUSETTS DOES WELL

Talent

- Massachusetts students performed #1 in the LTS in both math and science at grades 4 and 8.
- Massachusetts had the most Post-Secondary degrees awarded per capita of any of the LTS (17.84 per 1,000 residents in 2017-2018).
- Massachusetts has the most STEM degrees awarded per capita, with the largest field being Engineering, followed by Biological and Biomedical Sciences, Computer and Information Sciences, Mathematics and Statistics, with the smallest field being Physical Sciences.
- Massachusetts attracted significant levels of international migration (+53,013 in 2018).

Research

- \$30.9B was invested in R&D in Massachusetts in 2016 (2nd nationally), equivalent to 5.7% of the Commonwealth's GDP (1st among LTS).
- Massachusetts had the most technology patents per capita of any of the LTS (871 per million residents in 2018).
- Massachusetts had the most science & engineering academic articles per doctorate holder in academia of any of the LTS and internationally (1,328 per 1,000 doctorate holders in 2017).

Capital

- Venture capitalists invested \$10.6B in Massachusetts in 2018 (3rd among the LTS), up 42% from 2017. Massachusetts receives more VC investment as a % of GDP than all LTS except for California.
- Massachusetts received the most SBIR/STTR award funding relative to GDP of the LTS (\$594 per million GDP in 2017), more than twice what 2nd place New York received. In absolute terms Massachusetts, received the 2nd most after California (\$271 in 2017).

Economic Impact

- Massachusetts saw strong job growth in key innovation sectors from 2013-2018, with 5 of the 11 seeing double digit growth in employment and 4 seeing double digit growth in wages.
- Massachusetts had higher per capita output in every key innovation sector except for Advanced Materials than the LTS average.

Massachusetts
<p>2018 POP: 6,902,149 2018 GDP(\$M): 569,488 # of IE Jobs: 1,341,147 % of IE Jobs: 37.4%</p>
Key Sectors
<ul style="list-style-type: none"> • Biopharma & Medical Devices • Computer & Communications Hardware • Defense Manufacturing & Instrumentation • Financial Services • Healthcare Delivery • Postsecondary Education • Scientific, Technical, & Management Services • Software & Communications Services

2019 Leading Technology States
Massachusetts
California
Pennsylvania
New York
Ohio
Minnesota
Illinois
Connecticut
Texas
North Carolina

Entrepreneurship Ecosystem Special Analysis

Entrepreneurship's Importance to the Innovation Economy

Entrepreneurship and innovation are inextricably linked. The Massachusetts Innovation Economy is driven by a diverse group of companies, both large and small, but all of them have to start somewhere. Entrepreneurship is almost universally seen as good for the economy (Praag, 2007).¹ Firms with fewer than 100 employees have created more net new jobs in the U.S. than firms with over 1,000 employees every year from 2011-2018. While announcements of major expansions by established tech giants tend to grab headlines, they are balanced by other legacy firms that have not adapted their business model to disruptive technologies. The entrance of new and innovative businesses is critical to the health of any economy.

Despite the rise of start-up culture in tech hubs such as Greater Boston, Silicon Valley, and New York City, entrepreneurship is in decline nationwide.² Massachusetts must continue to build a welcoming entrepreneurial ecosystem statewide, which will help to revitalize the economies of communities around the Commonwealth. Entrepreneurs are also a critical link between the renowned talent, research, and access to capital available in Massachusetts and the economic impact resulting from the innovative deployment of these resources. Entrepreneurs are needed to transform smart people, good ideas, and savvy investors into new and growing businesses.

Massachusetts needs a deep understanding of entrepreneurship ecosystems around the state. This will enable the Commonwealth to better meet the needs of entrepreneurs. As a first step in this effort, the Innovation Institute at Massachusetts Technology Collaborative has interviewed a selection of entrepreneurs and entrepreneurship organizations to examine how entrepreneurship ecosystems have evolved and what the largest unmet needs are.

What is the Entrepreneurship Ecosystem?

Entrepreneurship is commonly idealized as a lone entrepreneur developing a successful business through his or her own ingenuity and drive. While entrepreneurs create their own success, they do not exist in a vacuum. The ability to tap into useful resources such as mentor support, educational opportunities, flexible workspace, professional networking opportunities, and seed stage capital is important for entrepreneurs as they grow their businesses. Entrepreneurs, mentors, pitch contests, angel and venture investors, collaborative workspaces (coworking, incubators, accelerators, etc), college and university entrepreneurship programs, and federal, state, and local government small business development resources are all part of an "ecosystem" that is interconnected to varying degrees. We will use the term "entrepreneurship support organization" to refer to any entity that provides one or more version of a service similar to the list mentioned above.

Access to the resources discussed above differs by region in Massachusetts. While we are interested in making Massachusetts the best place to start an innovative business, the state's

What is a Collaborative Workspace?

Compared to a few decades ago, startups now have a plethora of options to choose from when seeking relatively low-cost, flexible workspaces. Some of these spaces provide simple, functional necessities such as a shared lobby and basic infrastructure like bathrooms, while at the other end of the spectrum, the working space itself is secondary to the services provided such as mentorship and access to capital.

Shared workspaces are becoming increasingly important to the innovation economy as more firms want to cluster in desirable locations and may not necessarily be able to afford a traditional private workspace at the outset. In some cases, the exchange of ideas among companies and individuals in shared workspaces result in fortuitous collaborations and exchanges of know-how that can make these spaces more desirable than a private space. For more information about the different types of collaborative workspaces, please refer to the 2015 *Index* at masstech.org/index.

regions are how entrepreneurs experience the ecosystem on the ground. A regional lens is essential to evaluating the entrepreneurial ecosystem in Massachusetts.

Takeaways

Interviews were conducted with 8 individuals across a range of organizations in different parts of Massachusetts. Interviewees were allowed to direct the conversations in ways that allowed them to comment on both the strengths and needs of the local ecosystems that nurture and support entrepreneurs across the Commonwealth. Entrepreneurship is bigger than just the tech industry and a welcoming entrepreneurial ecosystem is valuable to start-ups in both tech and non-tech fields of discipline. The broad scope of these interviews allows for observations and takeaways effecting entrepreneurship at many levels in Massachusetts, not simply addressing influences specific to the tech industry.

Ecosystem perception is an issue statewide, but in different ways

Everyone interviewed brought up the need for more organized promotion of their region's assets as a place for innovation & entrepreneurship. Boston is already seen as such as a mecca for innovation and entrepreneurship, but it has a reputation for being a region dominated by entrepreneurs from elite schools and is seen as not as welcoming to the contributions of individuals from more diverse populations and ethnicities. The rest of the state needs more emphasis on the promotion of regions as good places to start and grow a tech company. People in Boston are generally unaware of the start-up activity in the rest of the state.

In the regions, start-ups struggle to raise funds from the much smaller pools of local capital. Venture capital (VC) firms do occasionally make forays into the Commonwealth's regions, but this can often result in pressure to relocate to Boston, the Bay Area, or New York. The ability to raise funds from investors is important to many, but not all start-ups. Entrepreneurs outside of Greater Boston have still been able to succeed through self-funding and growing organically. However, the disparity in the availability of investment capital is a limiting factor in the regions as it closes off certain paths to success. Creative solutions to this problem are needed to fully unlock the entrepreneurial potential of Massachusetts.

Perception goes far beyond business assets. Tech companies can locate anywhere in the world and often choose places where they can attract young creative and technical talent. These people want funky bars and restaurants, an art scene, music, and museums. While these features exist in Massachusetts across all of its regions, that message does not seem to be resonating through existing promotional channels with young talent and with the start-up audience. Boston, for instance, is not seen as a 24/7 global city at the same level of social engagement and entertainment as what is perceived is happening in peer regions such as New York and San Francisco.

Getting an authentic pitch tailored to unique local assets is critical. Marketing a Gateway City as "Boston, but cheaper" will fall flat. Each city/region is unique and can sell itself on more than just proximity to Boston.

Regional organization is important

The success of regional entrepreneurship ecosystems is enhanced by the ability of various actors in a region to come together to offer a coordinated set of services with minimal duplication of effort. Niche organizations can and do succeed in Massachusetts, but they also risk splitting nascent communities of entrepreneurs who benefit from interaction between each other, even if they exist in different industries. This is less important in Greater Boston, which has sufficient density that disconnected organizations can thrive by targeting a specific niche. In the regions, it is helpful to have a connecting hub so entrepreneurs do not need to build multiple support networks on their own. There is no "secret sauce" for this, but community leaders need to be intentional and proactive about organization. "It's all about relationships" says UMass Lowell Innovation Hub Director Tom O'Donnell, "Shared regional success depends upon ongoing strategic collaboration between public, private, non-profit, academic and industry players within the region. And this collaboration doesn't happen by accident." As an example, the Innovation Hub's Haverhill location also serves as the main office for the Greater Haverhill Chamber of Commerce. The Chamber and Innovation Hub teams work closely together in providing complementary support services to

entrepreneurs and established businesses in the region, effectively extending the reach of both organizations.

Collaboration creates valuable outcomes, but needs to be incentivized

Everyone interviewed thought inter-organization collaboration was a desirable feature for the overall ecosystem. However, many entrepreneurship support organizations are small non-profits that are under fundraising pressure with competition for resources being an unspoken concern. Some of these concerns can be addressed with funding agencies requiring entrepreneurship support organizations to collaborate where possible. For example the Boston Foundation has successfully urged collaboration between the Venture Café Foundation and EforAll-Roxbury to stretch resources and to improve services for entrepreneurs in that region.

Long term commitment is needed to sustain ecosystems in regions

This comes into play in a variety of ways. Entrepreneurship ecosystem organizations with financial backers who are able to give the organization a long lead time have helped to enable success. This can happen in several ways, but is most commonly seen with organizations tied to large foundations or universities. EforAll has been successful in creating groups of committed local partners that include credit unions, community foundations, and municipal governments to fully fund programs for up to three years.

Beyond a commitment to keep the doors open, simply offering consistent programming can go a long way towards creating a more cohesive community of entrepreneurs. The lower density of the ecosystems outside of Greater Boston offers cost and lifestyle advantages, but comes with a deficit of serendipitous connections and networking opportunities. This can be overcome by creating places for entrepreneurs in less dense ecosystems to come together, whether for educational opportunities or simply after-work drinks.

A broader definition of financial stability is needed

While not impossible, financial sustainability wherein the Entrepreneurship Support Organization funds itself through user fees is tough to pull off outside of Boston, where valuable real estate can be leveraged to create and support an entrepreneurial community. In many cases, grant support is a permanent part of the financial mode for Entrepreneurship Support Organizations. This happens largely due to the nature of the businesses being targeted, which need a lot of support and can't usually pay market price for the services.

Some will argue that financial sustainability of Entrepreneurship Support Organizations is a false promise and that public support to foster and accelerate local entrepreneurial activity has an intrinsic value which can have far greater benefits on the culture and economic performance within a broader community (e.g., neighborhood, university, city, or region). A widely applicable model in which the Entrepreneurship Support Organizations could somehow sustain itself from the success of client entrepreneurs has not yet emerged on the landscape. Interviewees will argue it is more important that communities recognize the intrinsic values of Entrepreneurship Support Organizations and that they coalesce around the organization to support the services they provide. Codifying the impacts of Entrepreneurship Support Organizations is an important discipline to help substantiate the value of these institutions on their communities.

Entrepreneurship for All (EforAll) is a nonprofit organization that partners with communities nationwide to help under-resourced individuals successfully start and grow a business through intensive business training, mentorship and an extended professional support network. To date, EforAll alumni have launched nearly 350 businesses and created 687 local jobs. Programs are available in both English and Spanish. EforAll is currently available in the following MA communities: Berkshire County, Cape Cod, Fall River, Holyoke, Lawrence, Lowell, Lynn, New Bedford and Roxbury as well as Longmont CO. To learn more about EforAll, please visit eforall.org.

Programming is more important than physical space, but both are necessary

A repeated theme across the interviews was the importance of offering programming valued by the entrepreneurial community. This could be anything from mentorship and educational opportunities to simple networking. Programming is what draws entrepreneurs to collaborative workspaces, not the space itself.

However, the presence of a physical space is still important, even in situations where it is mostly symbolic. Outside of Boston, entrepreneurs often are less tech-oriented and have less need for affordable/flexible office space, so occupancy rates can be lower depending upon the target population of the organization. Physical spaces can serve as a “center of gravity” for an ecosystem by hosting regular events, even if most of the entrepreneurs served do not become tenants. Not all Entrepreneurship Support Organizations need to provide their own space. By deploying a partnership model – SPARK/EforAll Holyoke was able to host pitch contests and their business accelerator program in the collaborative workspace built by the Greater Holyoke Chamber of Commerce in downtown Holyoke.

Mentorship, Mentorship, Mentorship

Mentorship was singled out as a key element of success for collaborative workspaces in the 2015 Index and if anything, it has only become more important. Mentorship is critical to helping entrepreneurs navigate the challenges of starting and growing a business, especially one that is built upon a groundbreaking new idea. While entrepreneurs can and do source mentors through their own personal contacts, more often than not entrepreneurs, particularly those who are young or who come from economically challenged positions, do not have the networks necessary to identify and recruit a mentor. Many programs exist around the Commonwealth to pair mentors with entrepreneurs and these programs can have varying levels of intensity depending upon entrepreneur needs and program model. Mentorship can be time consuming in the models for some programs, which has caused challenges in finding enough qualified mentors in certain areas. More work needs to be done to improve match making and to increase the visibility and accessibility of mentorship programs as a way for successful entrepreneurs and business professionals to share their expertise and to support the needs of budding entrepreneurs in their communities.

More space needed for scaling companies

The Massachusetts Innovation Economy has a strong track record of generating highly innovative start-ups in a diverse array of industries. Despite this success, many people will argue Massachusetts has been less successful at growing these companies to scale, particularly when one evaluates successful growth companies as a percentage of startups in the state. There are many examples, Facebook being the most famous, of a promising start-up that was founded in Massachusetts leaving the state as it grows, most often for a competitor region like Silicon Valley or New York City. There are many reasons for this problem, explored in a report produced in 2015 by

Massachusetts Biomedical Initiatives (MBI) is a private, independent economic development organization that serves as a catalyst for life science and healthcare innovation. MBI supports early “seed stage” and scaling companies by providing private, dedicated laboratories up to 3,000 SF along with equipment, health and safety support, and business development assistance. Building and maintaining collaborative affiliations and partnerships is essential to MBI’s success. 89% of MBI companies have stayed in Massachusetts and the organization has generated \$900M of economic impact. For more information, visit: massbiomed.org

"Mentorship is the bedrock of the EforAll program, particularly given we have three mentors for each entrepreneur. Not only do EforAll's entrepreneurs benefit greatly from the mentors, but we find that mentorship is a great way for those who have achieved success in business to give back to the community. We're always looking for new mentors in EforAll's 8 communities around Massachusetts!"

-David Parker, CEO, EforAll

"Graduating from an incubator is an exciting milestone for early-stage startups and the Greentown Labs community is fortunate to have a supportive partner in the City of Somerville that works closely with our entrepreneurs when it's time for them to move into their own space. We work closely with our startups and the City to align timelines, goals, and real estate availability in Somerville to not only help our member companies find the space they need but also to try and keep them nearby! Many of our graduates maintain a membership at Greentown Labs once they secure their own space so having them remain in Somerville is a win-win."

- Emily Reichert, CEO, Greentown Labs

MIT's Industrial Performance Center with the support of the Innovation Institute in 2015.¹¹¹ While physical office space might not be the primary driver of the Commonwealth's issues with scaling companies, it still comes into play, especially in Greater Boston when start-ups look to expand beyond the capacity of an incubator and find a lack of available space nearby.

Many start-ups reach an inflection point where they have outgrown the needs of a traditional collaborative workspace, but are not quite ready to take on the commitments of a long-term commercial lease. A lack of obvious choices creates a window where companies are willing to consider a different location. Entrepreneurial Ecosystems that have a continuum of choices when it comes to office/lab space are better able to keep companies local as they grow. Pro-active relationships between Ecosystem Support Organizations (including local government) and start-ups can help smooth this transition period by making connections with landlords open to more flexible terms.

UMass Lowell Innovation Hub is an example of a successful partnership between an incubator and the local government. The City of Lowell maintains office hours for its business development staff within the Innovation Hub, providing a readily available next step for companies that outgrow the incubator and helping to keep start-ups in Lowell.

Many Gateway cities have used collaborative workspaces such as incubators and accelerators as a local economic development tool. However, these cities do not always have a good location for companies taking their next steps beyond an incubator due to a real estate market that has not yet adapted to meet the needs of tech & innovation-based businesses. In Worcester, Massachusetts Biomedical Initiatives (MBI) has successfully incubated many companies only to find that their graduates leave the city for more readily available space in the suburbs. To counteract this, MBI is renovating a nearby building to serve the needs of start-ups that have outgrown the single room lab spaces in its original location, keeping this economic activity in the city.

UCF Incubator Network: Other regions provide models that Massachusetts can learn from. The University of Central Florida (UCF) is widely recognized within the national business incubation community as being a leader in the field. UCF operates an incubator network with more than 100,000 square feet of space that provides extensive support services to tenant companies. UCF typically locates its incubators within larger research parks operated by the university or a partnership consortium. This provides opportunities for exposure with the larger corporate members of the research park and an obvious location for expansion when the start-up outgrows the incubator. While Massachusetts does not have the same amount of land available for greenfield development, the UCF example demonstrates that a continuum of services for companies at different stages of development can help create an innovation ecosystem in a region without the advantages held by Massachusetts.

As Entrepreneurs Go – So Goes the Local Economy

Entrepreneurship is revitalizing cities across the Commonwealth by creating new energy and jobs. Massachusetts needs more entrepreneurs and needs to keep more of the entrepreneurs that are already here. The Commonwealth should strive to provide the most inclusive and supportive environment possible for entrepreneurs to ensure that more of the Commonwealth's homegrown start-ups can scale here and unlock the entrepreneurial potential of people around Massachusetts.

The unmet needs and issues outlined above are not meant to be comprehensive, but represent a starting point for understanding what the entrepreneurship ecosystem needs to thrive. We expect that there is much more to learn and we hope to connect with many more entrepreneurs and the people and organizations that support them around the Commonwealth. We look forward to continuing the conversation.

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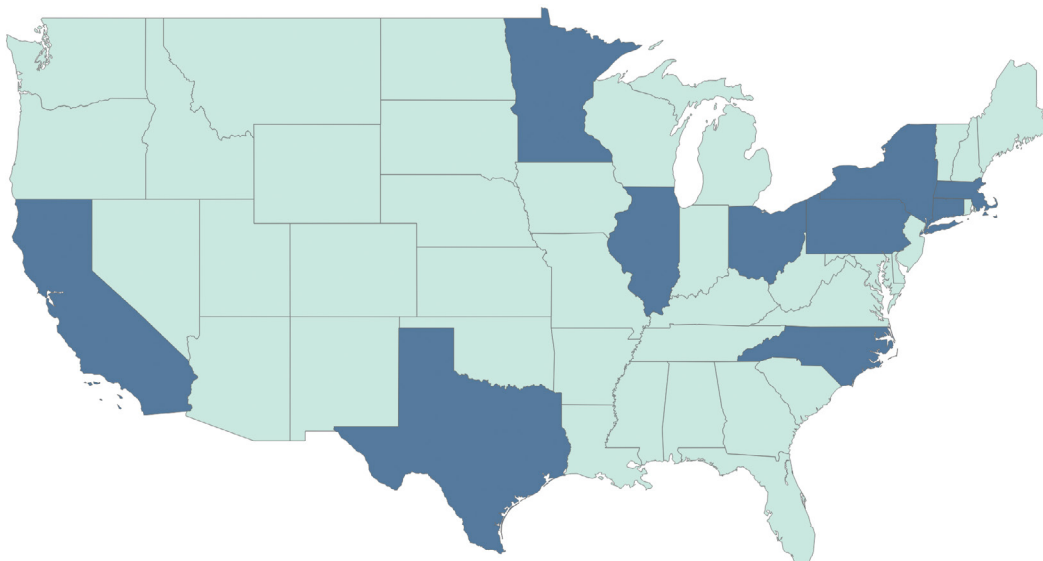
Leading Technology States (LTS)

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

2019 Leading Technology States (LTS)	
State	LTS Selection Score
Massachusetts	2.27
California	2.17
Pennsylvania	1.99
New York	1.82
Ohio	1.62
Minnesota	1.55
Illinois	1.50
Connecticut	1.42
Texas	1.40
North Carolina	1.40



The Metrics Used to Select the 2019 LTS

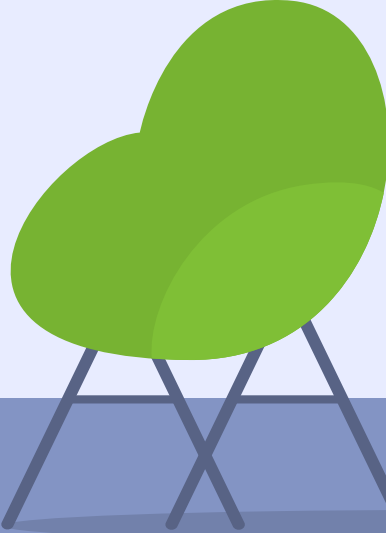
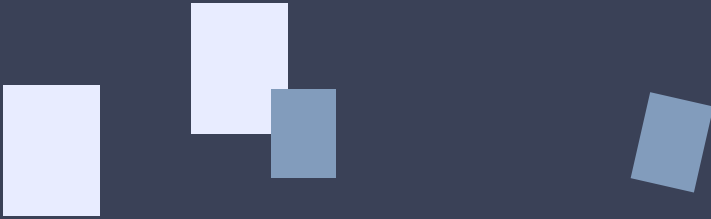
The number of key sectors with significantly above average employment concentration are defined as the number of innovation economy sectors in each state where employment concentration is more than 10% above the national average and is a measure of the breadth of a state's Innovation Economy.

Overall Innovation Economy employment concentration relative to the nation is 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 10.



Economic Analysis



Introduction

Massachusetts is home to one of the strongest innovation economies in the world. Three key resources: talent, research activity, and access to capital are the main drivers of the Commonwealth's Innovation Economy. These resources enable the transformation of basic research and new ideas into innovative products, services, and business models that serve as catalysts for economic growth and high-paying jobs. These assets provide a competitive advantage for Massachusetts in attracting a variety of business activity from individual entrepreneurs to established global firms. However, opportunities derived from the abundance of economic resources are not without their challenges and Massachusetts must actively work to address these challenges while preserving and strengthening their assets.

Here's what others are saying.

Massachusetts ranks:

- **#1 in Milken's "State Tech and Science Index" 2018**
- **#1 Most Innovative State in Bloomberg's "State Innovation Index" 2016**

The Commonwealth is one of the most attractive environments for innovation in the world due to the combination of the factors described above, which is an advantage that is hard to replicate. However, Massachusetts cannot afford to be complacent in its success as it faces competition for globally mobile talent and business from established innovation clusters such as California and New York, as well as rising states, such as North Carolina and Texas. Internal challenges such as the rising cost of housing and long commute times also create obstacles in the Commonwealth's continued success as an Innovation hub. On the pages that follow, the *Index* examines the factors that make Massachusetts a global hub of innovation and how the Commonwealth's performance compares to the Leading Technology States (LTS).

Talent

Talent is the most basic and crucial building block for the Massachusetts Innovation Economy. The Commonwealth is known world-wide for its high-quality public school systems, excellent collection of public and private colleges and universities, and innovative workforce development programs that sustain the state's well-educated workforce. These strengths are frequently cited as main reasons that businesses choose to locate and grow in Massachusetts. Access to top notch intellectual, technical, and managerial talent allows innovative companies of all sizes to develop ground-breaking products and services in Massachusetts.

"The density of talent makes Boston a great location for our business, since there are so many other marketing tech companies and open-source companies here," – David Hurley, Mautic Founder and CTO (The Boston Globe, 2016)^A

COMMITMENT TO PUBLIC EDUCATION

Development of talent in Massachusetts begins with a strong commitment to high-quality K-12 education. This commitment is evidenced by the 15% growth rate in per pupil spending from 2012 to 2019. In 2017, the Commonwealth invested \$16,197 per pupil, the 3rd highest per-pupil investment among the LTS. Investments in elementary, middle, and high schools are critical for preparing an innovation ready workforce. The Commonwealth's strong education systems helps to attract and retain workers who want excellent educational opportunities and skills for themselves and their children.

The value of these educational investments is demonstrated with test results at all levels. The National Science Foundation (NSF) assesses Science and Mathematics performance nationally for grades 4 and 8, with the most recent years available being 2015 for Science and 2017 for Mathematics. Massachusetts ranked #1 in the LTS in science and math performances at both

tracked levels, tying Minnesota for 1st in 8th Grade Science and 4th Grade Math.

Per Pupil Spending
Public Elementary/Secondary School Systems
LTS & U.S., 2017¹

State	Per Pupil Spending	Percentage Change
New York	\$23,091	3.24%
Connecticut	\$19,322	1.92%
Massachusetts	\$16,197	3.87%
Pennsylvania	\$15,798	2.34%
Illinois	\$15,337	8.16%
Minnesota	\$12,647	2.14%
Ohio	\$12,645	4.49%
United States	\$12,201	5.64%
California	\$12,143	3.98%
Texas	\$9,375	3.18%
North Carolina	\$9,072	3.72%

Here's what others are saying.
Massachusetts also ranks:

- **#1 State for Education in Education Week's "Quality Counts" 2018 report**
- **#1 in Human Capital Investment Composite Index and #3 – Technology and Science Workforce Composite Index from Milken's "State Tech and Science Index" 2018**
- **#7 in Science & Engineering Degree Holders from Bloomberg's "State Innovation Index" 2016**

4th Grade Science Performance
MA, U.S., & LTS, 2015 (Out of 300)³

State	Score
Massachusetts	161
Minnesota	157
Ohio	157
Texas	155
Connecticut	154
North Carolina	154
United States	153
Illinois	151
New York	150
California	140
Pennsylvania	NA

8th Grade Science Performance
MA, U.S., & LTS, 2015 (Out of 300)³

State	Score
Massachusetts	162
Minnesota	162
Ohio	157
Texas	156
Connecticut	155
United States	153
Illinois	150
New York	150
North Carolina	150
California	143
Pennsylvania	NA

4th Grade Math Performance
MA, U.S., & LTS, 2017 (Out of 500)³

State	Score
Massachusetts	249
Minnesota	249
Pennsylvania	242
North Carolina	241
Ohio	241
Texas	241
Connecticut	239
United States	239
Illinois	238
New York	236
California	232

8th Grade Math Performance
MA, U.S., & LTS, 2017 (Out of 500)³

State	Score
Massachusetts	297
Minnesota	294
Ohio	288
Pennsylvania	286
Connecticut	284
Illinois	282
New York	282
North Carolina	282
Texas	282
United States	282
California	277

The Commonwealth's education system also compares favorably with global education leaders, particularly in science performance. In the 2015 Programme for International Student Assessments (PISA), a global study of education systems conducted by the Organization for Economic Cooperation and Development (OECD) with more than 70 participating countries, Massachusetts ranks 6th in science literacy in the world, and 20th in math literacy.

- **U.S. News Ranks Massachusetts as the state with the best overall High Schools, with 49% of MA High Schools in the top quartile of best High Schools**
 - **In the LTS California follows at 40% and Connecticut with slightly below 40%.**
- U.S. News 2019 Best High Schools**

POST-SECONDARY EDUCATION

The Commonwealth's strong education commitment and performance continues into the Post-Secondary level where Massachusetts has the highest number of degrees conferred per capita (17.84 per 1,000 people). 48.7% of the workforce in Massachusetts has at least a bachelor's degree, higher than any other state in the nation, and well above the U.S. average of 38.4%. At the post-secondary level, Massachusetts has increased higher-education appropriations per student by 32% from 2013 – 2018. In 2017, the state appropriated \$8,965 per student in higher education at its public institutions, placing Massachusetts 6th amongst LTS.

This commitment to post-secondary education helps Massachusetts maintain its competitive edge in attracting talent, particularly in science, technology, engineering, and math (STEM). STEM education is a core component of the Commonwealth's innovation economy as it provides skills that increase business productivity, creates new technologies and high-growth companies, and establishes the basis for higher-paying jobs. STEM degree holders also provide value beyond the tech sector, as more than 65% of graduates with STEM degrees work in non-STEM occupations. Demand for innovation in industries across the economy will continue to blur the line between STEM and non-STEM skill sets.

Massachusetts is well-situated to meet this demand as it has grown the number of STEM degree completions by 32.6% since 2014, the second highest growth rate in the LTS after Connecticut which had 43.2%. During the 2017-2018 school year, Massachusetts had the highest rate of STEM degree completions per capita of any state in the LTS with 3,358 STEM degrees per million residents, representing more than 1,000 completions ahead of 2nd place Pennsylvania. Engineering accounts for the largest proportion of STEM degrees conferred in Massachusetts with 35.9%, followed by Biological and Biomedical Science (26.0%), Computer and Information Science (22.1%), Mathematics and Statistics (8.9%), and Physical

Here's what others are saying. Massachusetts has:

Two of the top 5 Most Innovative Universities in Reuter's "Most Innovative Universities 2019"

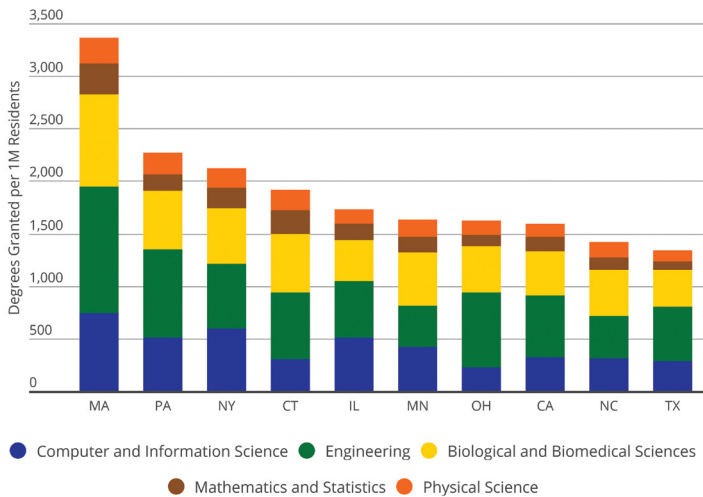
- **#2 -Massachusetts Institute of Technology**
- **#3 -Harvard**

State Higher Education Appropriations per Full Time Equivalent Student MA, LTS, & U.S., 2013-2018²

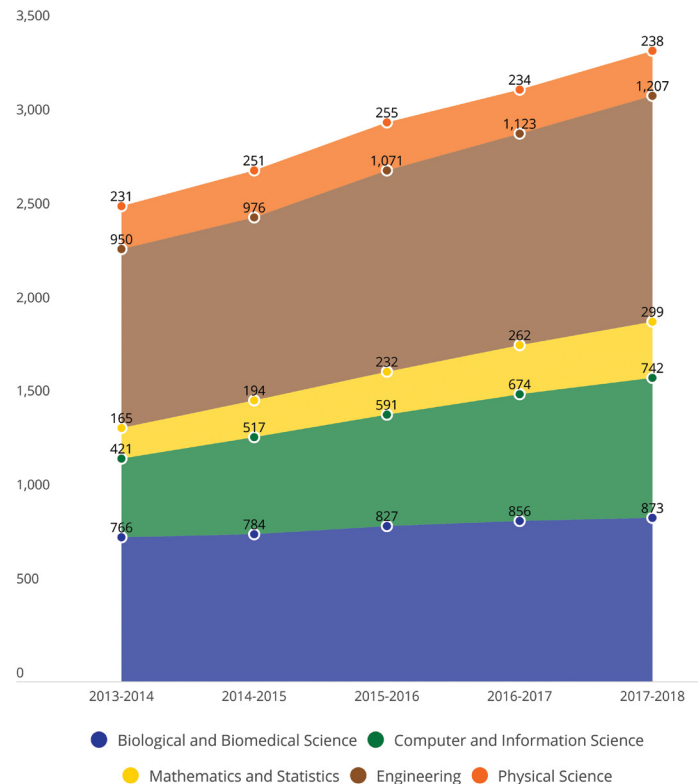
State	State Educational Appropriations per Students 2018	2013-2018 % Change
Illinois	\$14,587	17.2%
New York	\$11,135	26.5%
California	\$10,703	50.6%
Connecticut	\$9,861	23.2%
North Carolina	\$9,018	14.1%
Massachusetts	\$8,965	31.6%
U.S.	\$7,853	27.3%
Minnesota	\$7,363	50.1%
Texas	\$7,232	17.8%
Ohio	\$5,698	33.0%
Pennsylvania	\$4,552	15.2%

Science (7.1%). This success of STEM degree programs positions the Commonwealth as an excellent place for innovative companies to hire STEM talent, whether it is in biotech, software development, engineering, mathematics, or non-traditional tech industries that are increasingly reliant upon STEM skills.

**Degrees Granted in STEM Fields,
All Degree Levels per 1 Million Residents
MA & LTS, 2017-2018⁴**



**Massachusetts STEM Completions
per Million Residents⁴**



State	Computer and Information Science	Engineering	Biological and Biomedical Sciences	Mathematics and Statistics	Physical Science	Total
MA	742	1,207	873	299	238	3,358
PA	507	840	557	162	200	2,267
NY	595	621	525	197	180	2,118
CT	300	642	553	228	197	1,919
IL	510	539	387	157	142	1,734
MN	419	397	500	148	169	1,634
OH	220	715	443	106	143	1,627
CA	319	586	422	135	132	1,594
NC	315	402	436	120	148	1,421
TX	287	516	350	83	108	1,344

INNOVATIVE WORKFORCE DEVELOPMENT PROGRAMS

The Commonwealth is also pioneering innovative models such as registered apprenticeships and extended work experience paired with bootcamp style training to diversify pathways into the Innovation Economy beyond the traditional 4-year degree route. The needs of industries throughout the state are being addressed through expanded access to the tech sector through innovative entrepreneurial programs, apprenticeships, and internships. One such program is Tech Foundry, a non-profit founded in 2014 that partners with businesses to train students in the skills those businesses need.

ATTRACTION

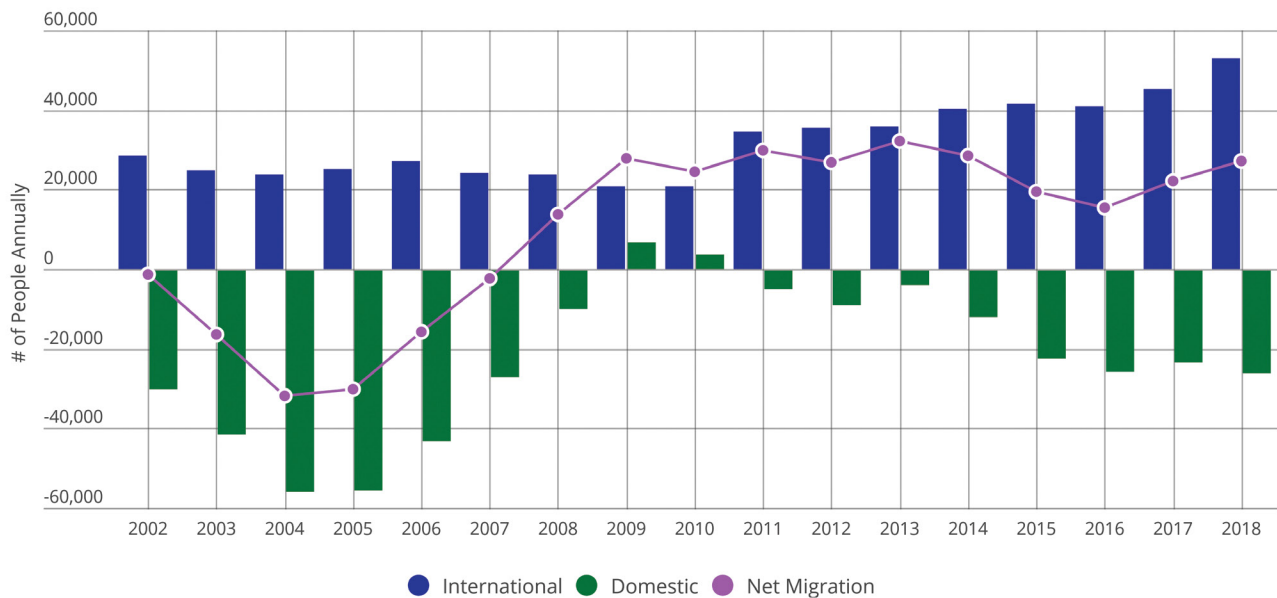
Talent has been a primary factor in the attractiveness of Massachusetts for new business development and a driver of the state’s strong innovation economy. Investments in post-secondary education are critical to increase the ability of public academic institutions and non-degree training programs to 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, many of whom choose to work in the Commonwealth after graduation.

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 with an infusion of diverse and high-demand skill sets. Since 2010 international migration, people moving here from out of the country, has more than made up for domestic out-migration, people moving within the country. Massachusetts has seen much less domestic out-migration since 2010 than it did in the years preceding the Great Recession while international migration has increased as well. This indicates that Massachusetts has become a more attractive place to live and work over the last decade, despite challenges with housing costs and transportation infrastructure.

These numbers should, however, be viewed with the understanding that they are potentially subject to significant changes, and factors influencing those changes are not necessarily controllable by Massachusetts. United States’ federal immigration policy and increased competitiveness of universities in developed countries such as Canada, the United Kingdom, Russia, and Australia pose a threat to the Commonwealth’s international talent pool.(Fernandes, 2019)^B

**Domestic & International Migration
MA, 2002-2018⁵**



	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
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	53,013
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	-25,755
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	27,258

Research

The second key pillar of the Massachusetts Innovation Economy is research activity. The Commonwealth benefits from a dense network of research universities and institutes performing cutting-edge science and blazing new trails in transformative fields such as artificial intelligence, biotechnology, and robotics. R&D performance is an indicator of the size and health of the science and technology enterprise. Although not all new ideas or products emerge from defined R&D efforts, R&D performance provides a basis for estimating a region’s general capacity for knowledge creation.

R&D FUNDING

R&D occurs across the economy in a mix of entities that contribute to an innovative and diverse ecosystem. R&D entities are referred to as “performers” and fall into five categories: federal R&D, federally funded R&D centers, business R&D, university R&D, and other non-profits R&D. The aggregate R&D investment in Massachusetts across these categories accounted for 5.7% of the

Commonwealth’s GDP in 2016. When adjusted for inflation this totals \$30.9 billion in R&D performed in the Commonwealth, that year placing Massachusetts second among the LTS in absolute R&D expenditures, behind California which led with \$144 billion. However, in proportion to statewide GDP, Massachusetts has led the LTS in total R&D expenditures since 2011, followed by California with 5.2%, while no other LTS had more than 4% of GDP derived from R&D. The Commonwealth’s sustained commitment to R&D investment is evident in its 23.2% R&D investment growth rate since 2011. Massachusetts ranks third in this metric among LTS behind California (38.5%) and North Carolina (34.4%).

The R&D that was carried out in 2016 was mostly funded by businesses, which accounted for more than 65% of R&D expenditures in all of the LTS, and more than 70% in all except New York (67.7%). In Massachusetts business R&D accounted for 74.5% of all R&D, which reflects leading home-grown and multinational companies that have located their R&D facilities in Massachusetts, including Biogen, Sanofi-Genzyme, Amazon Robotics, Google, and Microsoft.

Massachusetts also attracts significant levels of federal funding for R&D. In 2017, the Commonwealth received \$3.5 billion for R&D initiatives at universities, colleges, and other non-profits. Although this total in absolute dollars lagged behind the top attractor, California (\$5.2 billion), the awarded amount equates to \$6.01 of R&D investment per \$1,000 of GDP. The LTS with the second highest funding award relative to its GDP was Pennsylvania at \$2.92, while California fell to 7th in the ranking with \$1.79 per \$1,000 of GDP.

Massachusetts draws significant levels of healthcare R&D in particular, with the National Institute of Health (NIH) awarding \$2.9 billion to Massachusetts institutions in 2018, the second highest of any of the LTS after California. Per \$1 million GDP, Massachusetts received \$5,337 from the NIH which is more than twice as much as second place North Carolina (\$2,607). Ten institutions in Massachusetts received more than \$100 million each in funding from the NIH.

**Total R&D Expenditures
MA & LTS, 2011 & 2016¹⁰**

State	2011 Total R&D Expenditure	2016 Total R&D Expenditure	% Change 2011-2016	2016 R&D as a % of GDP
California	\$104,356	\$144,561	38.53%	5.16%
Massachusetts	\$25,138	\$30,961	23.16%	5.72%
Texas	\$23,541	\$25,066	6.48%	1.46%
New York	\$21,193	\$24,832	17.17%	1.55%
Illinois	\$18,234	\$18,716	2.64%	2.20%
Pennsylvania	\$15,583	\$18,636	19.59%	2.41%
North Carolina	\$10,680	\$14,351	34.38%	2.59%
Ohio	\$11,825	\$12,828	8.48%	1.92%
Connecticut	\$9,972	\$9,944	-0.28%	3.62%
Minnesota	\$8,440	\$8,954	6.09%	2.47%

**Distribution of R&D by Performer
Massachusetts & LTS, 2016⁷**

State	Federal R&D	Federally Funded R&D Centers	Business R&D	Universities and Colleges R&D	Other Nonprofits R&D
CA	1.66%	3.99%	87.01%	6.58%	0.69%
CT	0.94%	0.00%	85.93%	12.65%	0.26%
IL	1.40%	6.04%	78.50%	13.72%	0.33%
MA	1.37%	5.62%	74.50%	13.12%	5.35%
MN	0.53%	0.00%	84.64%	11.48%	3.33%
NY	1.02%	2.49%	67.70%	26.24%	1.53%
NC	2.33%	0.00%	75.02%	21.90%	0.62%
OH	5.94%	0.00%	74.16%	18.29%	1.60%
PA	4.04%	0.84%	70.61%	22.68%	1.80%
TX	2.91%	0.04%	74.06%	22.44%	0.54%

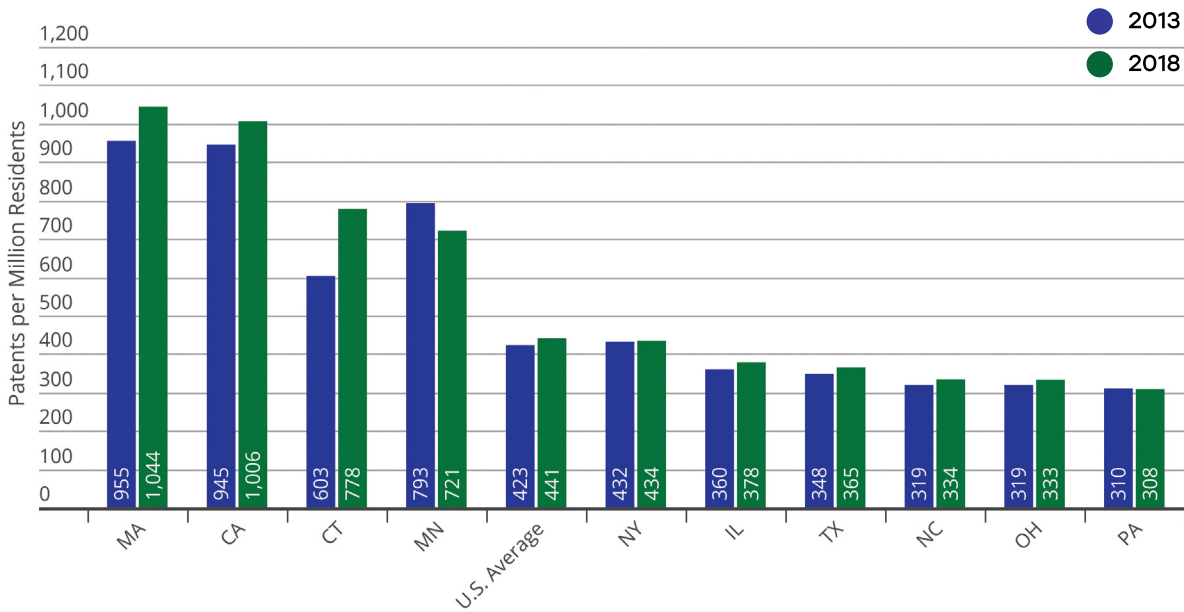
INTELLECTUAL CAPITAL

Utility patents provide a gauge of the innovation and idea generation quality present in an economy. 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. While not all utility patents turn into new products, these are where many new products or new versions of existing products or services come from. In many cases patented technology forms the basis for the creation of new businesses. Massachusetts had the most utility patents per million residents of any of the LTS at 1,044.

What are utility patents?

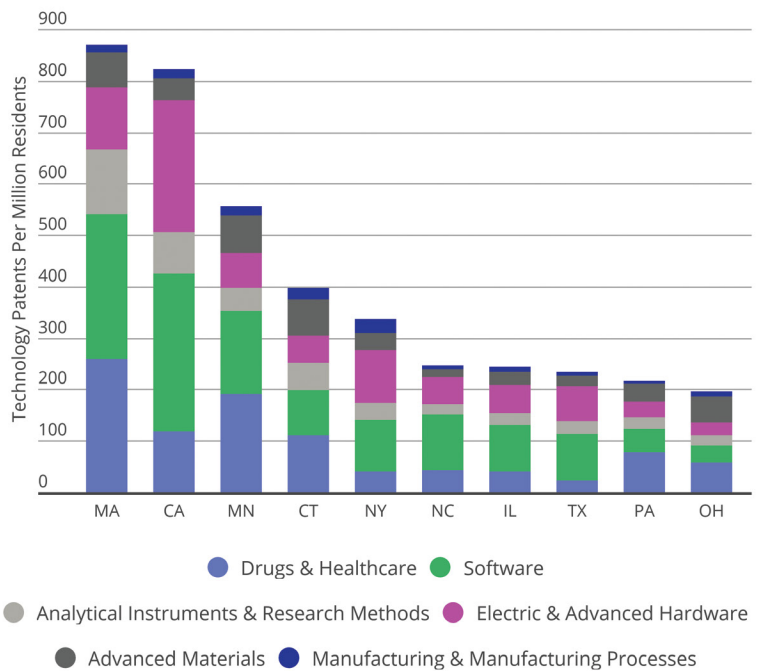
Utility patents are those for unique and novel inventions that have some practical purpose, as opposed to purely aesthetic design patents.

Utility Patents per Million Residents
MA, LTS, & U.S., 2013 & 2018¹¹



Technology Patents per Million Residents by Field
Massachusetts & LTS, 2018¹²

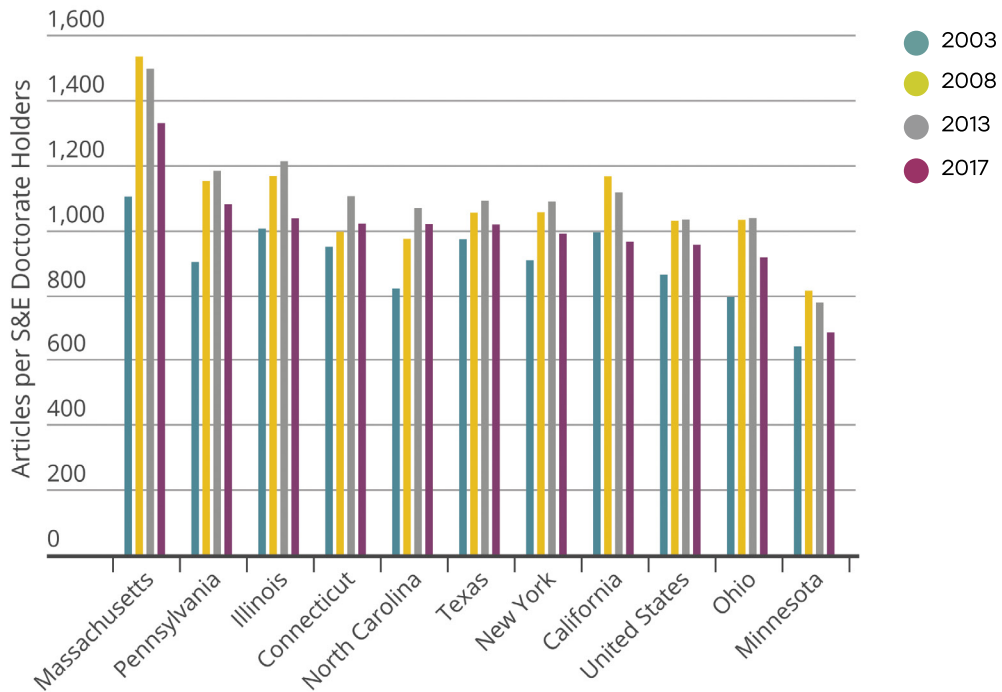
Technology patents, which are simply patents for technology, is another field which Massachusetts leads. In 2018 it had the most technology patents per million residents with 871, and was the leader in Drugs & Healthcare and in Analytical Instruments & Research Methods patents. Massachusetts placed either second or third place in all other technology patent fields except manufacturing.



Another measure of the idea generation of an economy is academic article output per 1,000 doctorate holders in academia, a statistic tracked by the National Science Foundation. Massachusetts has led this category since 2003, the first year that data was available. Doctorate holders in the Commonwealth produced 23% more academic articles in 2017 than second place Pennsylvania. Massachusetts also does exceptionally well when compared internationally, where

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

Massachusetts & Top LTS, 2003, 2008, 2013, 2017¹³



statistics are tracked by academic articles per capita. The most recent international data available is from 2015, where Massachusetts ranks first with 3,411 articles, followed by Switzerland (2,642), and Denmark (2,473).

S&E Academic Article Output per Million Residents
Massachusetts, Top LTS, & Top 5 International, 2015¹³

Location	S&E Article Output per million residents
Massachusetts	3,411
Switzerland	2,642
Denmark	2,473
Australia	2,186
Sweden	2,109
Singapore	2,027
Connecticut	1,615
Pennsylvania	1,473
New York	1,323
North Carolina	1,129

Here's what others are saying. Massachusetts also ranks:

- #1 – Research and Development Inputs Composite Index from Milken’s “State Tech and Science Index” 2018**
- #2 – R&D Density from Bloomberg’s “State Innovation Index” 2016**

**Federal Funding for R&D
Universities, Colleges, & Non-Profit Organizations
MA & LTS, 2007, 2012, 2017¹⁴**

State	2007 Absolute Funding (Millions \$)	2012 Absolute Funding (Millions \$)	2017 Absolute Funding (Millions \$)	2007 Funding per \$1000 GDP	2012 Funding per \$1000 GDP	2017 Funding per \$1000 GDP
California	\$5,511	\$5,358	\$5,264	\$2.28	\$2.23	\$1.79
Connecticut	\$727	\$626	\$625	\$2.47	\$2.30	\$2.25
Illinois	\$1,407	\$1,296	\$1,241	\$1.75	\$1.61	\$1.44
Massachusetts	\$3,489	\$3,622	\$3,456	\$7.42	\$7.29	\$6.10
Minnesota	\$722	\$734	\$730	\$2.25	\$2.23	\$1.98
New York	\$2,984	\$2,893	\$2,988	\$2.17	\$1.96	\$1.78
North Carolina	\$1,450	\$1,452	\$1,482	\$2.95	\$2.95	\$2.63
Ohio	\$1,162	\$1,080	\$1,037	\$1.91	\$1.79	\$1.53
Pennsylvania	\$2,451	\$2,286	\$2,303	\$3.53	\$3.19	\$2.92
Texas	\$1,898	\$1,837	\$1,856	\$1.30	\$1.16	\$1.07
United States	\$38,268	\$37,357	\$37,211	\$2.14	\$2.06	\$1.82

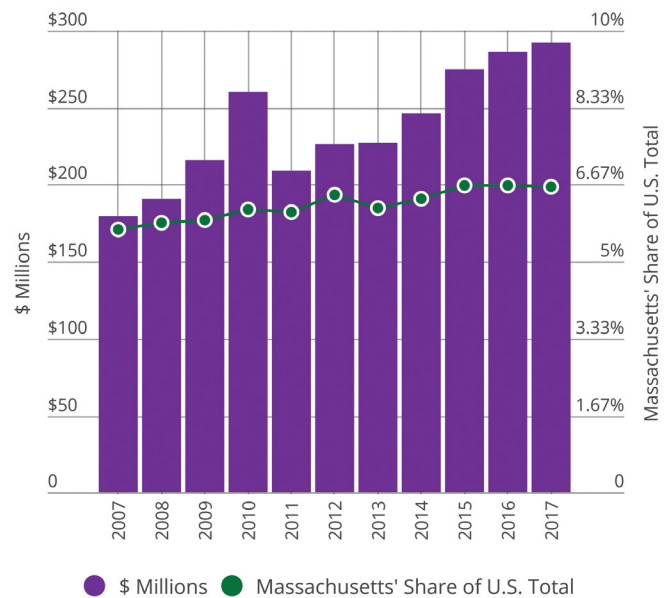
**National Institutes of Health (NIH) R&D Funding
per 1 Million GDP
MA & LTS, 2018¹⁵**

NIH R&D Funding by State	Number of Awards	Absolute Funding	Funding per \$1 Million GDP
Massachusetts	5,367	\$2,887,150,148	\$5,337
North Carolina	2,435	\$1,402,438,380	\$2,607
Pennsylvania	3,747	\$1,810,217,516	\$2,406
Connecticut	1,240	\$560,899,834	\$2,112
New York	5,448	\$2,632,652,693	\$1,647
Minnesota	1,160	\$561,671,411	\$1,594
California	8,362	\$4,243,446,496	\$1,510
United States	57,206	\$28,106,121,128	\$1,442
Ohio	1,817	\$816,911,217	\$1,265
Illinois	2,100	\$895,375,844	\$1,084
Texas	2,949	\$1,243,375,373	\$752

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

Massachusetts has increased its share of total U.S. industry funding for academic science and engineering research by almost a full percentage point (5.7% to 6.6%) from 2007-2017, indicating that the Commonwealth's research institutes and universities are an increasingly attractive asset to industry.

Industry Funding for Academic Research in S&E MA, 2007-2017¹⁶



Capital

Capital is the third pillar of the Massachusetts Innovation Economy. While the Commonwealth is a national leader in the quality of its workforce and R&D, it does not have a monopoly in these areas. Other states have skilled workforces and/or cutting-edge research institutions, but very few states can combine these assets with access to capital. Capital is the critical factor that allows a skilled workforce to turn cutting-edge research into new or expanded businesses creating jobs and providing innovative products and services.

**Here's what others are saying.
Massachusetts also ranks:**

#1 in the Risk Capital and Entrepreneurial Infrastructure Composite Index from Milken's "State Tech and Science Index" 2018

Access to various sources of capital is important for the growth of innovative businesses whose needs vary at each stage of the growth cycle. Massachusetts performs well across the capital spectrum, from grant funding to seed and early stage investments to initial public offerings (IPOs).

SBIR & STTR PROGRAMS ATTRACT PROOF-OF-CONCEPT CAPITAL

The number and value of Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) awards that go to the Commonwealth's businesses are excellent indicators of the ability of the R&D in Massachusetts to attract proof-of-concept capital. Massachusetts received the second most grant awards in the nation in 2017 with 604 awards totaling \$271 million. Although the value of California's SBIR and STTR 2017 grant programs was roughly double the Massachusetts value, Massachusetts received the highest award funding relative to GDP, with \$594 worth of funding per \$1 million in GDP, while California received \$248 per \$1 million in GDP.

What is SBIR/STTR?

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 programs 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.

**SBIR/STTR Awards Funding
MA & LTS, 2017¹⁷**

State	SBIR/ STTR Awards Total Funding Amount	Award Funding per \$1 Million GDP
Massachusetts	\$270,969,255	\$594
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
Connecticut	\$26,629,271	\$119
Illinois	\$52,865,649	\$75
Texas	\$107,532,688	\$71

VENTURE CAPITAL (VC) ACCELERATES THE INNOVATION ECONOMY

The wealth of talent and R&D activity in the state makes Massachusetts an attractive destination for investors. VC firms provide an important source of funds for the creation and development of high-growth companies that accelerate the Massachusetts Innovation Economy. VC investment grew 158% from 2013-2018 to \$10.6 billion. This represents the third fastest growing VC environment in United States, behind California and New York, respectively. In relative terms, Massachusetts ranks second in the nation in attracting VC in terms of the size of the state economy. Massachusetts received \$18.65 in VC investments per \$1,000 of its GDP, behind California’s \$23.54. Massachusetts exceeded New York’s \$7.98.

**Venture Capital Investment
MA & LTS, 2013-2018
Millions of 2018 \$¹⁸**

State	VC Investment 2018 (Mill \$)	2017-2018 % Change	2013-2018 % Change	2018 VC Investment per \$1000 GDP
CA	\$69,858	84%	270%	\$23.54
MA	\$10,582	42%	158%	\$18.65
NY	\$13,371	10%	228%	\$7.98
NC	\$2,321	143%	332%	\$4.10
IL	\$2,007	-3%	168%	\$2.32
MN	\$698	-3%	116%	\$1.90
PA	\$1,020	-2%	66%	\$1.29
TX	\$2,284	28%	19%	\$1.29
CT	\$259	-27%	-7%	\$0.94
OH	\$517	51%	44%	\$0.76

Stages of VC Investment

- **Seed:** Very early, has an idea but potentially no product. Funding for is for R&D and prototypes.
- **Early:** The core of the business is established and investors are setting up infrastructure to support it.
- **Expansion:** Investors are looking to expand access to markets, products lines, or both.
- **Late:** The company is mature enough to look into mergers and acquisitions, positioning against competitors, or moving towards an IPO.

Trends in venture investment can indicate emerging technology and recruiting opportunities in the Innovation Economy. Of the ten sectors tracked by the *Index*, healthcare emerges with the strongest trends in attracting VC in Massachusetts, receiving more than half of all VC invested in the state, accounting for \$6 billion (57.0%) in 2018. Healthcare includes industries such as biotech and medical devices. Biotech received the largest amount of VC funding in the healthcare sector with 36% of all healthcare VC while medical devices received 8%.

The Internet sector was the second largest VC investment target in Massachusetts with \$2.2 billion (20.7%) in 2018. Combined, the internet and healthcare sectors account for 77.7% of all VC in Massachusetts. Since 1995, healthcare has been the largest venture capital sector every year, except a three year stretch from 1999-2001 where Software took the top spot.

In addition to tracking venture capital by sectors, it can also be tracked by stages; seed, early, expansion, and late depending on where the business is in its lifecycle. Businesses in Massachusetts attract VC sooner than the LTS on average. 65% of venture investment is awarded in the primary stages of the business lifecycle (seed, early, and expansion), compared to 39.8% among the LTS as a whole which experiences the majority of its funding in the later stages.

Venture Capital by Sector
MA, Millions of 2018 \$¹⁸

Sector	VC Investment - Millions of 2018 \$	% of Investments
Healthcare	\$6,031	57.0%
Internet	\$2,194	20.7%
Mobile & Telephone	\$633	6.0%
Software	\$451	4.3%
Computer Hardware	\$325	3.1%
Other	\$304	2.9%
Electronics	\$278	2.6%
Industrial	\$219	2.1%
Consumer	\$112	1.1%
Auto	\$35	0.3%

Venture Capital Distribution by Stage
MA & LTS, 2014-2018, % of VC by Stage¹⁸

Year	MA					LTS				
	Seed	Early	Expansion	Late	Other	Seed	Early	Expansion	Late	Other
2014	3.5%	19.5%	34.0%	41.0%	2.0%	3.2%	12.0%	29.4%	50.8%	4.5%
2015	2.6%	20.2%	41.5%	30.3%	5.4%	2.4%	10.6%	23.6%	59.8%	3.7%
2016	3.6%	23.9%	32.6%	34.7%	5.1%	3.4%	14.6%	27.8%	48.3%	5.9%
2017	2.7%	21.3%	42.7%	27.9%	5.5%	3.3%	12.4%	28.6%	49.0%	6.7%
2018	3.1%	19.7%	42.2%	28.9%	6.1%	2.6%	11.9%	25.3%	41.4%	18.9%

The exit of startups from their initial phases is also important information for venture capitalists. The prevalence of businesses that exit the startup lifecycle through IPOs or M&As can be an attractive metric as investors consider their return prospects. IPOs and M&As represent important business outcomes through which emerging companies can access capital, expand operations, and support business growth beyond their initial funding rounds. 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. Massachusetts has placed second among the LTS in numbers of IPOs held every year since 2013. In 2018, Massachusetts companies raised \$2.9B through IPOs, placing 3rd among the LTS, behind California and New York.

**Number of Initial Public Offerings (IPOs)
MA & LTS, 2014-2019¹⁹**

No. of IPOs by State	2014	2015	2016	2017	2018	2019	2019 IPO Total \$
California	47	35	14	27	48	53	\$20,693,840,156
New York	0	0	0	0	3	13	\$3,873,501,000
Pennsylvania	5	4	0	4	3	5	\$3,290,144,488
Massachusetts	21	10	13	17	20	15	\$1,706,289,964
Texas	7	4	4	12	4	7	\$634,000,000
Illinois	4	2	0	2	2	3	\$352,600,000
Connecticut	5	0	0	1	2	2	\$217,000,000
North Carolina	3	3	2	3	9	1	\$126,400,000
Minnesota	1	0	1	2	4	2	\$79,973,566
Ohio	0	0	0	0	4	2	\$7,000,000

**Number of Companies
Being Acquired
MA & LTS, 2014-2019¹⁹**

No. of Companies Acquired, by State	2014	2015	2016	2017	2018	2019
California	536	534	721	651	730	642
Texas	93	109	169	190	216	204
New York	106	112	179	143	186	191
Massachusetts	132	101	176	168	168	166
Illinois	65	73	101	96	141	113
Pennsylvania	43	67	99	94	91	110
Ohio	32	35	67	67	81	69
Minnesota	26	24	61	63	59	68
North Carolina	41	45	57	55	78	62
Connecticut	25	21	34	37	47	53

**Number of Companies
Acquiring Others
MA & LTS, 2014-2019¹⁹**

No. of Companies Acquiring Others, by State	2014	2015	2016	2017	2018	2019
California	542	503	698	648	748	721
New York	181	189	310	301	338	331
Texas	118	109	182	204	261	211
Massachusetts	127	120	170	171	223	207
Illinois	117	129	183	157	190	203
Pennsylvania	63	43	115	105	120	128
Ohio	33	32	70	88	93	88
North Carolina	32	26	46	52	76	71
Minnesota	37	40	62	67	76	66
Connecticut	35	52	69	49	64	37

Economic Impact

The combination of world-class talent, R&D capabilities, and access to capital gives Massachusetts a competitive advantage among global innovative ecosystems. This trifecta attracts business formation and expansion in the state and has considerable benefits for the economy and people of Massachusetts.

MASSACHUSETTS IS ONE OF THE HIGHEST INCOME STATES IN THE NATION

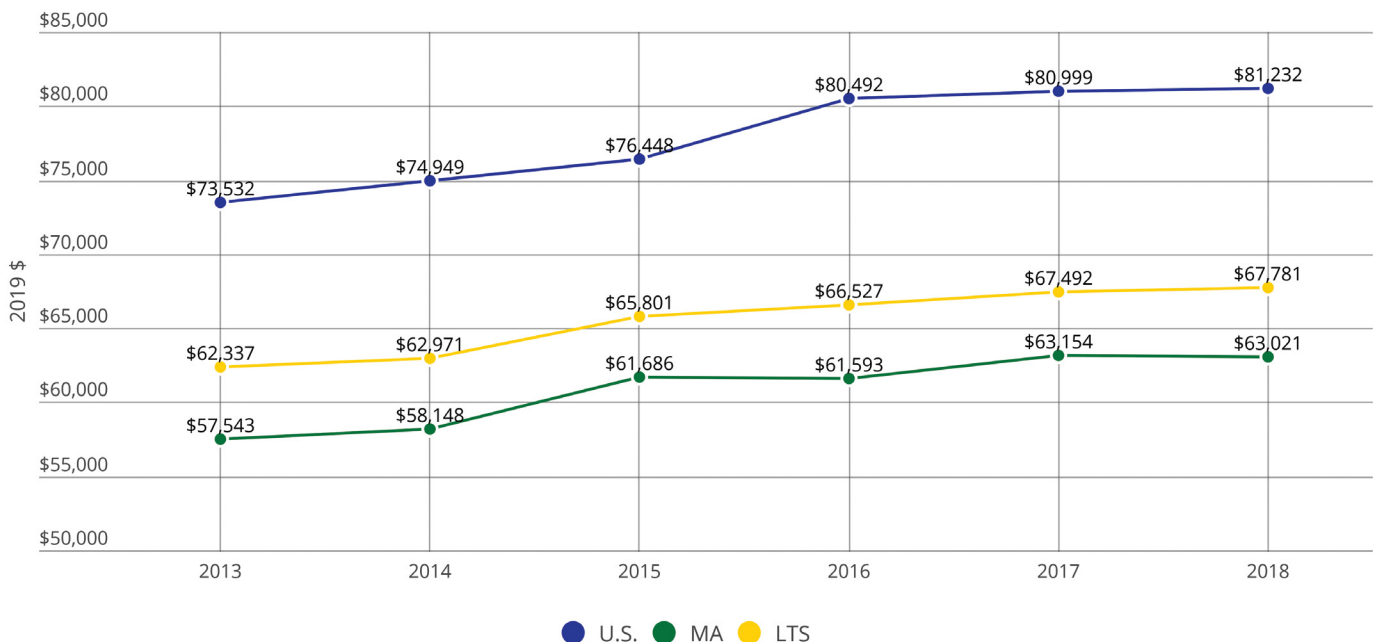
One of the most telling impact metrics of the innovation economy is GDP per capita. The Commonwealth's GDP per capita ranks 2nd in the U.S. and would rank 4th in the world if Massachusetts were an independent country. This productivity leads to a high level of prosperity

Percentage of Households by Income Level
Massachusetts, LTS & U.S., 2017²¹

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%

for the state's residents, as evidenced by growth in median household income. 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. Massachusetts saw median household income grow again in 2018 to a new high of \$81,232 (in 2019 dollars), significantly higher than both the U.S. average of \$63,021 and the LTS average of \$67,781. There is also a higher distribution of households earning more than \$100,000 in Massachusetts than in the LTS on average and the U.S. as a whole.

Median Household Income
MA, LTS, & U.S., 2013-2018²⁰



INNOVATION WORKFORCE, WAGES, AND OUTPUT CONTINUE TO GROW

Technology and knowledge-intensive industry sectors critical to the Innovation Economy lead the way in increasing prosperity through high-paying jobs across the state. Increased employment concentration in these sectors indicates a competitive advantage for Massachusetts and the potential for future economic growth. The innovation workforce in Massachusetts has continued

to expand, with double digit growth in employment from 2013-2018 in five of the eleven key industry sectors tracked by the *Index*. Two of the key sectors saw employment growth of more than 20% with Scientific, Technical & Management Services (SciTech) growing 23% and Biopharma & Medical Devices (Bio) growing 30%. Conversely, four sectors witnessed declines in employment. This trend was strongest in the Computer & Communications Hardware sector which saw employment in the industry decline by 12%.

The fastest growing sectors, SciTech and Bio, also experienced considerable wage growth between 2013 and 2018. Wages for Bio occupations were the fastest growing in the state with 20.1%, while SciTech (16.1%) ranked 3rd, behind the Financial Services sector which posted 18.3% wage growth in the period. It is worth noting that the sectors with the highest growth in wages align with the top categories for venture investment in Massachusetts (Healthcare and Internet). Two sectors experienced slight declines in wages during this period, Computer & Communications Hardware (-1.1%) and Healthcare Delivery (-0.3%).

Employment and Annual Average Wage in Key Sectors, MA 2013-2018²²

Sectors	2013 Total Employment	2018 Total Employment	% Change in Employment 2013-2018	2013-2018 Trend in Employment	2013 Average Wage	2018 Average Wage	2013-2018 % Wage Change	2013-2018 Trend in Average Wages
Advanced Materials	29,898	28,345	-5.2%		\$71,756	\$72,327	0.8%	
Biopharma & Medical Devices	54,634	71,061	30.1%		\$135,765	\$163,104	20.1%	
Business Services	147,175	163,706	11.2%		\$113,251	\$120,350	6.3%	
Computer & Communications Hardware	34,172	29,956	-12.3%		\$125,847	\$124,473	-1.1%	
Defense Manufacturing & Instrumentation	38,110	36,291	-4.8%		\$114,541	\$120,908	5.6%	
Diversified Industrial Manufacturing	38,769	38,453	-0.8%		\$80,584	\$82,174	2.0%	
Financial Services	154,813	160,002	3.4%		\$141,693	\$167,615	18.3%	
Healthcare Delivery	355,938	387,587	8.9%		\$72,675	\$72,434	-0.3%	
Postsecondary Education	139,420	162,303	16.4%		\$69,210	\$70,064	1.2%	
Scientific, Technical & Management Services	79,275	97,098	22.5%		\$110,905	\$128,794	16.1%	
Software & Communications Services	145,675	163,939	12.5%		\$127,343	\$143,887	13.0%	

Employment Growth in Key Sectors, MA & LTS, 2017-2018²²

State	Advanced Materials	Biopharma & Medical Devices	Business Services	Computer & Communications Hardware	Defense Manufacturing & Instrumentation	Diversified Industrial Manufacturing	Financial Services	Healthcare Delivery	Postsecondary Education	Scientific, Technical & Management Services	Software & Communications Services
California	0.3%	7.7%	5.3%	2.6%	2.1%	2.5%	-0.1%	3.0%	1.9%	7.1%	4.9%
Connecticut	1.1%	6.4%	1.5%	-1.6%	2.7%	-0.6%	-1.9%	1.3%	1.8%	1.8%	-0.7%
Illinois	0.3%	7.4%	-1.7%	0.8%	3.5%	0.9%	1.4%	0.9%	1.1%	3.1%	-0.6%
Massachusetts	-0.2%	9.5%	4.6%	-3.6%	1.5%	1.1%	-0.1%	-0.8%	2.3%	7.8%	1.0%
Minnesota	1.7%	6.9%	0.7%	-0.9%	4.7%	2.2%	1.8%	2.5%	0.7%	5.2%	-0.8%
New York	-1.1%	10.5%	0.0%	-0.1%	0.6%	-1.3%	0.8%	3.9%	1.9%	2.3%	4.0%
North Carolina	1.4%	10.0%	2.2%	2.6%	0.3%	4.9%	3.2%	2.4%	2.1%	6.4%	2.9%
Ohio	1.3%	10.5%	-1.1%	1.5%	1.6%	3.3%	1.0%	1.2%	0.3%	6.6%	1.0%
Pennsylvania	0.2%	4.7%	0.3%	-0.9%	4.0%	1.6%	1.4%	2.4%	0.9%	3.2%	1.7%
Texas	2.4%	10.0%	4.8%	0.5%	3.6%	4.3%	2.6%	1.6%	1.3%	6.6%	4.2%

Comparatively, wages in Massachusetts are higher than those of the US and the LTS in 10 of the 11 occupational categories tracked by the *Index*. The only exception is Social services, where wages fall between the LTS average and national average. Relatively high wages can make it more expensive to grow a business in Massachusetts. In some cases this is influenced by a shortage of employees.

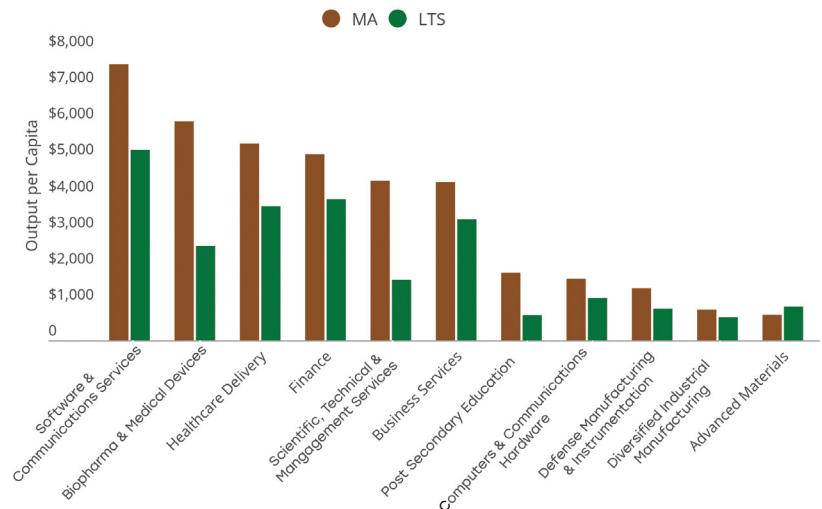
Average Wages by Occupation
MA, LTS, & U.S., 2018²³

Occupation	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

Output per Capita in Key Industry Sectors
MA & LTS, 2018²⁴

The strength of the Massachusetts Innovation Economy is also evident in its economic output. Every sector, with the exception of Advanced Materials, outperformed the LTS average in per capita output in 2018. Software & Communications (\$7,636), Biopharma & Medical Devices (\$6,057), and Healthcare Delivery (\$5,442) are the top three sectors in output per capita in Massachusetts, each outperforming the LTS average by more than \$1,500. The divergence of Massachusetts' Biopharma & Medical Devices sector and that of the average LTS is particularly strong with the Commonwealth outperforming the LTS by \$3,445 worth of output per capita. In every sector, except Advanced Materials, Massachusetts output per capita was more than 30% higher than the LTS average.

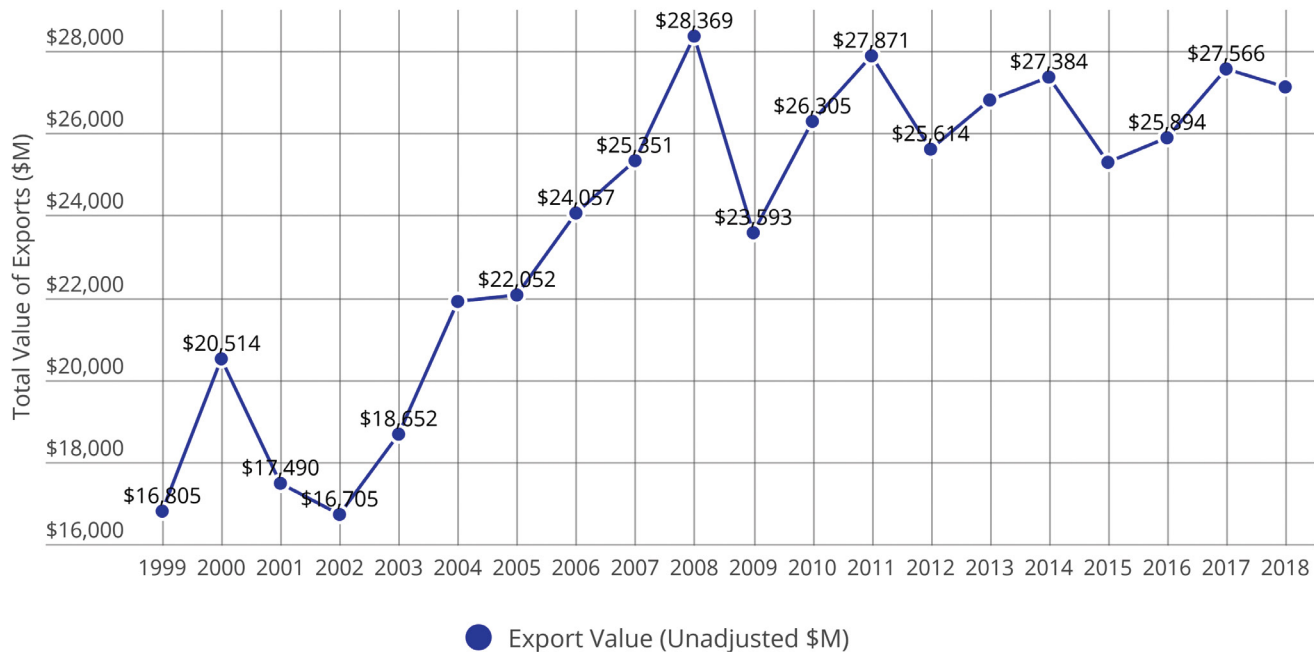
Although the Commonwealth is a clear leader in economic productivity, much of its success has come from service



Key Sectors	MA	LTS
Software & Communication Services	\$7,636	\$5,268
Biopharma & Medical Devices	\$6,057	\$2,612
Healthcare Delivery	\$5,442	\$3,711
Finance	\$5,150	\$3,909
Scientific, Technical & Management Services	\$4,413	\$1,682
Business Services	\$4,378	\$3,351
Postsecondary Education	\$1,870	\$704
Computers & Communications Hardware	\$1,704	\$1,175
Defense Manufacturing & Instrumentation	\$1,441	\$880
Diversified Industrial Manufacturing	\$848	\$643
Advanced Materials	\$712	\$936

sectors which can be difficult to track quantitatively, particularly as it relates to exports. The total value of Massachusetts' exports decreased in both total value and as a percentage of U.S. exports from 2017-2018. Since 2008, exports have fluctuated year-to-year between periods of growth and decline.

Total Value of Exports
MA, 1999-2018, Unadjusted (Millions \$)²⁵



Challenges

Massachusetts is a strong competitor in the three pillars of the Innovation Economy (talent, research, and capital) and shows good results in the economic impact enabled by those pillars. Although these areas are considered the Commonwealth's strengths, there are several obstacles that could slow the growth trajectory of the Innovation Economy.

While Massachusetts has an excellent talent development ecosystem that attracts global talent, there are areas for improvement in the development and support of local talent. Massachusetts students, and U.S. students in general, are being outperformed by their international peers at the elementary and secondary levels in science and mathematics, where Massachusetts students scored 6th and 20th respectively. Beyond not being top performers, this shows a significant gap between the subjects, the third largest gap between scores after North Carolina and Vietnam. Appropriations for post-secondary education are another area where Massachusetts support falls behind, dropping from 3rd in per pupil spending from the K-12 level to 6th in appropriations for higher education. Domestic migration continues to pose a major challenge for Massachusetts. The high cost of living could be a main driver of the domestic out-migration of Massachusetts residents experienced since 2011. Although inflows in the state's international population have meant there has been positive net

Here's what others are saying.

Massachusetts ranks:

- **#3 - Technology Concentration and Dynamism Composite Index and Milken's "State Tech and Science Index" 2018**
- **#1 - High Tech Density in Bloomberg's "State Innovation Index" 2016**

migration in Massachusetts since 2008, there have only been two years (2009 and 2010) of positive domestic migration since 2002.

For R&D Massachusetts still received more than twice as much federal funding relative to its GDP as any other LTS for R&D in 2017, but it has declined since 2012. While federal funding for R&D has declined in the nation as a whole, Massachusetts had the largest decline from 2012 to 2017, decreasing 4.6% while California, the largest in total federal funding fell only 1.7%, and New York with the 2nd most total federal funding grew 3.3%. The LTS in 2nd place in funding relative to GDP, Pennsylvania, also saw growth of 0.8% in the 2012-2017 period.

While Massachusetts is a top state for VC investment (2nd in the LTS in investment relative to GDP, and 3rd in total investment), the Commonwealth is far behind California in terms of overall investment and has been surpassed by New York since 2015. When looking at the growth in VC investment though, Massachusetts lags behind more significantly, coming in 5th in the LTS, having grown 158% since 2013. During that same period California investment grew by 270% and New York by 228%. Massachusetts also has some risk of becoming overly focused on healthcare which accounts for over half (57%) of the VC investment. This sector can potentially crowd out other startups who might look for opportunities elsewhere.

Spillover effects from the health of the innovation economy also contribute to a number of problems, notably in the high cost of housing and increasing commute times, both of which are widely viewed as challenges to the Commonwealth’s economy. Greater Boston experiences the worst traffic congestion and the highest housing prices, with growth of the last decade pushing people to live further from Boston, causing shortages of affordable housing and traffic congestion in other regions of the state.

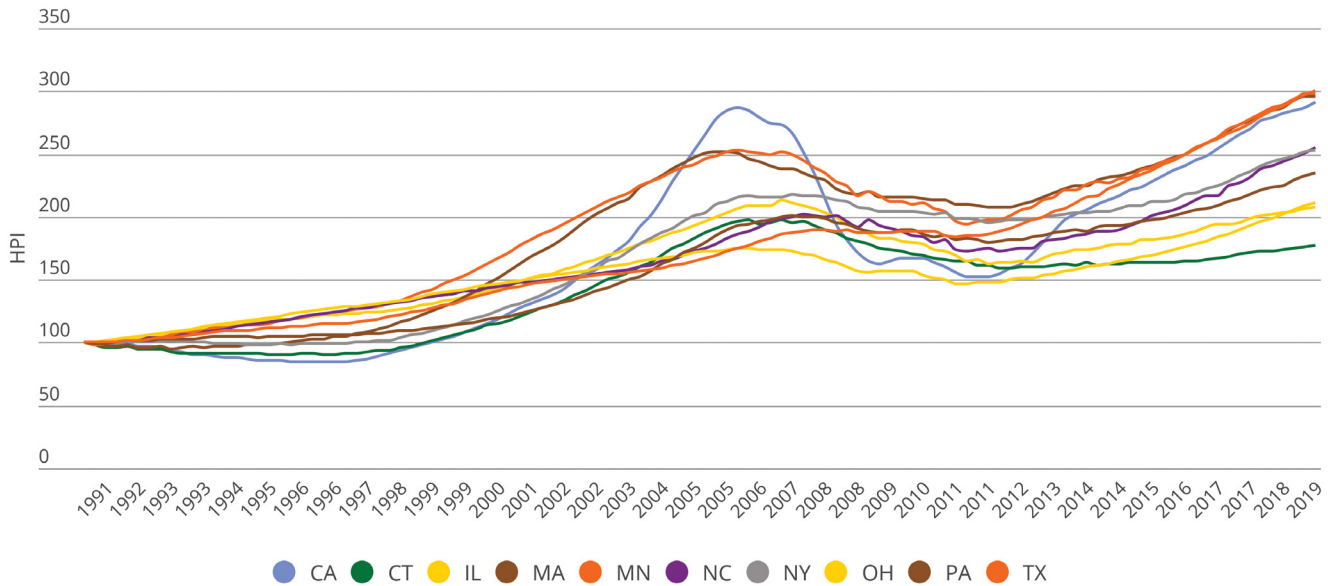
Affordable housing in particular is a challenge experienced in most regions of the Commonwealth, where residents of Gateway Cities and vacation destinations struggle to compete with Boston commuters and the second home/vacation rental market. 27% of Massachusetts homeowners spend more than 30% of their income on housing costs, which is the federal government’s threshold of being considered “burdened by housing costs.” The problem is worse for renters, with 46.8% being burdened by housing costs, placing Massachusetts 4th highest among the LTS although this is close to the U.S. average of 46.2%. Proximity to the national average poses a particular problem for MA since its above average median household income and high distribution of households making more than of \$100,000 annually would suggest that a lower percentage of households face burdensome housing costs. Although the percentage of homeowners and renters burdened by housing costs has actually declined since 2013, it is likely a result of buyers and renters being priced out of the state’s most expensive metro areas and relocating to more affordable suburbs and mid-sized cities. Over the last five years, this trend has pushed real estate values up throughout the state. For example, affordability is an increasing concern in Worcester as it has witnessed an in-flux of renters who find the city a more affordable alternative to Boston. (Worcester Chamber of Commerce, 2019).^c

**Percent of Households Spending at least 30% of Income on Housing
MA & U.S., 2013-2018²⁷**

Location	2013 Homeowners	2013 Renters	2018 Homeowners	2018 Renters	2013-2018 Homeowners % Change	2013-2018 Renter % Change
U.S.	25.3%	47.6%	22.3%	46.2%	-3.0%	-1.5%
CA	34.3%	54.1%	31.2%	51.9%	-3.1%	-2.2%
CT	31.5%	49.3%	27.8%	49.7%	-3.7%	0.4%
IL	27.0%	45.8%	23.1%	44.1%	-3.9%	-1.6%
MA	29.6%	47.5%	27.0%	46.8%	-2.7%	-0.7%
MN	21.1%	44.8%	18.1%	43.6%	-3.0%	-1.3%
NY	31.4%	50.8%	27.4%	49.1%	-4.0%	-1.7%
NC	23.1%	45.1%	19.7%	43.8%	-3.4%	-1.4%
OH	21.0%	44.6%	18.0%	41.2%	-3.1%	-3.4%
PA	23.8%	46.1%	20.8%	44.2%	-3.0%	-1.8%
TX	21.1%	44.2%	20.9%	45.2%	-0.2%	1.0%

With a Housing Price Index (HPI) of 295.3 Massachusetts has one of the highest HPIs in the nation. Only Texas and New York have experienced a similar increase in prices relative to the HPI baseline year of 1991. The Commonwealth's HPI is currently almost 20% higher than its previous peak in 2005 during the housing bubble.

Housing Price Index
MA & LTS, Q1 1991-Q2 2019²⁶



While increasing home prices are good news for homeowners, they can also act as a brake upon the growth of the Innovation Economy, causing new graduates and young professional couples to leave the state for opportunities elsewhere and making it harder to attract talent from regions with lower housing costs. State and local governments are increasingly realizing that the housing shortage threatens the Commonwealth's economy, and are working on solutions to the problem. The Metro Mayor's Coalition, made up of 15 cities and towns in the Greater Boston Area announced a Regional Housing Partnership in 2018 with the goal of building 185,000 new units by 2030. In 2019, the Baker-Polito Administration has proposed a Housing Choice Initiative that would incentivize local governments to plan and build the diverse housing stock needed around the state.

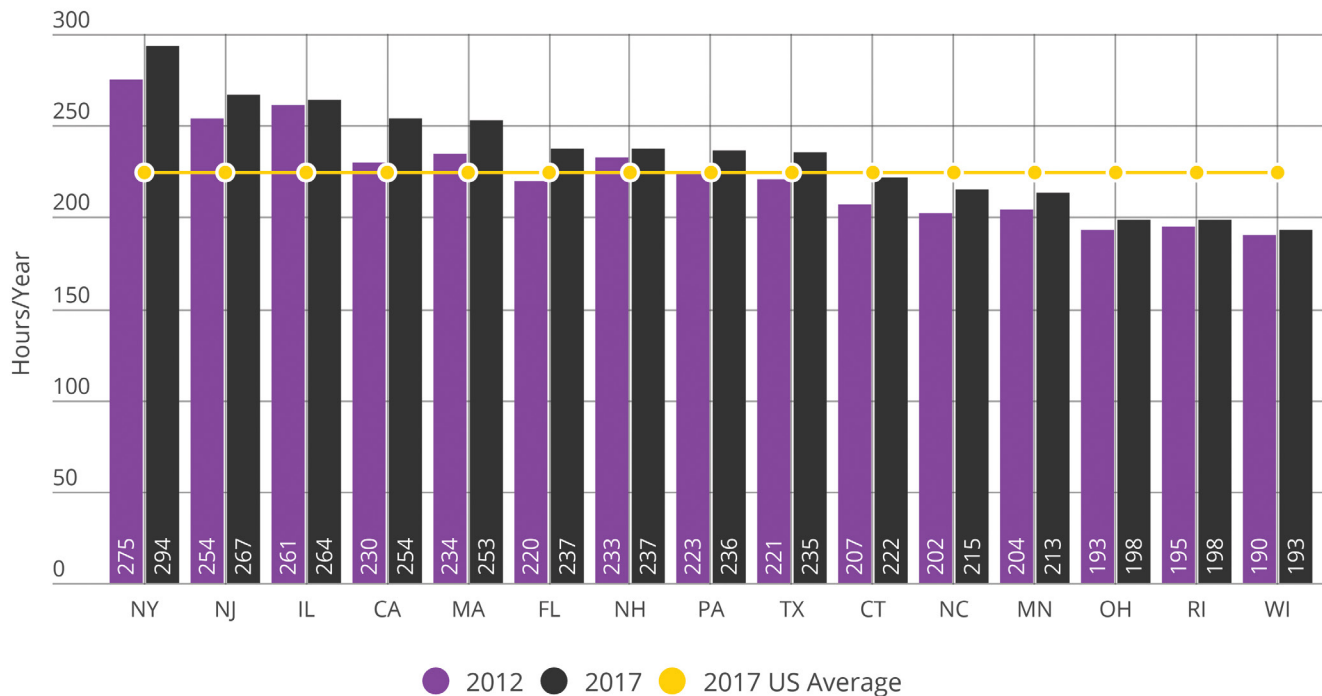
Alongside housing costs, commute times is one of the largest challenges facing Massachusetts. The average large metro (>250k commuters) commuter in Massachusetts spent 253 hours commuting in 2017, making Massachusetts the 4th worst among the LTS, and more than a full day (29 hours) above the U.S. average.

In a recent survey:

- **30% of fulltime workers who drive to work have considered changing jobs for a better commute, as have 37% of transit users**
- **52% of drivers have been late to work because of traffic recently, and for transit users that number was 63%**
- **23% of drivers reported that they have thought about leaving the area entirely, and within Route 128 that rises to 32%**

-MassINC Poll on Transportation, 2019^D

Average Metropolitan Commute Time, Large Metros (above 250k commuters)
Hours/Year, MA, LTS, & U.S. Average (2012-2017)²⁸



Increasingly arduous commutes across all modes of transportation create a serious quality of life issue for the Commonwealth’s residents. Economic growth in Massachusetts is driven by the state’s well-educated workforce, many of whom could choose to live elsewhere. Employers are increasingly frustrated by lost productivity from workers stuck in traffic where there are 300,000 more vehicles on the road than five years ago, 59,000 of which are driving solo (Ryan, 2019)^E or stranded by the aging public transportation system. Transportation apps, such as Uber and Lyft, are also exacerbating the problem, creating an increase in the number of vehicles on the road and reaching as much as 20% of the traffic on the road in some areas. There has been a significant increase in the use of such services, in 2012 there were a total of 14.6 million taxi rides in the Boston area while in 2018 there were 4.8 million taxi rides and 42 million rides from transportation apps. Many of those people when surveyed said they would not have been in a car at all without the apps, with around 42% saying they would have taken the train or bus and 12% saying they would have biked (Dungca, 2019).^F Massachusetts is not alone in facing the problem of rising commute times as six of the LTS have large metro commute times above the national average. However, Massachusetts commute times increased by 19 hours, or 8.1% from 2012-2017, more than any other LTS except California.

Massachusetts is investing more in public transportation as a means of improving the commutes of transit riders and decreasing highway congestion through a five year, \$8B capital improvement plan for the MBTA. In addition, the MBTA’s Fiscal Management and Control Board adopted a resolution calling for the development of a Regional Rail system in the Commonwealth, providing faster and more frequent service to the MBTA’s existing commuter rail system, which connects gateway cities such as Brockton, Lawrence, Lowell, and Worcester to jobs in Boston.

“We can’t sustainably maintain an innovation district if we don’t address these issues now, I really do believe if we don’t solve this, it’ll impact a [future] innovation that could change the course of humanity.”- YeSeul Kim, Vice President of the Kendall Square Association (Curbed, 2018)^G

Appendix

The 2019 Edition of the Index (data gathered 2019 and earlier) tracks a selection of categories that MassTech and its Index Advisory Committee (page 38) view as being the most comprehensive set of data for benchmarking the Innovation Economy. Category choices 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 categories each year to determine whether to add or remove any sections and whether or not better sources of data are available.

Data Sources For Categories And Selection Of Leading Technology States (LTS)

- I. Note on Data Availability:** Categories 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 category. *The Index* always displays the most recent year of data available for data at the time of writing.
- II. Note on Price Adjustment:** *The Index* uses inflation-adjusted figures for most data. 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).
- 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 LTS for Benchmarking Massachusetts' Performance:** *The Index* benchmarks Massachusetts' performance against other leading states and nations to provide the basis for comparison. In 2019, 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 10 highest overall scores are then chosen for the LTS. The Innovation Economy Score is used only to select the LTS as described above, it does not reflect performance on all data used in the *Index*.
- V. Note on Selection of Comparison Nations:** For all the data that include international comparisons, countries displayed on the table 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 categories, 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.

2019 Leading Technology States (LTS)

State	# of IE Jobs	Size Score	IE Concentration	Concentration Score	# of Sectors >1.1	Diversity Score	Total Score
Massachusetts	1,341,147	0.27	37.40%	1.00	8	1.00	2.27
California	4,919,398	1.00	28.30%	0.55	5	0.63	2.17
Pennsylvania	1,884,248	0.38	32.10%	0.73	7	0.88	1.99
New York	2,999,824	0.61	31.80%	0.72	4	0.5	1.82
Ohio	1,657,781	0.33	30.70%	0.66	5	0.63	1.62
Minnesota	932,308	0.18	32.30%	0.75	5	0.63	1.55
Illinois	1,808,671	0.36	30.30%	0.64	4	0.5	1.5
Connecticut	565,558	0.11	33.80%	0.82	4	0.5	1.42
Texas	3,526,803	0.71	28.70%	0.56	1	0.13	1.4
North Carolina	1,328,574	0.26	30.10%	0.63	4	0.5	1.4

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Data sources for charts may be found in the Index Appendix at <https://masstech.org/sites/mtc/files/documents/2019-Index/Appendix-2019Index.pdf>

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