

SPECIAL ANALYSIS: 20 YEARS OF ADAPTATION

20 YEARS OF ADAPTATION AND INNOVATION by MassTech Staff

For two decades, the *Index of the Massachusetts Innovation Economy* has tracked the performance of the Massachusetts economy on a diverse set of indicators covering economic impact, research, technology development, business growth, capital, and talent. Since the late 1990's when the *Index* was first published, the Commonwealth of Massachusetts has consistently performed well on these metrics as compared to a group of "Leading Technology States" (LTS), a kind of advanced economic peer group. During the last twenty years, this comparative methodology has been reinforced by examining the proliferation of other 'tech state' rankings and economic comparison studies that have emerged, many of which also score Massachusetts very highly.

Nonetheless, the last 20 years have not been free of challenges, many of which appeared quite severe as they came into view. 'Massachusetts' Flagship Technology Company Acquired by Upstart from Texas' sounds like a recent headline given the merger of Dell and EMC in 2015; yet, this same headline would have been appropriate almost 20 years ago as well. Shortly after the publication of the inaugural *Index of the Massachusetts Innovation Economy* in 1997, Texas-based Compaq acquired Digital Equipment Corporation (DEC). DEC was a rapidly growing computer company and a national leader in the 1970s and 1980s, one of the key forces driving the "Massachusetts Miracle." At that time, this transaction was the largest merger in the history of the technology industry. Worryingly for any remaining prognosticators, neither company exists anymore as, just a few years later, Compaq itself would be acquired and DEC wound down to nothing. At about this same time, two of Massachusetts' former technology titans -- Wang Laboratories and Data General — were also acquired and soon after dismantled. While high profile mergers and acquisitions of Massachusetts companies are understandably viewed as signaling a loss of competitiveness, they are more often indicative of a shift in the growth trajectory of certain industries, and should be viewed as an opportunity to shift focus onto the development of new and emerging trends.

As indicated above, the *Index* was created during a tumultuous economy, one that would eventually suffer severe negative shocks twice during the 2000s. Looking up from the depths of the Dot-com recession of the early 2000s and the Commonwealth's anemic recovery, it would be easy to forgive people that wrote off Massachusetts as yet another post-industrial northeastern state destined to become a permanent member of the Rust Belt.

Yet in 2016 Massachusetts is one of the fastest growing leading technology states (**31% GDP per capita growth since 1997**, 2nd among LTS), has among the highest wages in the United States (\$70k median household income), and has a thriving and diverse Innovation Economy that is the envy of the entire world, with the exception of perhaps Silicon Valley. The indicators tracked by the *Index* have consistently shown Massachusetts at or near the front of the LTS, a selection of states that can be viewed as our primary competitors. Today, the Innovation Economy is not powered by computer manufacturers (although they are still strong here), but by the biotech hub in Kendall Square, Cambridge; by upstart software companies that are creating entirely new industries in digital health, cybersecurity, and big data; and by small- to mid-sized manufacturers across the Commonwealth that have adapted to global competition by doubling down on innovation. While existing industries are still an important foundation to build on, Massachusetts has always reinvented itself in order to stay at the forefront of innovation in any era. Whether it was the textile mills in the 19th century, the mini-



Third Party Publications Rankings for Massachusetts:

- **"Most Innovative State"** - Bloomberg's "Most Innovative States in America" for 2016
- **First in every edition since 2002** - Milken Institute's State Technology and Science Index
- **#1 in the "State New Economy Index"** - Information Technology & Innovation Foundation

GDP Per Capita

Massachusetts, LTS, & U.S., 1997 & 2015

	1997	2015	Absolute Increase	% Increase
California	\$41,658	\$56,374	\$ 14,716	35.3%
Massachusetts	\$48,079	\$62,925	\$ 14,846	30.9%
Texas	\$42,126	\$53,716	\$ 11,590	27.5%
New York	\$50,415	\$63,939	\$ 13,524	26.8%
Minnesota	\$43,318	\$54,437	\$ 11,120	25.7%
Pennsylvania	\$39,515	\$48,951	\$ 9,435	23.9%
New Hampshire	\$39,757	\$49,230	\$ 9,474	23.8%
Rhode Island	\$39,208	\$48,335	\$ 9,127	23.3%
Wisconsin	\$39,262	\$47,419	\$ 8,157	20.8%
U.S.	\$41,559	\$49,851	\$ 8,292	20.0%
Ohio	\$39,724	\$46,873	\$ 7,150	18.0%
Illinois	\$46,274	\$53,648	\$ 7,373	15.9%
Connecticut	\$56,138	\$64,124	\$ 7,986	14.2%
New Jersey	\$50,689	\$56,729	\$ 6,040	11.9%
North Carolina	\$40,635	\$44,060	\$ 3,425	8.4%
Missouri	\$40,294	\$42,989	\$ 2,696	6.7%

Source: Census Bureau, Bureau of Economic Analysis



Massachusetts had the highest absolute increase and second greatest % increase in per capita GDP in the LTS from 1997-2015.

computer boom around Route 128 in the 1970s and 1980s, or the biotech boom of today, Massachusetts has succeeded due to its strong foundation of research institutions and well-educated workforce to pioneer new, cutting-edge industries to replace those in which its competitive advantage has been eroded. While Massachusetts is clearly not immune to national and global economic trends, it is well positioned to adapt to them and has a successful history of doing so.

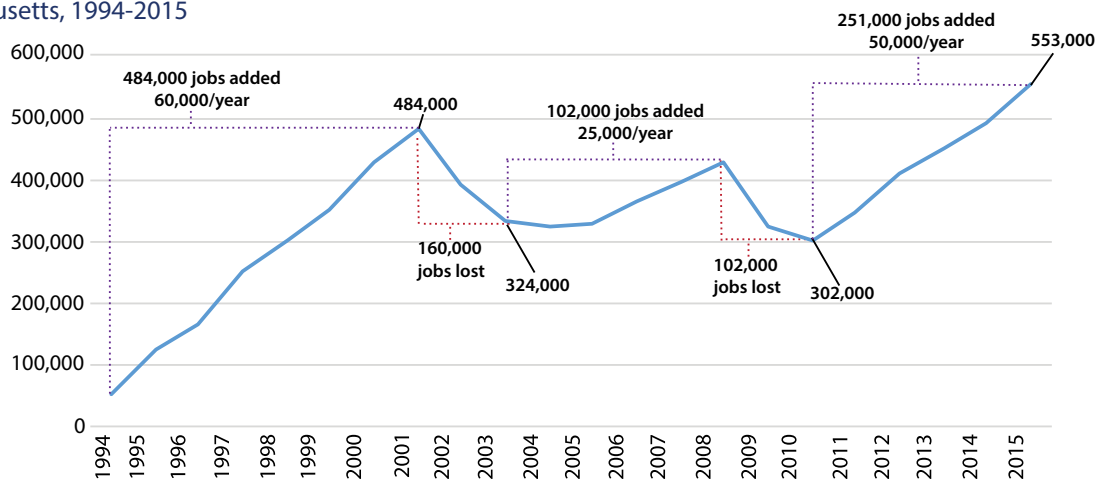
Greater Boston is and likely always will be the beating heart of the innovation economy in Massachusetts, but it is far from the only place pushing the boundaries of technology in the Commonwealth. Massachusetts has a long track record of developing new, innovative industries to support economic growth and making long-lead public and private investments in innovation which are now driving increased growth in the state.

In the 1990's, major investments in the University of Massachusetts Medical School and its affiliated medical center in Worcester have turned it into the city's largest employer (4,700

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Cumulative Net Job Growth

Massachusetts, 1994-2015



Source: BLS Business Employment Dynamics



In 1997, the best year for net job creation on record, Massachusetts was in the midst of a broad-based national economic upswing. However, the dot-com bubble burst in 2001 and Massachusetts suffered a severe recession, losing 160,000 jobs between 2001-2004, worse than the 124,000 jobs lost during the Great Recession of 2008. Between recessions, Massachusetts never fully recovered the jobs lost during 2001-2004. Yet since 2010, Massachusetts has created 251,000 net jobs, erasing the losses suffered during the 2000s. Since 1994, Massachusetts has created 553,000 net jobs while the labor force has grown by only 342,000, resulting in the unemployment rate dropping from 5.9% in 1994 to 3.9% now.

school & 6,900 hospital employees), **while helping to attract \$224 million in research funding in 2015, up from just \$2 million in 1977** (roughly \$8 million in 2015 dollars). A nascent biotech cluster has catalyzed around the school with a major presence from AbbVie (440,000 sq ft, 700 employees) as well as several start-ups and contract manufacturers, some of which are located in nearby Gateway Park, a private development led by Worcester Polytechnic Institute.

Additionally, in 2013, as part of a \$1 billion statewide initiative, the Massachusetts Life Sciences Center approved \$100 million in grant funding to support biotech in the western part of the state in an effort to duplicate the success of Gateway Park. This effort included a \$95 million grant toward a \$150 million capital project at the University of Massachusetts - Amherst to construct the Institute for Applied Life Sciences, a facility which includes the Models to Medicine Center, Center for Bioactive Delivery, and Center for Personalized Health Monitoring. The Pioneer Valley Life Sciences Institute (PVLISI), a joint venture between UMass and Baystate Medical Center, also received \$5 million to support bioinformatics work in Springfield, highlighting additional statewide growth in this dominant sector.

Massachusetts has also promoted entrepreneurship through private and public sector investments that support homegrown start-up accelerator and mentoring programs, including the now global non-profit MassChallenge, based in Boston; Entrepreneurship for All (EforAll) in the Merrimack Valley and South Coast regions; and Valley Venture Mentors in Springfield. As of 2015, MassChallenge had accelerated 835 companies, 82% of which were still active, which directly generated 6,500 jobs.

EforAll's startups have generated \$5.2 million in revenue, 271 jobs, and raised \$7 million in capital, bringing much needed growth to Massachusetts' Gateway Cities, small and mid-sized municipalities that have faced long-term economic challenges.

Today, Massachusetts continues to invest in new innovation

assets to help seed and promote growth around the state for generations to come. The Commonwealth's Collaborative R&D Matching Grant program has provided capital funds for a series of research centers located outside Greater Boston, which include the Printed Electronics Research Collaborative at UMass Lowell, the Center for Marine Robotics at Woods Hole Oceanographic Institution, and the UMass Data Science and Cybersecurity Collaborative at UMass-Amherst. Each of these research centers has attracted significant private sector contributions and present opportunities for the surrounding regions to be future drivers of economic growth.

Massachusetts is also investing in four Manufacturing Innovation Institutes, part of the Manufacturing USA initiative administered by the federal government. Three institutes (Flexible-Hybrid Electronics, Advanced Photonics, and Biopharmaceutical Manufacturing) have Massachusetts-based nodes, while the Advanced Functional Fabrics of America (AFFOA) program will be based at MIT. These initiatives will work with partners across the Commonwealth to support new start-ups and mid-sized firms, as well as train the workforce required for these new sectors to innovate and grow. **Financial, material, and organizational support for innovative R&D projects exemplifies the Commonwealth's efforts to leverage its well-educated workforce and robust network of research institutions;** enduring strengths that have and will continue to help keep the Massachusetts economy resilient.

Massachusetts has undoubtedly been affected by the same trends that have shaped the U.S. economy over the last 20 years, but the Commonwealth has come through the Dot-com recession and the Great Recession of 2008 with a resilient economy that is growing steadily and rich in high wage jobs. The next 20 years look to be shaped by trends that Massachusetts is well-positioned to capitalize on. As long as they are properly fostered, the Commonwealth's talented workforce and network of higher education and research institutions are natural assets that will continue to make Massachusetts an attractive place to start and grow an innovation-driven business well into the future.

SPECIAL ANALYSIS: COMMENTARY

This year's Special Analysis is a reflective look at the Massachusetts economy and actions taken to remain competitive since the inception of the Index. For this edition, we have also included commentaries from both national and international thought leaders on how the economy is shifting and the importance of tracking innovation. - MassTech Staff

Commentary by Mark Zandi, Chief Economist, Moody's Analytics

Moody's Analytics is proud to contribute economic data used to construct the *Index of the Massachusetts Innovation Economy*. The *Index* provides a vital source of information regarding this rapidly growing and integral part of the broader economy.

Accurate and timely information and data like that provided by the *Index* is necessary for designing and effectively implementing policies to support economic growth and innovation. There is no better testimonial to this than the current debate over the causes behind the decline in new business formation in recent years. New businesses have historically been the fountain of innovation and technological change, and they distinguish the Massachusetts and U.S. economies from the rest of the world.

Business starts peaked during the internet-technology boom of the late 1990s, took a dive during the tech bust, and have more-or-less declined ever since. There was a brief pause in the decline during the housing boom of the mid-2000s, but the Great Recession that followed was devastating to entrepreneurship. And while new business formation appears to have picked up very recently, it remains well below that of two decades earlier.

Many theories have been proffered for the low number of new businesses and what it means for productivity growth and, ultimately, for growth in our living standards. The severity of the downturn clearly matters, given the psychological pall that it cast on risk-taking. Perhaps the age composition of the population is behind the innovation slump. Most people who start companies do so in their mid and late 30s, and the large millennial cohort isn't quite there yet. It may also take the millennials longer than past generations to start new companies given the student debt they have had to take on.

There is also the possibility that potential new businesses can't get going because they can't get the necessary capital. Indeed, venture capital investments have become increasingly focused on a handful of tech centers across the country, Massachusetts being one of them. Another, of course, is Silicon Valley. VC money is also flowing freely in the software and biotechnology areas, but much less so in other key areas of likely innovation.

More worrisome, it could be that the pace of technological change has slowed. Yes, there is explosive changes occurring in nanotechnology, the discovery of new cancer drugs, cloud computing, drones, 3D printing, and perhaps even in the apparent coming of driverless cars. But some argue that these innovations, while impressive, fall well short of the innovations of time past. Think of electricity or the transistor.

Gaining an understanding of what is driving the decline in new business formations is key to designing policies to address it. The policy response is one thing if the problem is a lack of equity capital,

and it is altogether another if it is onerous student loan debt or a lack of path-breaking new technologies.

These questions can't find answers, at least not quickly enough, without the data and type of analysis that underlies the *Index of the Massachusetts Innovation Economy*. Thank you for allowing Moody's Analytics the opportunity to participate in your important endeavor.



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**- Mark Zandi, Chief Economist
Moody Analytics**



SPECIAL ANALYSIS: COMMENTARY

**Commentary by Erica Groshen, Commissioner,
Bureau of Labor Statistics**



The Index relies heavily on the products of several federal statistical agencies and one of the most important is the Bureau of Labor Statistics (BLS). The Innovation Institute at MassTech relies on BLS data to complete our Leading Technology States selection process, as well as in the compilation of the Employment & Wages, Occupations & Wages, and Output Indicators. The reliability of BLS data and the continued improvement in both the range and accessibility of its data products are essential in ensuring that the Index continues to be a useful tool for measuring the Innovation Economy. - MassTech Staff

Innovations and the Bureau of Labor Statistics

To my mind, the Big Data era and the Bureau of Labor Statistics (BLS) really began together—as innovations in Massachusetts a long time ago. Why? It was Massachusetts that established the first state-level bureau of labor statistics in 1869. Just a decade and a half later, in 1884, Congress established the first national statistical agency, the Bureau of Labor—which became today's BLS. And, Carroll D. Wright, the Massachusetts bureau's second Chief, became our first Commissioner. During Wright's tenure, the Bureau published numerous ground-breaking studies, including 19 annual and 12 special reports on a wide variety of labor, industrial, and related issues.

Today, BLS carries on that innovative tradition as we produce 7 Principal Federal Economic Indicators (PFEI), such as unemployment and inflation rates, as well as a wide variety of other data, including many that are required or referenced by law. This is an ever present challenge. From the beginning we have had to balance two imperatives: maintaining comparability and reliability of measures over time and evolving to improve our measures and ensure relevance in a rapidly changing economy.

Even for our data series that began 50 or more years ago, how we collect, process, and disseminate surveys has changed over the years. Once, we collected data only via mail, phone calls, and in-person interviews. Now, the BLS makes heavy use of Internet and other electronic platforms. Our Internet data collection center accepted 3.6 million transactions in 2015 and continues to grow.

We also continually investigate new data sources for possible use. Many decades ago, we pioneered the statistical use of administrative Unemployment Insurance records kept by state agencies. We still depend on this partnership. In today's increasingly digitized economy, we are leveraging new alternative, non-survey sources such as government administrative data, private sector aggregators, and corporate data. The goals are to expand coverage, reduce collection costs, and lessen respondent burden. Our challenge is that each opportunity needs to be fully evaluated for quality, consistency, sustainability, and costs. Nevertheless, the potential for tangible long-term benefits of these Big Data sources is real.

To make the best use of our resources, we must always be modernizing how we process data also. For example, in the Consumer Price Index program, we now scrape websites for the product characteristics used to adjust for quality changes in goods. We also now use Computer-Assisted Coding for illnesses

and injuries data. Our system “reads” text in survey responses and determines appropriate codes. This improves accuracy and frees staff time to concentrate on unusual entries.

To serve the public well, we continually improve dissemination of data to reach a growing, diverse universe of data users. When BLS began www.bls.gov in 1995 we were among the first federal agencies to have a website. That year, we averaged 72,000 page-views by visitors per month. Today, our website offers 107 million data series, including 540 million estimates. With over 300,000 pages, our website now averages 18 million page-views per month.

Here's a small taste of cool things you can find on bls.gov. When we began online publication of our Occupational Outlook Handbook (the 1996-97 edition), it was a novel concept. A reader favorite ever since, the latest edition now attracts 5.8 million page views per month. More recently, we created The Economics Daily, an online-only visualization of intriguing economic data. You can join the over 40,000 followers of our Twitter account (@BLS_gov). You can automate your access to BLS data with our Application Programming Interface. You can personalize the interactive charts that now accompany most of our PFEI news releases. We are on track to complete the full set by December 2016, and to add charts to other releases after that.

These days, the Big Data world extends far beyond statistical agencies, giving BLS more opportunities to innovate in producing gold-standard data that affect lives and commerce. As in the past, in the future we plan to expand the above efforts, seek further opportunities to collaborate with others and develop more common platforms within BLS—all to create new products, lower costs, and improve data quality.



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**- Erica Groshen, Commissioner
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SPECIAL ANALYSIS: COMMENTARY

Commentary by Dr. John Hardin, Executive Director, NC Board of Science, Technology & Innovation

One of the most useful functions of the Index is as a tool for comparing the Commonwealth's performance against a selection of competitor states. While most states do not release a similar publication, some of our top competitors do. North Carolina has been periodically included in the Leading Technology States that we compare Massachusetts to in the Index and once again made the list in 2016. North Carolina and Massachusetts have important similarities that tie them together, the most apparent of which is a cluster of leading research universities. There are also many business connections between both states with Massachusetts-based companies such as GE, Biogen, and Fidelity Investments having major operations in North Carolina while several North Carolina-based firms such as Red Hat and LabCorp have a large presence in Massachusetts. Both North Carolina and Massachusetts are popular research bases for large companies with Google, IBM, Cisco, and Novartis as some of the companies with a major presence in both states.

- MassTech Staff



Since 2000, the North Carolina Board of Science, Technology & Innovation has produced a periodic *Tracking Innovation* report that assesses the state's performance vis-à-vis other states, the U.S. overall, and other countries across dozens of innovation measures. The report has sparked several initiatives and programs in the last 10 years. Examples include:

- The 2015 *Tracking Innovation* reports showed that the state could broaden and expand innovation-based prosperity from the state's largest urban counties outward to its more rural counties. As a result, in 2015 the Board partnered with a diverse set of statewide partners to help implement the InnovateNC initiative, an intensive two-year cross-city learning collaborative supporting five North Carolina communities. Still underway, the initiative is providing mentoring and technical assistance to help the communities discover, refine, and enhance their distinct advantages in the innovation economy.
- The 2013 *Tracking Innovation* report showed that the state could enhance and speed the translation of its innovative R&D into commercial products and companies. As a result, in 2014 the Board staffed the Governor's Innovation-to-Jobs Working Group, which crafted a targeted set of actionable recommendations to enhance the state's innovation ecosystem by bolstering funding, talent, and processes. A majority of the recommendations resulted in legislation, and the others are currently being implemented.
- The 2003 *Tracking Innovation* report showed that the state could increase and augment its awards from the federal Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programs. As a result, in 2005 the Board worked with policy makers to establish one of the nation's first and longest running state-funded matching grant programs for businesses receiving SBIR and STTR grants. In the program's 11-year history, the businesses receiving the matching grants have greatly increased their rate of technology commercialization and the amount of follow-on funding from numerous sources.

Commentary by Charlotte Rønhof, Vice President, Confederation of Danish Industry

Looking globally, there are several examples of small countries that have had to rely on innovation and the skills of their workforce to develop and maintain a high standard of living. Denmark is a prime example of such a country and one that has shown increasing interest in the Index and tracking its own innovation economy. Both Denmark and Massachusetts are major players in biopharmaceuticals and the ties between the two regions are growing. Major Danish company LEO Pharmaceuticals is planning to establish a "Science and Technology Hub" in Massachusetts and Novo Nordisk, one of the world's largest pharmaceutical companies is a member of MassBIO. In addition, Denmark's strengths in marine technology have impacted Massachusetts through investments in the state's emerging marine robotics cluster, such as Danish underwater technology firm MacArtney, which operates a manufacturing facility in Massachusetts.

- MassTech Staff



A Danish "Detroit moment"?

In the 1960s Detroit was the world's largest center of manufacturing with the highest per-capita income in the USA. Nevertheless, somewhere in the past 40-50 years Detroit went – imperceptibly – from an upward economic trajectory to a downward trajectory.

Today Denmark is among the most research and development intensive countries globally and an innovative leader in Europe. However, Denmark may be facing – what Silicon Valley based entrepreneur Shomit Ghose has dubbed - a "Detroit moment".

The fact that Denmark has become an innovative leader in Europe is the result of a long-term commitment to the development of the Danish research and innovation system that began in 2006, when the Danish government committed to an ambitious plan to increase public investment in research, innovation and education in Denmark. The ambition was to ensure that Denmark would be ready to face the challenges of globalization and maintain a competitive society with a high standard of living.

The Confederation of Danish Industry (DI) – a private organization funded, owned and managed entirely by approx. 10,000 Danish companies within manufacturing, trade and service industry – has actively supported the national commitment to this development.

We have done so because we recognize that investment in research and development is vital for the individual companies and for the Danish society.

Historically, many large and successful Danish companies have been established through research and close collaboration with universities and public research institutions, and presently the 100 companies in Denmark that invest most in R&D are responsible for 24 percent of all Danish exports.

In recent years we have seen cut backs in public spending on R&D due to pressure on the public finances. At the same time, private investment in R&D has stagnated. That is worrying, as multiple studies have shown that companies investing in R&D have higher productivity levels and are more innovative

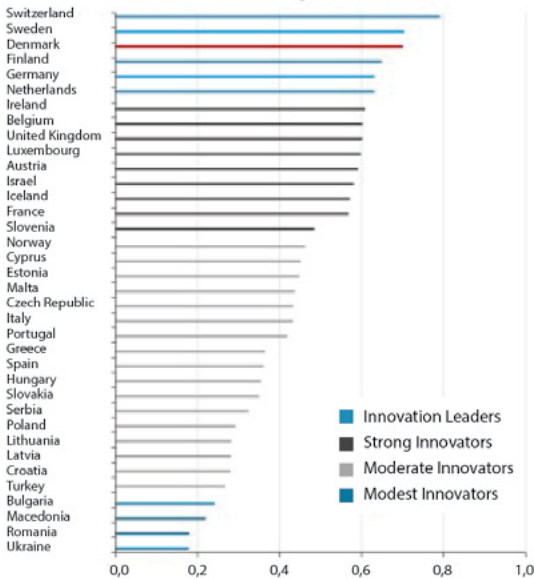
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and ready for global competition. At the same time, we see a connection between the R&D intensity and the standard of living. Consequently, we strongly recommend that public R&D investment is further increased and that this increase aim at supporting the competitiveness of Danish businesses and private investment in research and development. Our focus must be on securing both quality and relevance of public financed R&D investment.

Indeed the tendency is that global competition is becoming increasingly fierce, and regions in China, Korea, the United States and Germany have seen massive increase in R&D as a means to secure competitive, high value jobs. On a whole China has increased its R&D budget by a factor five in the past ten years, and in the Bei-jing region alone, R&D investment exceeds 5.5 percent of GDP.

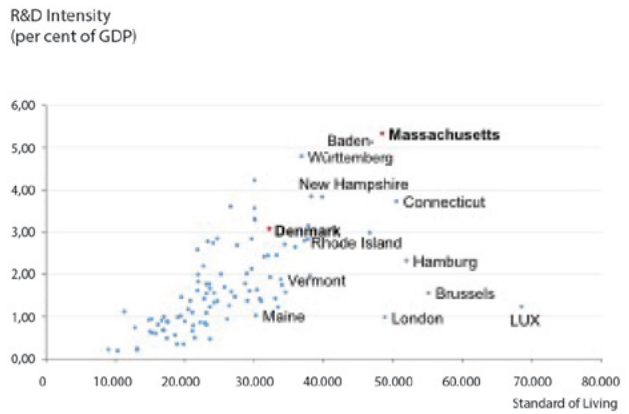
The result is that the global race to attract companies, researchers and talents is fiercer than ever. Thus, R&D investment has become increasingly important. Hesitation is not an option if we want to maintain our high standard of living and avoid a Danish “Detroit moment”.

Innovation in European Countries Innovation Index Scores for European Countries



Source: European Innovation Scoreboard 2016

R&D Intensity and Standard of Living for European and New England Regions



Source: Eurostat, OECD, 2016.

Note: Standard of living is measured as Purchasing Power Parity GDP, euro per inhabitant. For most regions, numbers are from 2013. US numbers are from 2011. EU regions are NUTS 1 regions by the EU NUTS classification. Finland is considered one region.