2007

INDEX
of the
Massachusetts Innovation Economy

MASSACHUSETTS
TECHNOLOGY
COLLABORATIVE
John Adams Innovation Institute

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2007 INDEX of the Massachusetts Innovation Economy

MASSACHUSETTS
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The Massachusetts Technology Collaborative

The Massachusetts Technology Collaborative is an independent, non-partisan public agency chartered by the Commonwealth to promote new economic opportunity in Massachusetts.

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

MTC works with state leaders to promote cluster growth in the formation, retention, and expansion of technology-related enterprises; it gets results through collaboration with local partners in every region of the Commonwealth.

MTC focuses on growing the state's knowledge-based economic sectors, in promoting the development and use of renewable energy technologies, and in implementing e-health solutions that save lives and reduce costs.

John Adams Innovation Institute

The John Adams Innovation Institute is the economic development division of the Massachusetts Technology Collaborative.

The Innovation Institute is entrusted with the management of two public purpose funds, making targeted, strategic investments to grow and strengthen industry clusters, support the research enterprise in Massachusetts, and grow the Commonwealth's knowledge-based Innovation Economy, region by region, sector by sector.

The overarching goals of the Innovation Institute are directed at projects and programs that:

- Support job creation and retention by the knowledge-based companies in the Massachusetts Innovation Economy, improving conditions that enable economic growth.
- Provide accurate and reliable information, data and analysis to shape growth strategies and inform policymakers.
- Grow and strengthen industry clusters to improve the competitiveness of industries and institutions, keeping Massachusetts a step ahead of competitor states and nations.
- Secure the economic benefits of downstream production and employment as new research and technologies are commercialized in the marketplace.
- Support rigorous collaborative R&D partnerships at Massachusetts universities as new ideas and technologies emerge, enhancing the success of the state's academic research centers to compete for federal research awards

The Innovation Institute employs numerous strategies and tools to grow the Commonwealth's Innovation Economy. They include:

- Sustainable cross-sector, cross-cluster collaboration
- Targeted investments, increasing industry competitiveness
- Research and analysis, producing objective quality information
- Strategic broker, convening policymakers and stakeholders

The Innovation Institute serves as the convergence point in creating productive, collaborative partnerships among Massachusetts companies and academic research institutions to compete for business, talent, and opportunities in the global marketplace.

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Executive Summary

This edition of the *Index of the Massachusetts Innovation Economy* marks the first of its second decade. As such, it provides an opportunity to assess changes in the dynamics of state economies as well as the growing influence of international hubs of innovation in what has truly become a vibrant global marketplace for goods, services, and talent. Therefore, in order that the *Index* remains innovative, current and relevant to its many audiences, this year's Special Analysis begins what will be a continuing process of research and analysis into the challenges and opportunities provided by international competition, particularly in those areas of economic activity that are at the core of the economies of Massachusetts and the other Leading Technology States (LTS).

As the growth and evolution of Innovation Economies has drastically changed the complexion of states and regions in the United States, so too are forces fundamentally changing the global economic landscape. The rules of the game for research and development investment, market access, and competition in and among states, regions, and countries are in flux and exhibiting near constant change. Global communications technologies coupled with favorable perceptions of cross-border business collaborations enable and drive a truly global supply chain of people, products, and services. Technology and manufacturing firms, research laboratories, academic centers, and others in the innovation ecosystem enjoy new freedoms to collaborate and innovate across town or across continents—wherever the mix of cost, quality, and opportunity is optimal. Both the risks and opportunities of this seismic shift are great. These risks demand that policymakers, business leaders, and other Innovation Economy stakeholders determine how best to leverage the assets and capabilities of their respective areas of responsibility and authority to optimize participation in this evermore global Innovation Economy.

Evidence of these sea changes abound. General Motors now employs a design team of more than 100 in Shanghai to develop its next generation of sedans in equal partnership with design teams in Detroit. In the life sciences, Novartis, already committed to investing more than $250 million in Kendall Square in Cambridge, is investing $100 million and recruiting 400 local scientists for an R&D center in Shanghai, and has recently announced plans for a $700 million large-scale cell culture facility in Singapore, the largest manufacturing investment in its history. In computer software and services, Microsoft has located its largest R&D operation outside of its Washington State headquarters in Hyderabad, India and is establishing a major software development center in Vancouver as a beachhead to more easily attract software developers from around the world. IT services and hardware giant IBM counts more than 50,000 employees in Bangalore (the greatest concentration of employees outside the US) and went so far as to hold its annual investors conference there in 2007, an event historically and exclusively held in New York.

What these changes suggest and what the data assembled for the Special Analysis section of the *Index* confirm is that the dominance of the United States and the developed economies of Western Europe is being challenged. The newly emerging economies of China, India, and Singapore, just to name a few, have been and are committed to continuing massive investments in research and development to become leaders in innovation and not merely copy-cat economies. Further, because of the speed with which these economies are growing and the wealth of funds that they can commit to the development of new technologies and cluster growth, it is not out of the question that they may soon be able to leapfrog developed centers of innovation with new innovations of their own. However, while these dynamics certainly pose challenges to current leading technology centers, they may also offer opportunities for collaboration and cooperation. Enormous potential exists in research, development, and product manufacturing for capitalizing on the opportunities afforded by global economic integration and the rich cross-border flow of people, ideas, and capital.

Key Findings of the Special Analysis of the **Index of the Massachusetts Innovation Economy**:

Investment in the R&D Enterprise:

- **Massachusetts and the Leading Technology States (LTS) remain the world's premier hubs of innovation by virtue of their innovation infrastructures, R&D intensity, and ability to attract public and private investment in R&D.** Massachusetts and the bulk of the LTS post impressive performance in attracting both public and private R&D dollars to fuel their Innovation Economies. In terms of total dollars invested, percentage of GSP, and distribution across key clusters, the LTS—and Massachusetts in particular—remain global hotbeds of innovative activity and are attractive hubs in which firms and the federal government can invest.

- **Most rapidly growing hubs of innovation are fueling their economies with corporate R&D, and are just beginning to backfill their R&D enterprises with government funds and government-related activity.** The United States, Japan, and South Korea are long established centers where both indigenous and global firms seek to conduct cutting-edge research across multiple sectors. In terms of emerging R&D hubs, China and India have relatively rapid rates of growth in total investment. China counts a significant share of its total R&D from corporate sources, while India relies much more heavily on government funding of R&D. Singapore and Ireland, while at geographical extremes, have both built robust R&D infrastructures by attracting corporate investment, only recently having augmented their R&D expenditures with government funds that typically support the more fundamental research necessary to create truly innovative products and new industries.

Trade & Immigrant Links:

- **Massachusetts excels in serving the global demand in the chemicals export sector, yet is not meeting the worldwide demand in traditional IT sectors.** In virtually all regions, the dollar value, rate of growth, and general demand for Massachusetts exports in the chemicals sector are high and rising. The chemicals sector includes pharmaceuticals and component sectors critical to the life sciences super-cluster, indicating Massachusetts' high degree of sophistication and specialization in life sciences overall. But while exports in life sciences related materials and products are steady and growing, Massachusetts isn't meeting rapidly growing demand for IT hardware such as computers and some component parts. Massachusetts fails to satisfy a booming thirst for these products in Asia in places such as Japan and Singapore.

- **Brazil leads the way as the BRIC countries (Brazil, Russian Federation, India, China) account for the largest immigrant flows to Massachusetts.** Immigrant flows to Massachusetts have offset considerable domestic population losses in recent years. The bulk of these flows originate in the BRIC countries, with Brazil representing almost 9,000 new residents since 2004. The People's Republic of China and India also contribute a significant portion of the immigrant flow to Massachusetts, with 8,000 to 9,000 people respectively from 2004–2006 originating in these nations.

Human Capital & Workforce Readiness:

- **Global talent bases are aggressively emerging in science, technology, and engineering disciplines and university systems are growing, especially in Asia.** The number and composition of graduates in the emerging and expanding innovation hubs of Asia, such as China, Japan, and South Korea, create the potential for dilution of the Commonwealth's historical competitive advantage in scientific and medical talent and could pose a long-term challenge to the Massachusetts Innovation Economy. In 2003, for example, the percentage of total graduates with four-year degrees in engineering and related fields was 30% in South Korea and 19% in Japan. In Massachusetts, the comparable percentage was 10%. Moreover, while only 7% of graduates in Massachusetts in 2003 earned degrees in a "hard science," Germany and Ireland produced 16% and 11% respectively of graduates with degrees in hard science disciplines. Domestic trends are only compounding this threat as Massachusetts continues to lag even the US average in the share of graduating high school seniors intending to major in engineering, science, and health-related disciplines at the post-secondary level.

Growth in Key Industry Clusters:

- **By measures of productivity and output in key clusters and in the size and strength of its**

education and knowledge creation capacity, Massachusetts is in a class by itself. The Commonwealth has the highest GDP per capita and some of the highest levels of productivity of all of the geographies examined. Yet it also experiences one of the lowest economic growth rates, besting only Japan by this measure. Massachusetts is the most specialized service-oriented economy of all of the countries examined. It also boasts one of the largest and most highly concentrated knowledge creation clusters in the Advanced Economies[1] and it is growing consistently. This pays dividends far beyond direct employment and is a key strategic tool in the competition for global talent. The BRIC countries do not yet contend with Massachusetts in the knowledge-creation clusters and neither India nor China demonstrates any significant strength in employment in this category. Further, the most recent data confirms that education-related clusters are in decline within the Russian Federation.

- **Employment shifts in key global clusters increasingly challenge Massachusetts' competitive position.** The presence of a developed financial infrastructure provides critical access to the capital and expertise that are requisite to support the Commonwealth's Innovation Economy. Partially driven by consolidation of financial institutions in the last decade, the most recent data for employment in this key cluster show declines not only in Massachusetts but in many of the LTS. At the same time, capital under management by US venture capital firms has declined more than 7% since 2001. This is in contrast to rapidly expanding financial services activity in Toronto and London. The biopharmaceuticals cluster in Massachusetts, while buttressed by tremendous activity in life sciences R&D, has yet to reach a concomitant level of job creation or the development of sizable production facilities. Moreover, competitive threats are rapidly emerging from India and China, which provide easy access to capital, lower costs, and increasingly more manageable regulatory regimes for the life sciences in both countries. Massachusetts' "early mover" advantage in the medical devices sector is still paying dividends as it remains an important and stable segment of the Innovation Economy. Unlike biopharmaceuticals, where significant competitive pressure is emerging in Asia, the competitive threat in medical devices arises from Western Europe, specifically Ireland and the United Kingdom.

Key Findings from the Twenty Indicators of the Massachusetts Innovation Economy

Consistent with trends highlighted in the *2006 Index*, the Massachusetts Innovation Economy posted noticeable turnarounds in employment in select clusters. It also maintained many of its key advantages such as educational attainment and its status as a principal recipient of federal funds from important federal programs, like those administered by the National Institutes of Health (NIH) and the Department of Defense (DoD). By other measures, the Commonwealth also retained its leadership position among the LTS in attracting corporate funding for R&D, venture capital, and in other critical measures of business output such as patenting and technology licensing revenues.

For 2007, steady, although modest, growth in employment is reflected and Massachusetts is still able to claim crucial and core competitive advantages that contribute to the nature and intensity of innovation. This compares quite favorably, not only to the LTS, but also to other global regions as well. The *Index*'s twenty economic indicators offer the following insights:

- **Key clusters are demonstrating a moderate rebound and greater overall health, yet trail many of the other LTS.** In the early part of this decade, employment growth across the key industry clusters was consistently anemic or posted negative growth. While the most recent data show, for example, that the Software & Communications Services cluster accounts for more than 124,000 jobs in Massachusetts and posts a year-to-year growth rate in employment of more than 2%, it is still outperformed by many other LTS including California, New Jersey North Carolina, and Virginia in this cluster. The Scientific, Technical, & Management Services cluster posted growth with an employment gain of approximately 4%, but it remains outpaced by many competing LTS.

- **The life sciences super-cluster contributes ever-increasing horsepower and performance to the Massachusetts innovation and economic engines.** Medical devices, biotechnology, biopharmaceuticals, and the myriad of related industries that comprise the cluster in Massachusetts account for more than 60,000 direct jobs (excluding healthcare delivery jobs), growing at more than 2% per year. Jobs in these clusters also provide one of the highest average wages at $98,000/year and create five jobs in other related clusters and support sectors for every direct job in life sciences. The cluster yielded more than $29 billion in corporate sales in 2006 for publicly traded Massachusetts firms, by far and away the best sales performance of any goods-producing cluster.

- **Driven by expanded job opportunities and moderating housing prices, the Commonwealth experienced less out-migration in 2006, reversing a multi-year trend.** For the first time in years, Massachusetts' net loss of residents eased, amounting to fewer than 20,000 residents in 2006, compared to more than 30,000 lost in 2005. Moderate employment growth in some sectors coupled with easing home prices—the first downtick in prices since 2001—is helping stem the tide of residents moving out of Massachusetts.

Conclusions

While many Innovation Economy dynamics are global—driven by larger markets, increased cross-border business activity, and easier human mobility—it is the local, more native weaknesses that could limit the success the Massachusetts Innovation Economy enjoys in a globalized world. It is apparent from both domestic and global data that emerging and established global hubs of innovation are maturing and are doing so directly in the areas of innovation that are at the heart of Massachusetts key historical advantages. With regard to workforce talent, Massachusetts must, at a minimum, keep pace with other global regions to ensure a competent and capable workforce. The state would derive critical long-term benefits from increased efforts to foster an interest in science and mathematics in our young students and in increasing overall enrollments in undergraduate and tertiary education. Already intense competition will continue to ratchet up for scientific and technological talent as developing economies demonstrate a renewed commitment to and elevated performance in educational enrollments, attainment and graduates, in disciplines such as math, engineering, and science.

Global firms have already indicated a willingness to take risks and expand operations, in both production and R&D. These firms actively seek and consider distant locales—taking jobs, facilities, and know-how with them. No longer basing decisions solely on cost, these firms seek the best and the brightest talent coupled with the appropriate balance of "innovation infrastructure"—embodied in universities, research centers, and dynamic business environments. Moreover, Massachusetts faces the real risk of the loss of companies to other national and international locations that can demonstrate a ready and able workforce in scientific disciplines. In short, firms increasingly perceive foreign Innovation Economies as solid and lucrative alternatives to our own—and at a bargain.

Notes on key industry clusters

The Index organizes historical cluster growth data for its eleven key industry clusters to understand changes affecting various cluster dynamics (employment, sales, capital, etc.) over time. Each year, the Index uses a consistent methodology and its cluster definitions rely on the North American Industrial Classification System (NAICS) so that the key industry clusters do not overlap and are mutually exclusive in terms of data. The Index provides a general framework for understanding the evolving Massachusetts economy.

To fully understand the dynamics of new and maturing clusters (e.g., medical devices, biopharmaceuticals) or industry groups that are at the intersection of multiple clusters (e.g., marine sciences, nanotechnology, telecommunications), a different research approach is necessary. For example, the clean energy industry spans diverse technology areas that cannot be accurately studied through NAICS codes alone. As a result, to produce the Massachusetts Clean Energy Industry Census, MTC's Renewable Energy Trust used contact lists from various sources and directly surveyed companies. Examples of survey-based, cluster-specific studies include:

Clean energy:

The 2007 Massachusetts Clean Energy Industry Census, MTC's Renewable Energy Trust (2007): http://www.masstech.org/renewableenergy/reports/2007census.html

Marine science & technology:

The Marine Science and Technology Industry in New England, UMass Donahue Institute (2005): http://www.massbenchmarks.org/publications/studies/descriptions/marinesci05.htm

Medical devices:

The Medical Device Industry in Massachusetts, UMass Donahue Institute (2007): http://www.massmedic.com/docs/profile01.pdf

Telecommunications:

The Telecommunications Industry in Massachusetts, UMass Donahue Institute (2004): http://www.massnetcomms.org/pdf/upload/AnnualReport1.pdf

2007 SPECIAL ANALYSIS:

Assessing Global Hubs of Innovation

As it enters its second decade, the *2007 Index of the Massachusetts Innovation Economy* examines established and emerging Innovation Economies to gauge performance, assess economic opportunities and threats, and gain understandings about the functional dynamics of each economy. Extending Innovation Economy benchmarking and analysis of Massachusetts and the LTS beyond US borders yields a more comprehensive and forward-looking understanding of competitive position and can more accurately illuminate economic strengths and weaknesses.

Understanding Cluster Dynamics Using a Four-Part Lens

The analysis considers and examines the characteristics of relevant global hubs of innovation via a four-part lens to determine how each relates and compares to the Massachusetts Innovation Economy:

I. Investment in the Research & Development (R&D) Enterprise[2]

The funding choices and priorities of governments and the resource allocation by private firms to the R&D enterprise speaks volumes about the vitality of a particular Innovation Economy, local industry dynamics, and available resources in a country or region. This lens will include an assessment of cluster and other sector R&D investments by both public and private entities to determine funding priorities and to better understand emerging product categories, markets, and geographic centers of innovation.

II. Human Capital & Workforce Readiness[3]

Understanding the composite skill levels of a resident population is an essential precondition in determining if a region or country has the fundamental competencies to compete as an Innovation Economy and yields insight into the potential for sustained growth. This lens will compare educational enrollment and attainment levels across borders and economies to assess the general aptitude of the workforce to gauge readiness in meeting the diverse and complex needs of Innovation Economy firms and organizations.

III. Growth in Key Industry Clusters[4]

Charting changes in cluster employment over time and as a percentage of total workforce is useful to determine overall and cluster-specific growth and to assess capabilities and characteristics of a given Innovation Economy. This lens will provide insights into both over- and under-performing regions in terms of employment growth to gauge levels of global competition as they pertain to Massachusetts.

IV. Trade & Immigrant Links[5]

Export data are useful in determining international demand for products and outputs and are a metric to measure growth in emerging economies where demand for component or raw materials is strong. In addition, the cross-border flows of both people and manufactured goods are indicators of the economic integration among and between Innovation Economies. Immigration data are telling both of the local opportunity for firms in a given region as well as workforce opportunities and needs of a larger innovation-intensive economy.

Completing each segment of this multi-part analysis are summary conclusions (**What it means for Massachusetts**) with emphasis on points of strength, weakness, and opportunity.

Countries and Regions of Analysis

The 2007 *Index* analyzes, at the macro-economic level, countries and regions generally understood to be either emerging or advanced centers of innovation and growth. Although somewhat constrained by data availability and its compatibility with domestic data sets, important insights can be drawn about the comparative levels of investments made by these countries and regions in critical areas of innovation and in the growth of key clusters. The analysis provides unique insights into those locales and regions that are likely to both challenge the preeminence of the Commonwealth in those same key areas of innovation and growth and also provide opportunities for linkages that might lead to mutual economic benefits. The 2007 Special Analysis includes an examination of the following regions and, where data are available, the individual countries listed:[6]

Asia-Pacific

- Japan (JPN)
- Republic of S. Korea (KOR)
- Singapore (SGP)

Brazil, Russian Federation, India, China (BRIC) countries

- Brazil (BRA)
- Russian Federation (RUS)
- India (IND)
- China (CHN)

North America

- Canada (CAN)

Western Europe

- Finland (FIN)
- Germany (DEU)
- Ireland (IRL)
- Sweden (SWE)
- Switzerland (CHE)
- United Kingdom (GBR)

I. Investment in the Research & Development (R&D) Enterprise

As the United States, and in particular Massachusetts and the LTS, inevitably become more globally-integrated as Innovation Economies and as markets, a key metric of understanding is the distribution and growth in expenditures of various types of R&D funding. A review of these expenditure data in other global innovation hubs illustrates their respective priorities and strengths, provides insight into their national or regional economic make-up, and demonstrates the interplay of various actors at work in the system of innovation. Understanding the mix of private versus public R&D expenditures and identifying sectors or clusters of particular growth provides a useful window to assess both emerging and established Innovation Economies and the Commonwealth's competitive position.

Global Overview

Overall, the performance of R&D is concentrated in only a handful of advanced and developed countries. As of the year 2000, global R&D expenditures totaled approximately $729 billion, 50% of which could be found just in the United States and Japan. More than 95% of global R&D is performed in North America, Asia, and Europe. Yet even within each of these geographies, a small number of countries dominate R&D performance: the US in North America; Japan and China in Asia-Pacific; and Germany, France, and the UK in Europe. Approximately half of all R&D expenditures in the United States are concentrated in only six states, including Massachusetts.[7] As the bulk of total R&D activity is concentrated geographically, so too is R&D spending by firms. Six of the top ten corporate R&D spenders are US firms, represented by the software, hardware and pharmaceutical businesses (see Figure 1).

FIGURE 1: Many global R&D leaders post double-digit growth in total R&D spending and as a share of total sales

Top 10 global R&D corporate spenders in 2006[8]				
Rank	Company (HQ)	R&D Spending		
		2006 (in US$ millions)	Change from 2005	% of total sales
1	Toyota (JPN)	$7,691	9.6%	3.7%
2	Pfizer (USA)	$7,599	4.7%	15.7%
3	Ford (USA)	$7,200	-10.0%	4.5%
4	Johnson & Johnson (USA)	$7,125	10.3%	13.4%
5	Daimler Chrysler (DEU)	$6,678	-5.6%	3.5%
6	General Motors (USA)	$6,600	-1.5%	3.2%
7	Microsoft (USA)	$6,584	6.5%	14.9%
8	GlaxoSmithKline (GBR)	$6,351	10.2%	14.9%
9	Siemens (DEU)	$6,294	11.4%	5.8%
10	IBM (USA)	$6,107	4.5%	6.7%
Source: Booz Allen Hamilton				

R&D in Massachusetts Compared with Other Global Innovation Hubs

Most recent data indicate that Massachusetts' gross expenditures on all types and performers of R&D exceed $15 billion annually. Between 1999 and 2003, the average annual growth rate in this R&D spending in Massachusetts was 6.6%, on par with the European Union-25 and ahead of the US average growth rate of 4.5% for the same period. Globally, however, the most rapid growth in R&D expenditures is clearly evident in Asian nations, as their average growth rates in expenditures range from just more than 9% to as much as 23% (see Figure 2). Collectively, Asia's average annual growth in R&D is 11% and its level of R&D activity was nearly 10% greater than the EU in 2003. China's total R&D expenditures appear to be rapidly approaching those of Japan, the world's second largest R&D-performing country.

FIGURE 2: China's average annual rate of R&D growth is more than triple Massachusetts

Growth Rates of Gross Expenditures on R&D, Select Regions, 1999–2003

(Millions of current purchasing power parity dollars)

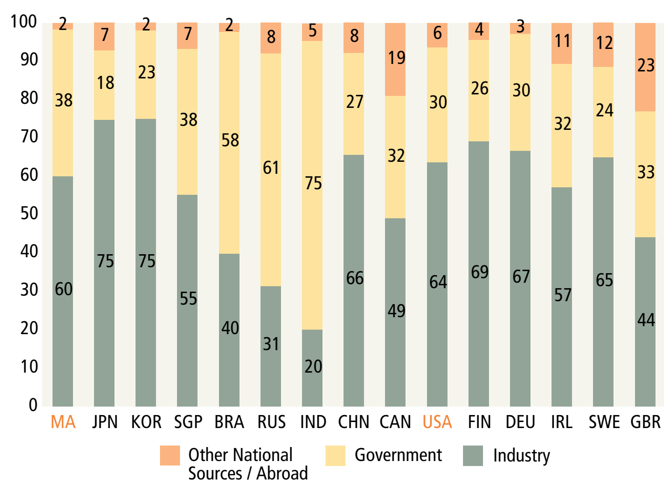
Year	China	South Korea	Asia	Taiwan	Singapore	EU-25	MA	Japan	United States
1999	$33,940	$15,793	$153,527	$9,437	$1,584	$163,028	$12,190	$92,774	$245,476
2000	$44,771	$18,395	$174,008	$10,182	$1,810	$182,567	$13,004	$98,850	$267,768
2001	$52,418	$21,166	$190,501	$10,749	$2,007	$194,759	$14,665	$104,161	$277,820
2002	$65,154	$22,247	$209,936	$12,085	$2,202	$205,263	$14,316	$108,248	$276,260
2003	$76,891	$24,274	$229,628	$13,494	$2,255	$210,168	$15,638	$112,715	$292,437
AAGR	22.8%	11.4%	10.6%	9.4%	9.3%	6.6%	6.6%	5.0%	4.5%

Note: Massachusetts R&D expenditures in millions of current dollars
Source: The John Adams Innovation Institute (Data source(s): National Science Foundation and OECD MSTI databases)

The degree of diversity in R&D funding sources, performers, and sectors can speak to the overall vitality of an Innovation Economy and can indicate the capacity for resilience and sustainable strength. In both the most developed and most rapidly expanding economies, industry-funded R&D tends to dominate the distribution of total R&D expenditures. In the highly-developed Innovation Economies of Massachusetts, Japan, South Korea, Germany and others, the percentage of corporate R&D is well over half of gross R&D expenditure, and typically accounts for approximately 60% to 75% (see Figure 3). This indicates an ability and willingness by companies to invest in new product development (particularly in technology intensive products) and is a necessary component of any Innovation Economy. Several BRIC countries do not appear to have large portions of their R&D supported by industry. The level of government investment in R&D is also believed to be a major driver of growth for Innovation Economies. Government investment is often in more risky basic research—the research necessary to create new knowledge that can lead to entirely new products and industries. Some of the more Advanced Economies (e.g., Japan and South Korea) have relatively low levels of government investment, compared to Massachusetts and the US. This suggests that these Innovation Economies are more likely to be driven by knowledge that is created elsewhere and that they are less likely to be at the forefront of emerging markets and new industries.

FIGURE 3: Sixty-percent of Massachusetts gross R&D funds are from industrial sources

Distribution of gross R&D expenditures by source of funds, 2004



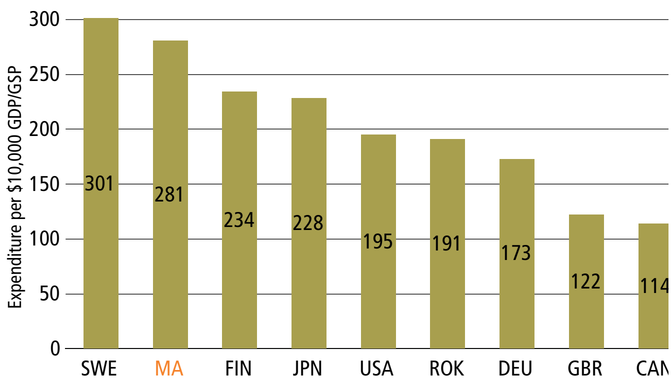
Source: The John Adams Innovation Institute
(Data source(s): NSF, OECD MSTI databases)

Past analyses conducted by the *Index* and other research reports demonstrate that Massachusetts consistently ranks highly in R&D intensity: the ratio of dollars invested in R&D to dollars of output as measured by gross state or domestic product (GSP/GDP). In global comparisons of the six-year average of corporate R&D per $10,000 of GDP ("purchasing power parity" or "PPP" dollars[9]), Massachusetts outranks many developed nations with $281 PPP invested, trailing only Sweden at $301 PPP (see Figure 4). Sweden leads not only all EU member states in R&D intensity but is the global leader as well. This result is primarily due to significant government expenditures for a total population of approximately nine million, extensive collaborations with industrial players, and a well-developed and commercially integrated, higher-education and university system.

In terms of average corporate R&D investment per GDP over the last six years, Massachusetts trails only Sweden by this measure and has greater R&D intensity than the competing innovation hubs of Japan, Finland, Germany, and Great Britain (see Figure 4).

FIGURE 4: Massachusetts is a global leader in attracting corporate R&D

Six-year average total corporate R&D per GDP/GSP. 1999-2004



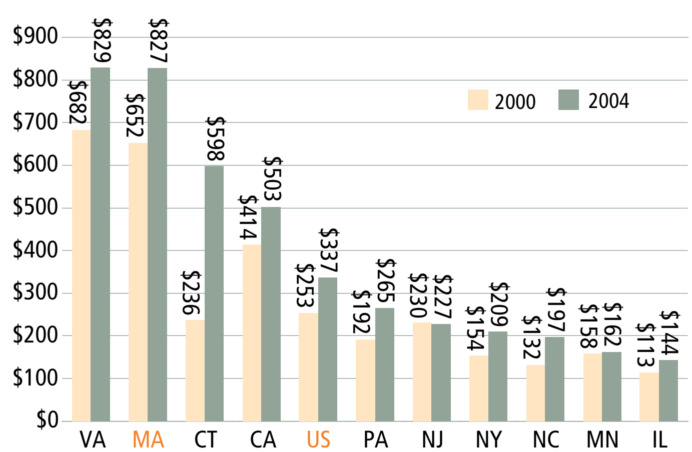
Source: The John Adams Innovation Institute
(Data source(s): S&P Compustat, OECD ANBERD databases)

Just as corporate R&D investments are fundamental to a nation's system of innovation, so too are government-funded R&D activities to the larger ecosystem of innovation. In the US, a variety of federal departments and programs have spawned a highly developed innovation infrastructure. These departments fund initiatives and activities deemed too risky for the private sector, too lengthy in terms of when revenues and/or profits are likely, or so novel or nascent that, while they could yield truly transformative technologies or products, private markets will not support them at such unproven and exploratory stages. These government initiatives include the Defense Advanced Research Projects Agency (DARPA) Small Business Innovation Research (SBIR), Advanced Technology Program (ATP), and the National Institutes of Health (NIH), among others. As a result, levels of investment by federal actors in the US typically outpace other North American, Asian, and European Innovation Economy counterparts. Consider that:

- **Per capita, the US federal government invests extensively in R&D in Massachusetts and the other LTS—to a greater extent than do governments in advanced Innovation Economies in Europe and Asia.** Massachusetts world-class universities and health centers give the state a substantial lead over most other states in attracting federal R&D dollars per capita, especially in the areas of academic and health-related R&D (see Figure 5). Virginia, however, fueled by substantial investments in federal agencies in the Washington, DC Metropolitan Area, leads the nation, marginally outperforming Massachusetts. But as federal R&D investment in Massachusetts in academic and health-related R&D remains strong, overall federal R&D investment in the Commonwealth is a flat-to-lower share of US total. The share of total federal R&D that Massachusetts attracts has either remained constant or declined slightly in the last 5 years, fluctuating around 5%. (See Indicator #15 for further information about US federal R&D).

FIGURE 5: Virginia and Massachusetts hold a substantial lead ahead of all other LTS in federal R&D per capita

Per capita federal R&D expenditures 2000 & 2004



Source: The John Adams Innovation Institute
(Data source: NSF)

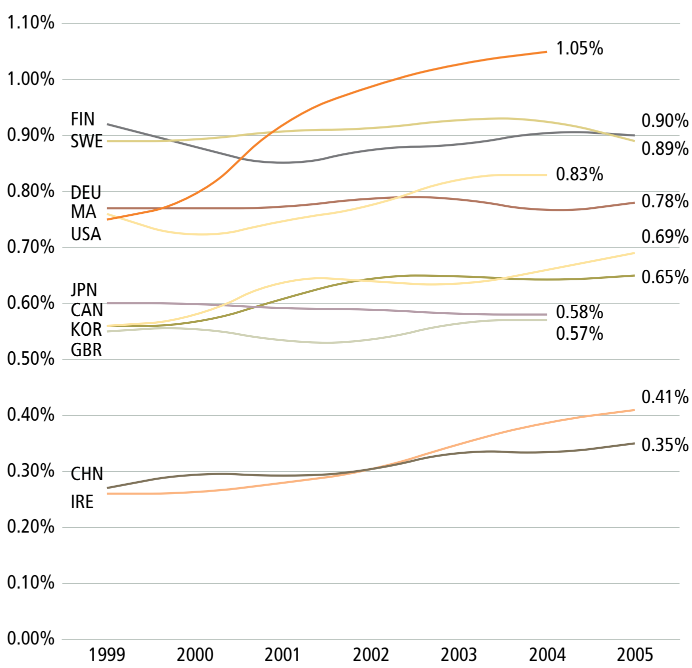
- **Advanced European nations are generally investing government R&D dollars at a high, but stagnant, level.** Advanced EU member states such as Germany, Finland, and Sweden invest a larger share of their total GDP than other European countries and emerging economies in Asia. Yet rates of growth trail Massachusetts, the US as a whole, and growing

Asian economies such as South Korea and China (see Figure 6).

- **In China and South Korea, overall expenditures and activity levels in the R&D enterprise are on the rise, with greater corporate investment.** Government sourced R&D funding in China and South Korea is a modestly growing share of total investment, while private R&D continues to dominate the landscape. According to OECD data, gross domestic expenditures on R&D (GERD)[10] in South Korea has more than doubled from 1999–2005 and in China, GERD has risen more than 200% in the same period. Yet while the level of overall R&D activity is rising, government funded R&D is on the decline in both countries, indicating that they are attracting more private sector interest and sources of R&D funding.

FIGURE 6: The Massachusetts' share of federal R&D from GSP/GDP leads and is rising compared to other advanced and emerging economies

Federal R&D as percentage of GDP/GSP



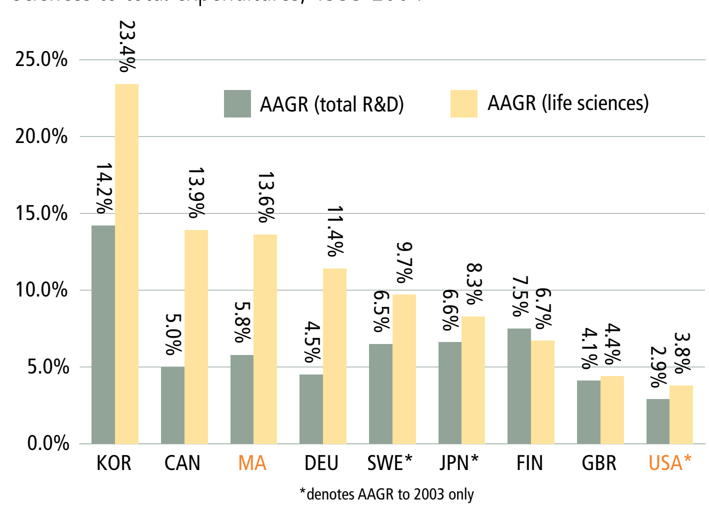
Source: The John Adams Innovation Institute
(Data source(s): NSF, OECD ANBERD databases)

Sector Focus: Life Sciences Corporate R&D

The life sciences "super-cluster," composed of pharmaceuticals, medical devices, biotech, and other affiliated industries, has been targeted by policymakers and economic development practitioners across the globe as a fertile opportunity for economic growth. Significant corporate expansion coupled with forecasted, long-term growth in the cluster has attracted the attention of investors and governments alike, with life sciences parks being developed in such diverse places as Beijing, Copenhagen, and Quebec to compete with the Commonwealth's life sciences hubs emerging in Boston, Cambridge, and Worcester. An indicator of this intense international focus on life sciences is growth in corporate R&D invested in the life sciences as compared to growth in total corporate R&D. For example, between 1999 and 2004, growth in total corporate R&D for Massachusetts was approximately 6% and $10 billion expended—healthy and leading most other countries surveyed, but significantly less than South Korea's 14% average growth rate and $22 billion worth of R&D expenditures in 2004. Considering only life sciences R&D, Massachusetts' growth in investment of 14% in this key industry is more than double the growth rate of its own total R&D investment, trailing only Canada and ahead of Germany among countries surveyed with at least $1 billion in corporate R&D expenditures in the life sciences cluster (see Figure 7. South Korea's rapid 23% rate of growth in life sciences R&D is derived from a base of only slightly more than $300 million in 1999).

FIGURE 7: Growth in life sciences R&D expenditures outpaces other types of R&D and usually by large margins

Comparing growth rates of corporate R&D expenditures in the life sciences to total expenditures, 1999-2004



Source: The John Adams Innovation Institute
(Data source(s): S&P Compustat, OECD ANBERD databases)

Corporate R&D Expenditures for Massachusetts and Global Regions by Cluster

To draw more discrete insights into corporate R&D expenditures, it is useful to analyze the distribution of R&D investments among key industry clusters. Data to assess the comparative size and share of investments in R&D in Massachusetts with other countries are available for the following industry clusters as traditionally defined by the *Index*:[11]

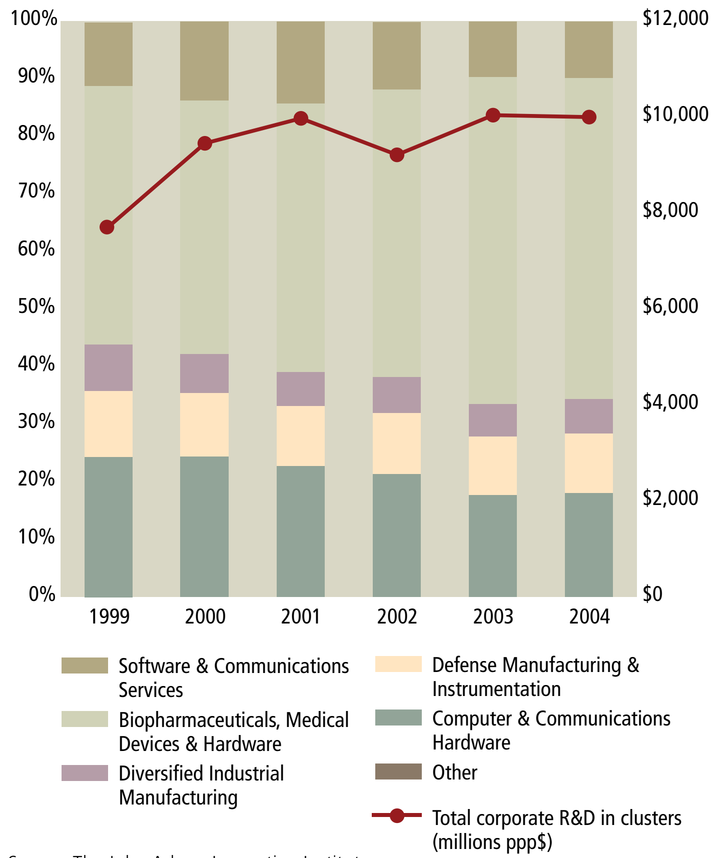
- Computer & Communications Hardware
- Defense Manufacturing & Instrumentation
- Diversified Industrial Manufacturing
- Biopharmaceuticals, Medical Devices, & Hardware
- Software & Communications Services

Historical R&D data for these clusters have been assembled for the international regions included in the Special Analysis in order to derive the level of activity and concentration of R&D in select key clusters as compared to the same clusters in Massachusetts. A direct nation-to-state comparison in terms of absolute R&D expenditures in the US is not particularly instructive for reasons of scale. Rather, an understanding of the R&D distribution across these key clusters is valuable in disclosing systemic strengths and weaknesses, and both cluster composition and evolution over time. It can also serve to highlight both potential growth industries going forward as well as industries that may be in distress.

Using this analytical framework, Massachusetts' strengths in the life sciences and computer and IT hardware clusters are demonstrated by the distribution of corporate R&D expenditures. The Biopharmaceuticals, Medical Devices, & Hardware cluster alone accounted for almost 56% of total corporate R&D expenditures in Massachusetts in 2004, making it far and away the most R&D-intensive cluster and an increase in share of more than 10% from 1999. The Computer & Communications Hardware cluster, the next most intensive, accounted for more than 18% of R&D expenditures in 2004, although this is a 6% decline compared to its 1999 share (see Figure 8).

FIGURE 8: Massachusetts' corporate R&D expenditures are concentrated in the Life Sciences and Computer Hardware clusters

Massachusetts: Distribution of corporate R&D expenditure within five clusters, 1999-2004

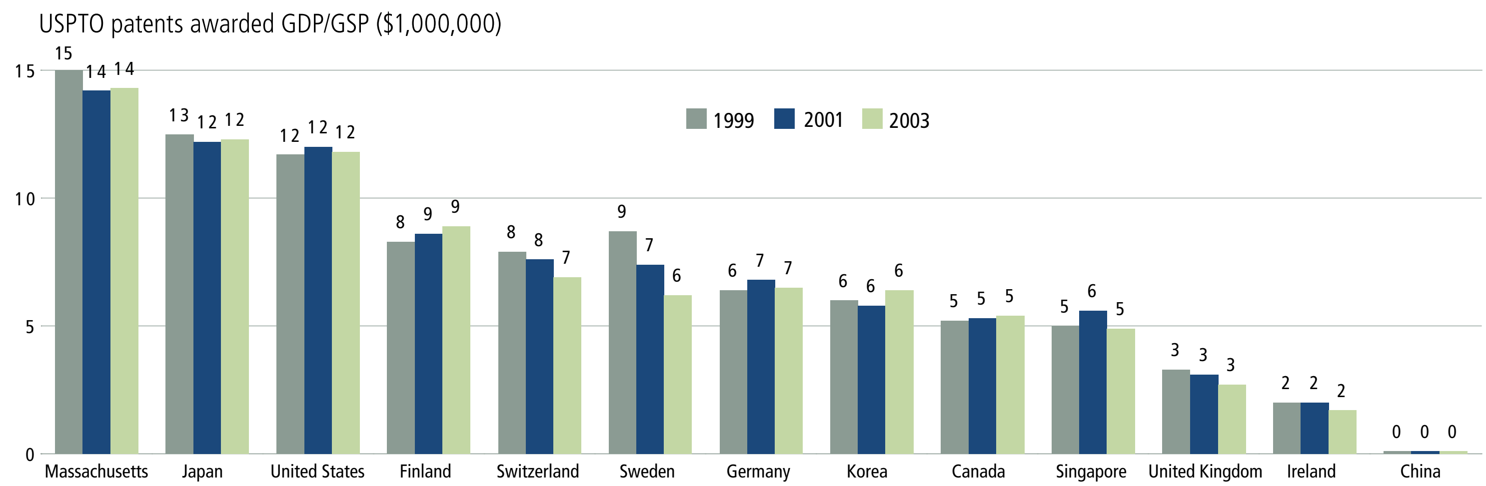


Source: The John Adams Innovation Institute (Data source(s): OECD ANBERD database)

Patent Output of Massachusetts R&D Enterprise in a Global Context

By the measures of R&D volume and growth from most sources, the leadership position of Massachusetts among the LTS and many other global regions is presently unassailable. But what has consistently confounded policymakers and observers alike is an accurate understanding of how effectively Massachusetts translates these enormous inputs into measurable economic and commercial outputs. One means of measuring the efficiency by which Massachusetts leverages the substantial investments of R&D funding from all sources into real economic benefit is the number of patents awarded by the US Patent & Trademark Office (USPTO) per GDP/GSP. By this measure as well, Massachusetts is the world leader, at the rate of fourteen USPTO patents awarded per $1 million of GSP (see Figure 9).

FIGURE 9: Massachusetts leads the world in USPTO patents awarded per GSP/GDP



Source: The John Adams Innovation Institute
(Data source(s): OECD MSTI database)

To draw insights into how the level and nature of R&D investment in the Massachusetts Innovation Economy compares and competes with other global innovation hubs, the analysis turns to our countries and regions of analysis: Asia-Pacific, BRIC, North America, and Western Europe. To consistently understand each country, data and analysis pertaining to R&D investment is organized using the following framework:

- Gross R&D Expenditures and R&D Intensity
- Privately Funded R&D: Cluster Comparisons with US Innovation Economies
- Publicly Funded R&D: Comparisons with US Innovation Economies

Spotlight: Asia-Pacific

JAPAN (JPN)

Gross R&D Expenditures and R&D Intensity in Japan

As Japan's economy was rebuilt in the decades after World War II, its industrial base emerged to be dominated by the manufacture of consumer electronics, various electronic components, and other technical, complex, and high-value added manufacturing activities. Japan's R&D infrastructure is highly-developed and disciplined—allocating 3.2% of its GDP to R&D—and represents a substantial share of global activity (see Figure 10). In fact, Japan's R&D intensity is on par with leaders in Europe such as Sweden and Finland and outpaces many of the LTS.

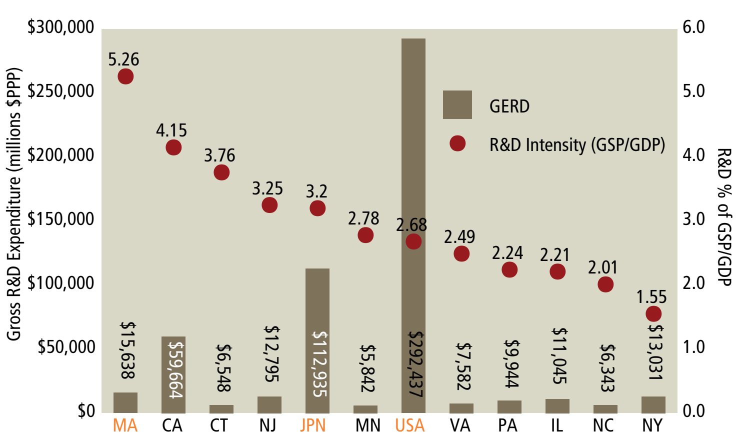
Privately funded R&D in Japan: Cluster Comparisons with US Innovation Economies

In terms of the key industry clusters, Japan has proven specialization in the Computer & Communications Hardware and Diversified Industrial Manufacturing clusters—which combine to account for more than 48% of total expenditures for the five clusters considered (see Figure 11). Other notable findings from the analysis of Japan's corporate R&D spending include:

- **The overwhelming majority of corporate R&D is funded by industry, not government.** More than 98% of corporate R&D performed is funded by industry, with less than 2% contributed by government, other in-country sources, or from abroad. In comparison, the US government funds approximately 10% of R&D conducted by private enterprises.[12]
- **The Computer & Communications Hardware cluster shows little sign of rebound from the 2000-2001 downturn.** As in many Innovation Economies around the globe, this sector in Japan has yet to match levels of R&D investment experienced in 2000. In fact, expenditures in the Computer & Communications Hardware cluster have declined more than 7% from 2000 to 2003. This suggests that activities within the cluster may be particularly vulnerable to relocation to low-cost production centers in India and China. At the aggregate level, Massachusetts share of its total R&D in comparable clusters exceeds that of Japan by almost 20%. Massachusetts has also consistently increased its share of total R&D in key clusters as a percentage of total corporate R&D. Moreover, between 2002 and 2003, Japan's share of its total R&D in these key clusters declined by more than 3% (see Figure 11).

FIGURE 10: Japan is a global R&D leader

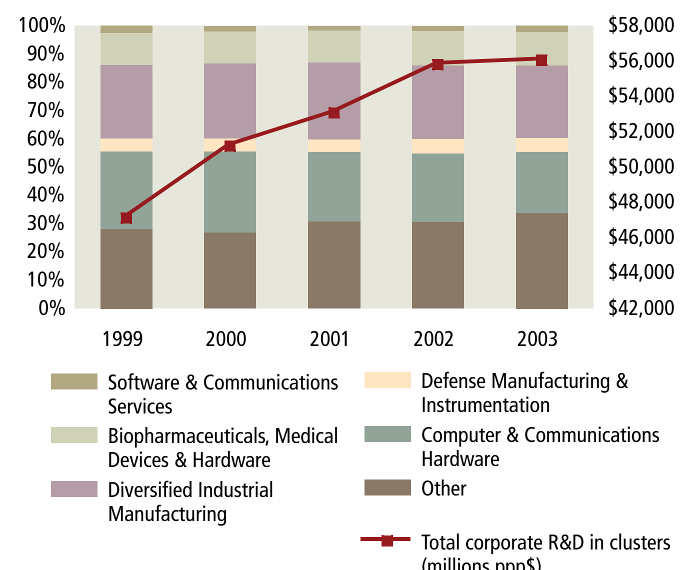
Gross R&D GSP/GDP, JPN, US and the LTS, 2003



Source: The John Adams Innovation Institute
(Data source(s): OECD MSTI database, NSF)

Figure 11: Japan's corporate R&D expenditures reflect stability in the composition of clusters and increasing amounts of total investment

JPN: Distribution of corporate R&D expenditure within five clusters, 1999-2003



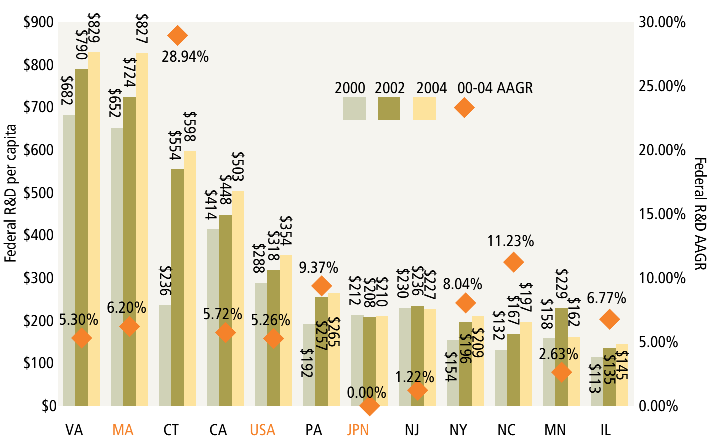
Source: The John Adams Innovation Institute
(Data source(s): OECD ANBERD database)

Publicly Funded R&D in Japan: Comparisons with US Innovation Economies

At 2%, the amount of publicly funded research performed by the private-sector in Japan is insubstantial when compared to the US and a subset of the LTS. Japan's investments in government-funded R&D per capita between 2000 and 2004, when measured in both dollar amount invested and average annual growth rate, are comparable to the LTS of Pennsylvania and New Jersey. Yet Japan's investments in R&D pale in comparison to those of LTS-leading Virginia and Massachusetts. On a per capita basis, Massachusetts in particular outpaces Japan by a four-to-one margin (see Figure 12).

FIGURE 12: Japan's level of federal R&D investment significantly trails Massachusetts but is comparable with most of the LTS

Federal R&D per capita, JPN, US, and the LTS, 2000-2004



Source: The John Adams Innovation Institute
(Data source(s): OECD MSTI database)

SOUTH KOREA (KOR)

Data for 2003 show that South Korea accounts for substantial R&D investments, some $24 billion (PPP), from diverse sectors such as biotechnology, nanotechnology, automotive, consumer electronics, and pharmaceuticals—and it is growing. For example, in only the last few years, planned R&D spending and investments include a five-year, $300 million commitment from Pfizer, a $60 million investment from Microsoft Corporation, and the Korean government directly investing $846 million in a life sciences R&D center with the stated goal to establish the country as a world leader in the life sciences sector by 2015.

Gross R&D Expenditures and R&D Intensity in South Korea

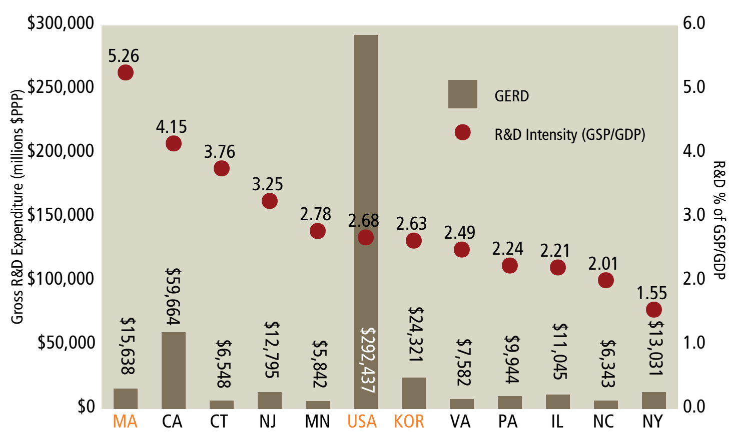
South Korea's R&D intensity ranks second among Asian nations, trailing only Japan, and would rank squarely in the middle of the LTS. According to the National Science Foundation, South Korea devotes approximately 2.6% of its GDP to all types of R&D, both corporate and publicly funded combined, a percentage comparable to the United States as a whole. In an LTS context, however, Massachusetts invests nearly 5% of its GSP to R&D and California, Connecticut, Minnesota, and New Jersey all have higher rates of investment than South Korea (see Figure 13).

Privately funded R&D in South Korea: Cluster Comparisons with US Innovation Economies

South Korea's corporate R&D enterprise is dominated by the Computer & Communications Hardware cluster representing approximately 50% of its aggregate cluster R&D expenditures. Total corporate R&D that can be attributed to five key clusters has also shown consistent increases between 1999 and 2004. Conversely, Diversified Industrial Manufacturing R&D expenditures have decreased by approximately 4% of the five-cluster total from 1999 to 2004, suggesting that this type of business activity that has traditionally been at the foundation of the country's manufacturing base may be relocating

FIGURE 13: R&D intensity in South Korea makes it a leader in Asia and the world

Gross R&D GSP/GDP, KOR, US and the LTS, 2003

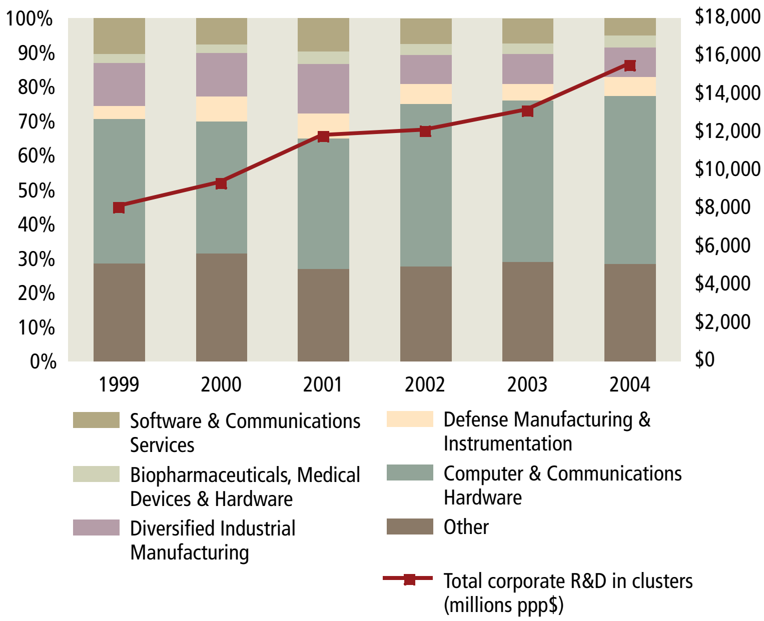


Source: The John Adams Innovation Institute
(Data source(s): OECD MSTI database, NSF)

to lower-cost Asian centers of production. This trend, therefore, not only appears to be undermining the US base in Diversified Industrial Manufacturing, but also in other highly developed economies such as South Korea. South Korea has historically invested a significant share of total corporate R&D dollars in key clusters, approximately 70%, compared with Massachusetts' 80% or more. While especially hard hit by the recession in the hardware and traditional IT sectors in 2000, levels of both total and sector-specific investment in South Korea are showing signs of rebounding since 2003 (see Figure 14).

FIGURE 14: South Korea's corporate R&D expenditures are dominated by the Computer & Communications Hardware cluster

KOR: Distribution of corporate R&D expenditure within five clusters, 1999-2003



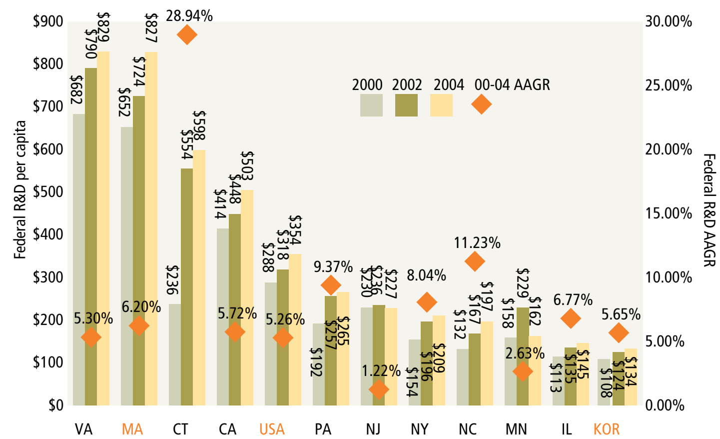
Source: The John Adams Innovation Institute
(Data source(s): OECD ANBERD database)

Publicly Funded R&D in South Korea: Comparisons with US Innovation Economies

When compared to the United States, South Korea's level of publicly funded R&D per capita pales at just more than $100 per resident. Moreover, it has declined in recent years.[13] On a per capita basis, federal R&D investment does not compare with the rates in the LTS, with federal R&D accounting for just $134 per capita, indicating a greater reliance on foreign and native corporate R&D spending to buttress its system of innovation (see Figure 15).

FIGURE 15: South Korea's level of federal R&D investment per capita significantly trails all of the LTS

Federal R&D per capita, KOR, US, and the LTS, 2000-2004



Source: The John Adams Innovation Institute
(Data source(s): OECD MSTI database)

SINGAPORE (SGP)

The island city-state of Singapore has made no secret of its ambition to become a leading R&D center, not only in Asia, but to compete with North America and Europe as well. Direct government funding of R&D is on the rise and, more importantly, a myriad of regulatory changes and incentives are aimed squarely at attracting greater amounts of R&D dollars. Between 1995 and 2003, Singapore's growth in R&D averaged 15%, the second best performance in Asia after China. Gross domestic expenditure on R&D has more than doubled between 1999 and 2005, now totaling more than $3.1 billion (PPP) per year. This increasing activity is not only represented by substantial increases in funding, but also in terms of talent dedicated to the R&D enterprise. Between 1990 and 2001, for example, the number of scientists and research engineers engaged in R&D activities in Singapore rose from 4,300 to more than 18,600.[14]

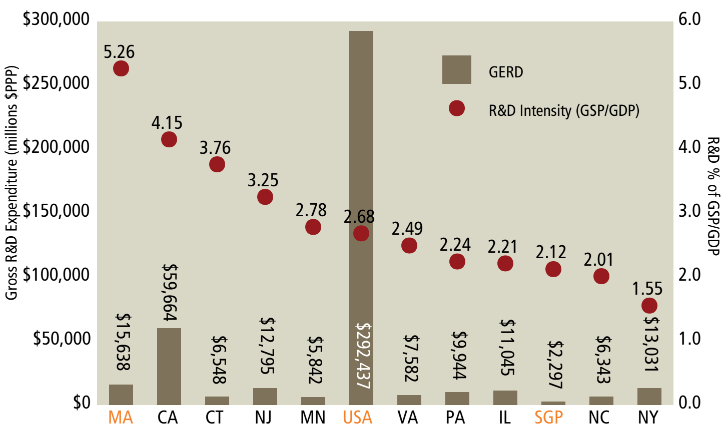
Gross R&D Expenditures and R&D Intensity in Singapore

Total R&D in Singapore remains relatively modest when compared to the LTS and to its regional competitive powerhouses of South Korea, Japan, and China. Total R&D in Singapore amounted to $2.3 billion (PPP) in 2003. More recent data indicate that the average annual growth of total R&D spending was greater than 12% between 1999 and 2005, which is on par with Korea and greater than the United States and United Kingdom, whose average annual growth rates were approximately 5%.

Singapore was, however, far behind China's 23% average annual growth in R&D spending for the same period (see Figure 16). Singapore's overall R&D spending is modest in total volume, but rates of growth reflect both a financial and philosophical commitment to an expanded R&D enterprise.

FIGURE 16: Singapore's gross R&D is a significant share of its GDP

Gross R&D GSP/GDP, SGP US and the LTS, 2003



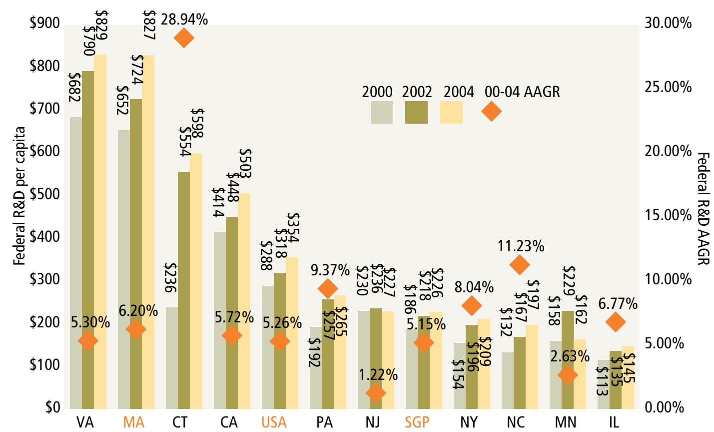
Source: The John Adams Innovation Institute
(Data source(s): OECD MSTI database, NSF)

Publicly Funded R&D in Singapore: Comparisons with US Innovation Economies[15]

Singapore's comparable R&D investment by government is on par with the middle-tier of LTS of New Jersey, New York, and Pennsylvania, but trailing the leaders of Virginia and Massachusetts. Like many of its counterparts in Asia, Singapore is successfully attracting corporate R&D dollars and investing less from government sources (see Figure 17).

FIGURE 17: Singapore's level of federal R&D investment significantly trails Massachusetts but is comparable with much of the LTS

Federal R&D per capita, SGP, US, and the LTS, 2000-2004



Source: The John Adams Innovation Institute
(Data source(s): OECD MSTI database)

Spotlight: Brazil, Russian Federation, India, China (BRIC)

Although not a political or trade alliance like the European Union (EU) or the Association of Southeast Asian Nations (ASEAN), Brazil, Russian Federation, India, and China (collectively referred to as "BRIC") are generally regarded as the most rapidly developing economies in the world. In fact, a report published in 2003 by the investment firm Goldman Sachs predicted that the economies of these four countries are poised to become an unparalleled and formidable economic trading bloc by the year 2050, surpassing the dominance of the United States, Europe, and all other G-8 countries.[16] Unfortunately, as they are non-member countries of the OECD—the best global source of comparative data on R&D—any consistent comparison of data sets with the LTS, the United States and OECD member states is not possible. There are, however, some facts that underscore the commitment to accelerated economic growth in the BRIC countries. Consider the following:

- **China's R&D expenditures are an estimated $95 billion (PPP) in 2004 with a five-year growth average of more than 20%.** China's total R&D expenditures have soared from approximately $45 billion in the year 2000 to more than $95 billion in 2004, representing 1.2% of its GDP. These data demonstrate that China in particular is proving itself as an attractive repository of corporate R&D, predominantly from US and European firms (see Figure 18).

- **China attracts the largest share of its R&D funds from corporate sources, more closely mimicking the funding mix of US Innovation Economies, including Massachusetts.** Unlike its BRIC counterparts that attract only 20%-40% of total R&D expenditure from corporations, China attracts more than 65% of its total R&D from corporate sources. This distribution is more closely aligned with developed Innovation Economies in the United States and underscores both the intensity of activity of commercially-focused R&D and the confidence that the private sector is increasingly placing in China's R&D infrastructure and capability (see Figure 19).

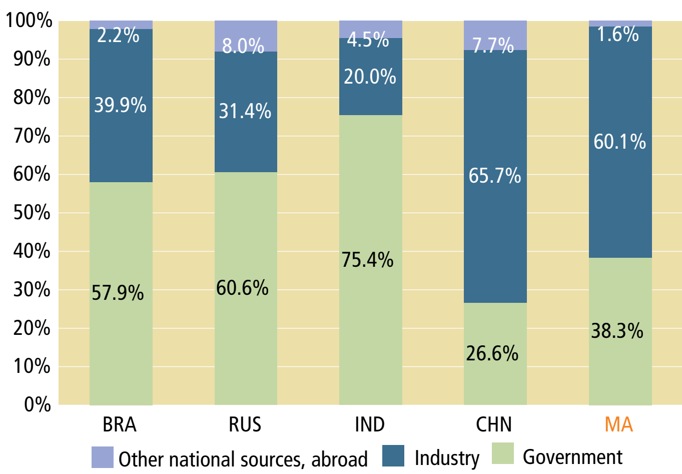
- **In 2004, Brazil conducted nearly $14 billion (PPP) worth of R&D, approximately half that of the United Kingdom.** Bolstered by a rapidly developing higher education system, Brazil's R&D economy counts many industry leaders among its top corporate R&D performers. Brazilian corporations such as Petrobás in natural resources, Embraer in aerospace, and Embrapa in agro-business, the largest global producer of ethanol, are all world leaders in R&D activity.

FIGURE 18: China spends the greatest share of its GDP on R&D of all BRIC countries

R&D Expenditures							
	2000		2002		2004		Total R&D AAGR, 2000-2004
	Total	% of GDP	Total	% of GDP	Total	% of GDP	
Brazil	$12,573,471	1.01%	$13,408,633	1.00%	$13,558,605	0.91%	2.0%
Russian Federation	$10,760,689	1.05%	$14,655,006	1.25%	$16,360,646	1.16%	11.3%
India	$20,177,825	0.84%	$18,933,267	0.69%	$21,189,162	0.63%	1.4%
China	$44,894,304	0.90%	$65,515,553	1.07%	$95,498,145	1.23%	20.8%

FIGURE 19: China attracts a greater share of corporate R&D than its BRIC counterparts at rates comparable with Massachusetts and the LTS

BRIC v. Massachusetts: Distribution of total R&D expenditures by source of funds, 2004



Source: The John Adams Innovation Institute
(Data source(s): UNESCO Institute for Statistics, NSF)

Spotlight: North America

Since 1994, the start of implementation of the North American Free Trade Agreement (NAFTA), the continent has evolved into a free trade zone of enormous size and influence. Between 1994 and 2005, trade among the NAFTA nations climbed 173%, from $297 billion to $810 billion and NAFTA countries conduct nearly $2.2 billion in trilateral trade each day.[17] Canada has solidified its position as the largest trading partner of the US, with total trade in 2005 exceeding $500 billion (US$).

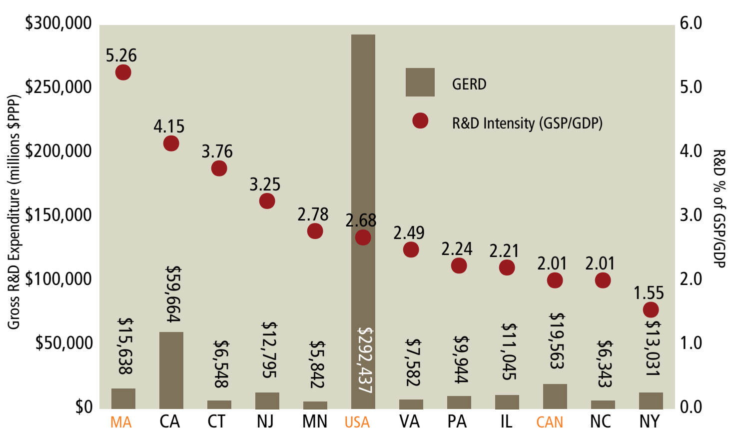
CANADA (CAN)

Gross R&D Expenditures and R&D Intensity in Canada

The total of gross expenditures on R&D in Canada amounted to approximately $20 billion in 2003, more than Massachusetts' total of $16 billion for the same year. This expenditure represents slightly more than 2% of Canada's GDP and is comparable to the lower R&D intensity of North Carolina and Illinois among the LTS (see Figure 20).

FIGURE 20: Canada's gross R&D expenditure is $20 billion annually

Gross R&D GSP/GDP, CAN and the LTS, 2003



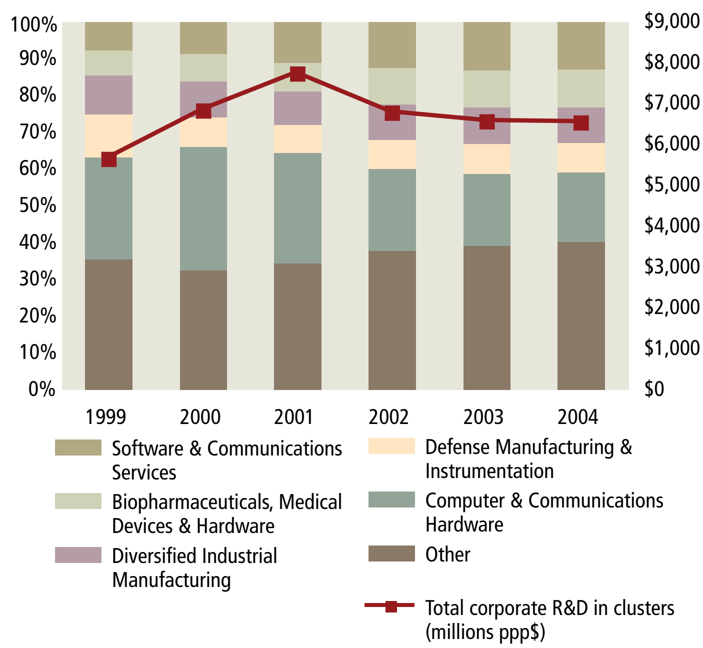
Source: The John Adams Innovation Institute
(Data source(s): OECD MSTI database, NSF)

Privately Funded R&D in Canada: Cluster Comparisons with US Innovation Economies

Overall, corporate R&D spending in Canada does not resemble the distribution seen in typical Innovation Economies. Total R&D in the five clusters has not recovered to the year 2001 high and has remained constant at approximately $6.5 billion (PPP) since 2002 (see Figure 21). Canada's corporate R&D investments are concentrated in the traditional IT sectors, such as computer software and hardware. The percentage of private sector investments in the biopharmaceuticals, industrial, and defense manufacturing clusters have remained remarkably steady between 1999 and 2004. Further, the share of corporate R&D spending made in non-Innovation Economy sectors, with at a least a minimum of $100 million invested per year, is in those sectors related to raw materials, wood and pulp, basic metals, and transportation.

FIGURE 21: Canada's corporate R&D is steady reflecting increasing investments in industries outside of key industry clusters

CAN: Distribution of corporate R&D expenditure within five clusters, 1999-2003



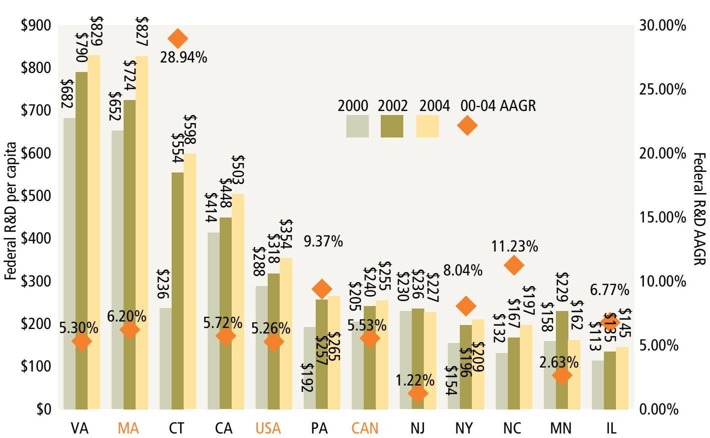
Source: The John Adams Innovation Institute
(Data source(s): OECD ANBERD database)

Publicly Funded R&D in Canada: Comparisons with US Innovation Economies

The Government of Canada uses a broad range of R&D programs, incentives, and policies to foster science and technology (S&T) research. These tools include the "science-based departments and agencies" (SBDAs) that perform intramural S&T research, and associated R&D funding programs specific to their mandates and issue areas, such as energy, environment, and others. These tools also include more horizontal funding mechanisms that the Canadian government uses to support R&D in other, broader sectors of the national innovation system. These federal R&D funding entities include granting councils (e.g. Canadian Institutes of Health Research), foundations (e.g. Genome Canada), and associated programs (e.g. Centres of Excellence) that support R&D in academia, as well as other tools supporting R&D in industry, whether through direct investment or indirectly via tax policy.[18] As a result of these priorities and funding structures, federal R&D per capita in Canada amounted to $254 per in 2004, around the median among LTS, with the investment growing at an average rate of 6% per year since 2000 (see Figure 22).

FIGURE 22: Canada's level of federal R&D investment significantly trails Massachusetts' but is comparable to most other LTS

Federal R&D per capita, CAN, US, and the LTS, 2000-2004



Source: The John Adams Innovation Institute
(Data source(s): OECD MSTI database)

Spotlight: Western Europe[19]

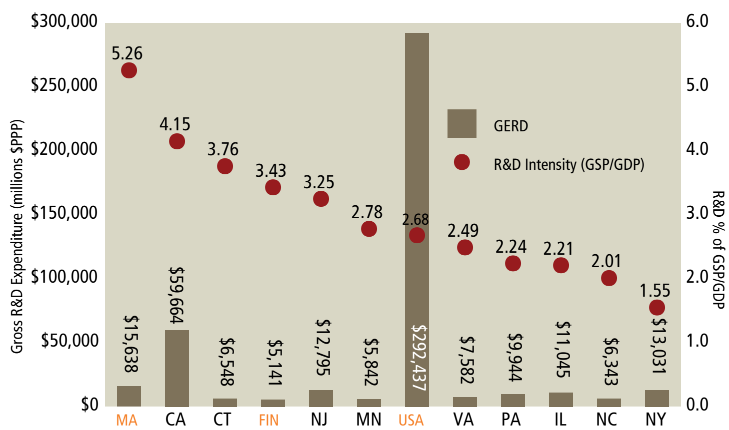
FINLAND (FIN)

Gross R&D Expenditures and R&D Intensity in Finland

Finland's innovation infrastructure is ordered and enjoys significant prominence among its government executives. Atop the innovation policy hierarchy in Finland is the influential Science & Technology Policy Council (STPC), comprised of S&T related ministers and department heads and chaired by the Prime Minister. Tekes, the principal government source of funding for applied research and industrial R&D, operates within this framework. Finland's rate of R&D intensity consistently leads most of Europe, excluding only Sweden. In 2003, Finland dedicated almost 3.5% of its GDP to R&D, more than $5 billion (PPP) in 2003 (see Figure 23).

FIGURE 23: Finland Is a global innovation leader with a high percentage of its GDP derived from R&D

Gross R&D GSP/GDP, FIN and the LTS, 2003



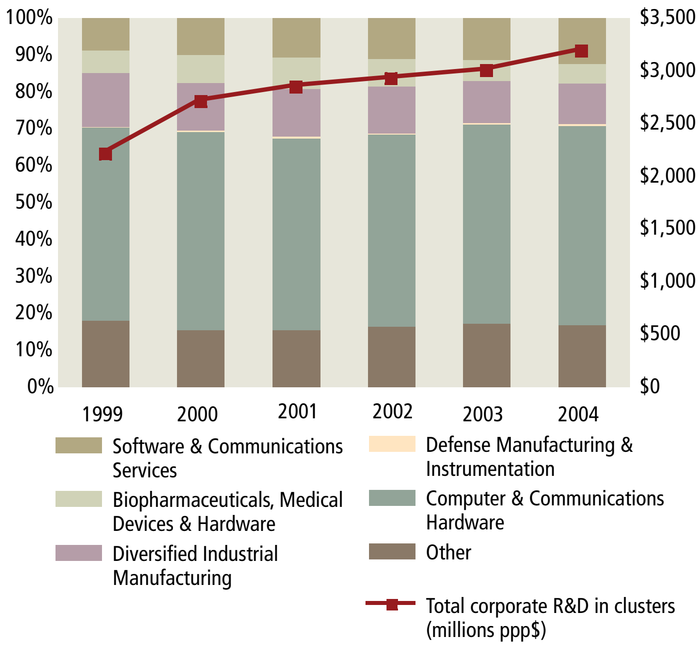
Source: The John Adams Innovation Institute
(Data source(s): OECD MSTI database, NSF)

Privately Funded R&D in Finland: Cluster Comparisons with US Innovation Economies

Finland's R&D enterprise is highly-developed and expansive, with 17 researchers per thousand of total employment, by far the most of any OECD country and exceeding the US ratio of 10 researchers per thousand of employment.[20] Also renowned for being home to industry leader Nokia in communications handsets and other telecom hardware, Finland's pronounced specialization is seen in the distribution of corporate R&D spending into that cluster. While Finland only attracted roughly one-third of the corporate R&D dollars of Massachusetts in 2004, total investments in the five clusters under study have been consistently rising since 1999 (see Figure 24).

FIGURE 24: More than half of Finland's corporate R&D investments are in the Computer & Communications Hardware cluster

FIN: Distribution of corporate R&D expenditure within five clusters, 1999-2003



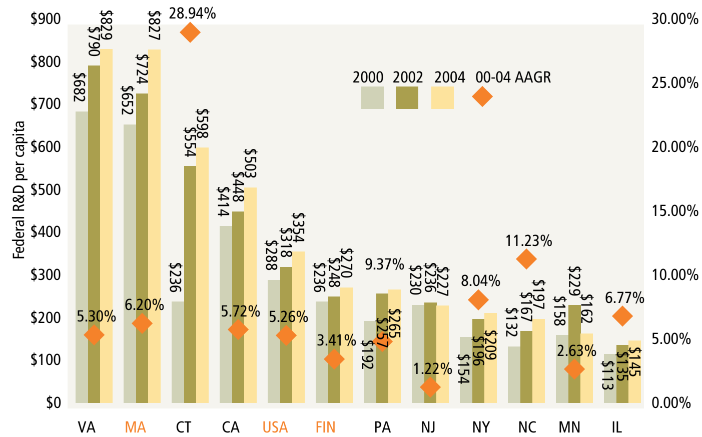
Source: The John Adams Innovation Institute
(Data source(s): OECD ANBERD database)

Publicly Funded R&D in Finland: Comparisons with US Innovation Economies

Total R&D expenditures in Finland accounted for nearly 4% of GDP in 2005 and 41% of this investment was derived from the public sector.[21] Government or federal R&D per capita in Finland amounts to $270, on par with the middle tier of LTS. But the rate of growth in federal R&D is slower than in both its European and US counterparts, just 3.4% on average from 2000-2004 (see Figure 25).

FIGURE 25: In 2003, federal R&D per capita was $270 per resident

Federal R&D per capita, FIN, US, and the LTS, 2000-2004



Source: The John Adams Innovation Institute
(Data source(s): OECD MSTI database)

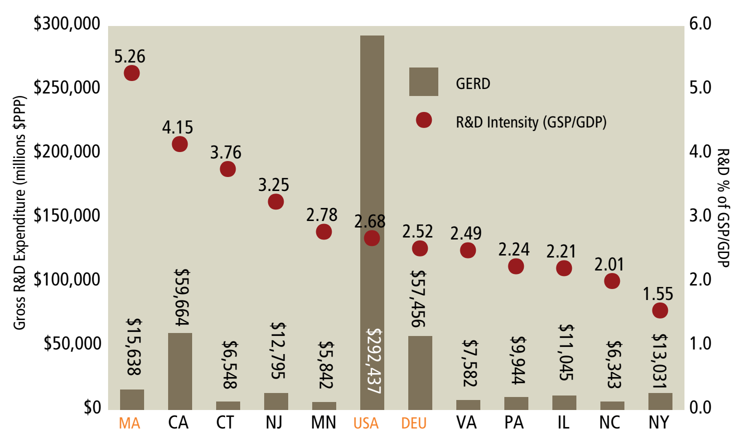
GERMANY (DEU)

Gross R&D Expenditures and R&D Intensity in Germany

With long established R&D expertise in the automotive, general engineering, and IT sectors, Germany's total R&D investment is nearly $58 billion (PPP), representing more than 2.5% of its GDP. This amount is comparable to California among the LTS, although California counts a greater share of its GDP from R&D at 4% (see Figure 26).

FIGURE 26: Germany's percentage of GDP derived from R&D compares with the US

Gross R&D GSP/GDP, DEU and the LTS, 2003



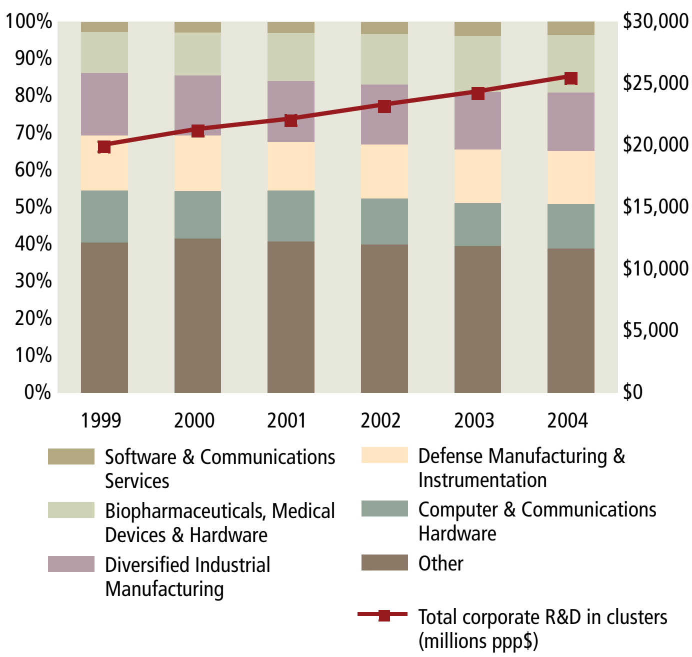
Source: The John Adams Innovation Institute
(Data source(s): OECD MSTI database, NSF)

Privately Funded R&D in Germany: Cluster Comparisons with US Innovation Economies

The distribution of Germany's corporate R&D spending has remained substantially unchanged from 1999–2004, with investments across the five clusters generally stable for the period. Total dollars invested in the five clusters have increased on average 5% per year and amounted to more than $25 billion (PPP) in 2004. Notable in Germany's corporate R&D distribution is the consistent and considerable R&D investment funds attracted to sectors and industries outside of the five key clusters, approximately 40% in 2004 (see Figure 27). Of sectors with at least $100 million (PPP) invested, the greatest rates of growth in Germany's R&D expenditures are observed in the textiles, paper and wood, printing and publishing, and materials sectors with 20% or more average growth per year between 1999 and 2004.

FIGURE 27: German firms direct 40% of their corporate R&D to activities outside of key clusters

DEU: Distribution of corporate R&D expenditure within five clusters, 1999-2003



Source: The John Adams Innovation Institute
(Data source(s): OECD ANBERD database)

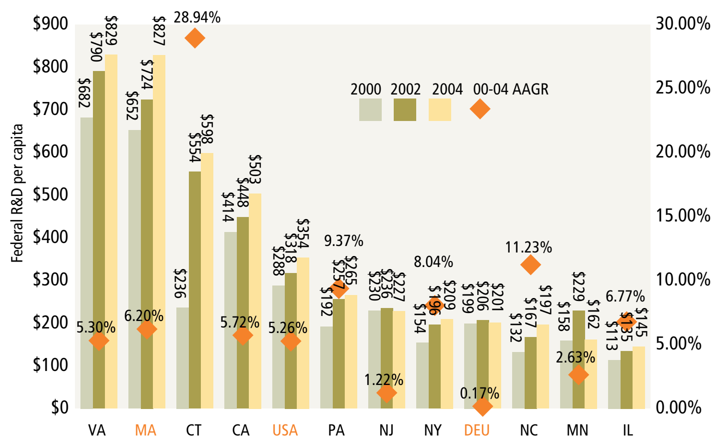
Publicly Funded R&D in Germany: Comparisons with US Innovation Economies

The German government invests heavily in a multi-tiered system of research laboratories, universities, and government research centers, contributing to a gross domestic expenditure on R&D of approximately 2.5% of GDP. In conjunction with Germany's federal states, the central government supports the two premier research organizations, the Max-Planck-Gesellschaft (MPG) and the Fraunhofer-Gesellschaft (FhG). The central government provides 50% of the support for the MPG and 90% of that for the FhG. The MPG conducts basic research in emerging fields and serves a complementary role to university research. The FhG concentrates on applied research and its principal objective is to translate and commercialize the results of research into new products, processes and services.

Overall, Germany's federal R&D investment per capita falls below the LTS median and is on par with North Carolina, Minnesota, and Illinois among the LTS. Germany's average rate of growth in federal R&D spending per capita also trails those LTS with comparable investment per capita (see Figure 28).

FIGURE 28: Germany's federal R&D investment remains largely constant from 2000-2004

Federal R&D per capita, DEU, US, and the LTS, 2000-2004



Source: The John Adams Innovation Institute
(Data source(s): OECD MSTI database)

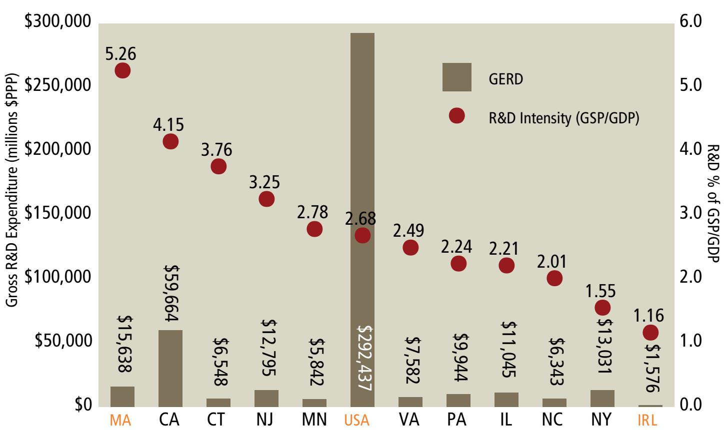
IRELAND (IRL)

Gross R&D Expenditures and R&D Intensity in Ireland

Often referred to as the "Celtic Tiger" since the unprecedented hyper-growth of the late 1990's in the software and information technology sectors, Ireland continues to exhibit a healthy degree of R&D activity and intensity. Total R&D expenditures in Ireland topped the $1 billion (PPP) mark for the first time in 2003, accounting for approximately 1.2% of its GDP (see Figure 29).

FIGURE 29: Ireland's gross R&D expenditure was $1.5 billion in 2003

Gross R&D GSP/GDP, IRL and the LTS, 2003



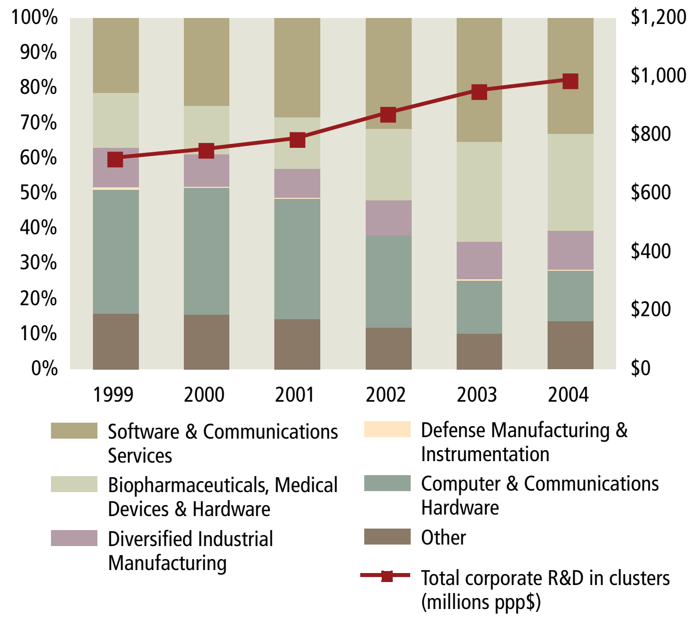
Source: The John Adams Innovation Institute
(Data source(s): OECD MSTI database, NSF)

Privately Funded R&D in Ireland: Cluster Comparisons with US Innovation Economies

Between 1999 and 2004, corporate R&D expenditures in the Emerald Isle grew at 6% per year on average to a total of $1.1 billion (PPP) in 2004. In terms of the five key clusters under consideration, the Software & Communications Services cluster continues to dominate the Irish Innovation Economy, with fully one-third of total corporate R&D dedicated to that cluster. Life sciences-related cluster growth represents the other cornerstone of Ireland's knowledge economy, with more than 28% of its total R&D dedicated to the Biopharmaceuticals, Medical Devices, & Hardware cluster (see Figure 30).

FIGURE 30: Ireland's corporate R&D expenditures are dominated by the life sciences and software clusters

IRL: Distribution of corporate R&D expenditure within five clusters, 1999-2003



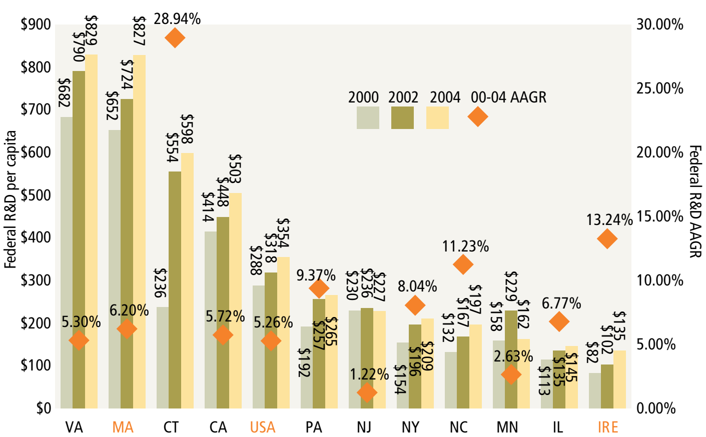
Source: The John Adams Innovation Institute
(Data source(s): OECD ANBERD database)

Publicly Funded R&D in Ireland: Comparisons with US Innovation Economies

Ireland's per capita investment in federal dollars cannot compare to amounts seen in Massachusetts and the other LTS, but the amount invested has more than doubled since the late 1990's. Ireland's well-known growth and expansion in the 1990s in knowledge economy sectors was fueled predominantly by attracting private-sector sources of funds. It is, however, showing an ongoing augmentation of the R&D enterprise by virtue of a federal infusion of capital. In 2004, the Irish government invested just $135 per capita, but average annual growth in that investment is more than 13% between 2000 and 2004 (see Figure 31).

FIGURE 31: Ireland's federal investment per capita does not yet compete with the majority of the LTS, but posts an impressive rate of growth between 2000 and 2004

Federal R&D per capita, IRL, US, and the LTS, 2000-2004



Source: The John Adams Innovation Institute
(Data source(s): OECD MSTI database)

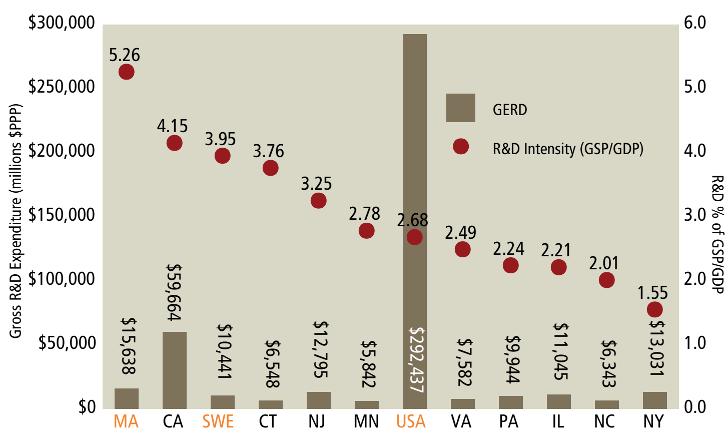
SWEDEN (SWE)

Gross R&D Expenditures and R&D Intensity in Sweden

Sweden is the global leader in R&D expenditure per GDP, devoting 3.9% of its GDP to R&D activities (see Figure 32). The United States ranks 5th internationally, with 2.7 % of its GDP dedicated to R&D. The Swedish central government and various agencies within the public sector are the largest sponsors of research at universities and other institutions of higher education. Public funding accounts for more than two-thirds of all research conducted at these institutions. Yet only 20% of these funds are allocated to research in business or industrial sectors, mostly in defense related research activities conducted by large multinational corporations. As a result, public funding of research is predominantly geared toward curiosity-driven university research rather than industrial development. Considering total R&D expenditures in Sweden, the largest share of funding is derived from industry, akin to most Innovation Economies in the US.

FIGURE 32: Nationally, Sweden is the world leader in R&D intensity

Gross R&D GSP/GDP, SWE and the LTS, 2003



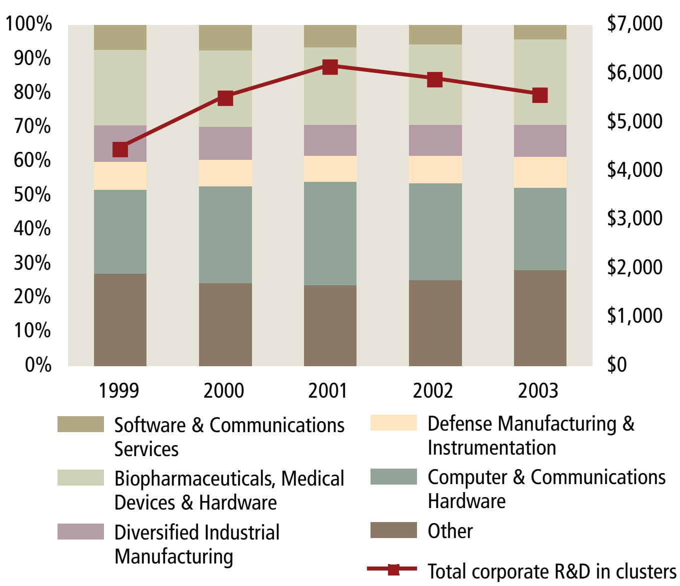
Source: The John Adams Innovation Institute
(Data source(s): OECD MSTI database, NSF)

Privately Funded R&D in Sweden: Cluster Comparisons with US Innovation Economies

As was witnessed in Innovation Economies across the globe, corporate R&D expenditures in Sweden accelerated in the latter half of the 1990s and reached a peak in 2001. Much like Massachusetts, the distribution of Sweden's corporate R&D is dominated by the biopharmaceuticals and computer hardware clusters, given the prominence of native firms such as AstraZeneca and Ericsson. Conversely, sectors comprising the software cluster have contracted by about 6% per year in R&D invested since 1999. Corporate R&D within the five clusters has not returned to the level of more than $6 billion (PPP) seen in 2001, and as of 2004, this amount had retreated further to $5.5 billion (PPP) (see Figure 33). Sweden's total corporate R&D spending of slightly more than $7.5 billion (PPP) in 2004 has also not returned to the 2001 level of more than $8 billion (PPP).

FIGURE 33: Biopharmaceuticals & Computer Hardware clusters represent concentrations of Sweden's R&D expenditure

SWE: Distribution of corporate R&D expenditure within five clusters, 1999-2003



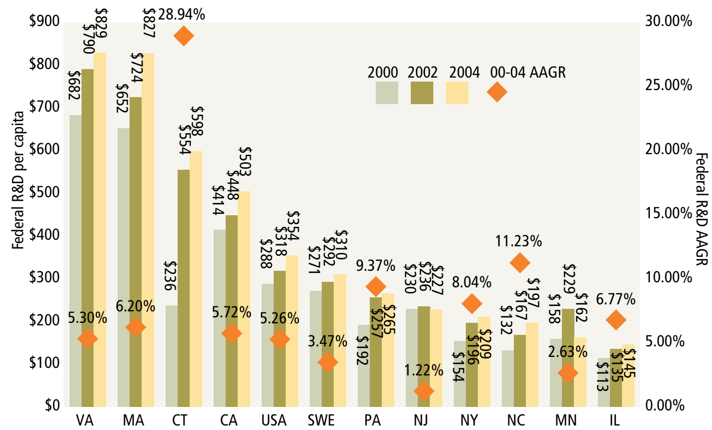
Source: The John Adams Innovation Institute
(Data source(s): OECD ANBERD database)

Publicly Funded R&D in Sweden: Comparisons with US Innovation Economies

A large proportion of all publicly financed research in Sweden is performed within universities. Most other OECD countries commit a larger share of public funds to research conducted outside universities and academic institutions. For example, Japan, the US, and France dedicate almost as much public research resources outsides universities as within them.[22] Federal R&D per capita in Sweden is most comparable to Connecticut and California on the roster of the LTS at more than $300 (PPP). Federal R&D in Sweden is also growing steadily, at an average rate of approximately 3.5% per year since 2000 (see Figure 34).

FIGURE 34: Sweden's federal per capita R&D expenditures are growing an average of 3.5% per year

Federal R&D per capita, SWE, US, and the LTS, 2000-2004



Source: The John Adams Innovation Institute
(Data source(s): OECD MSTI database)

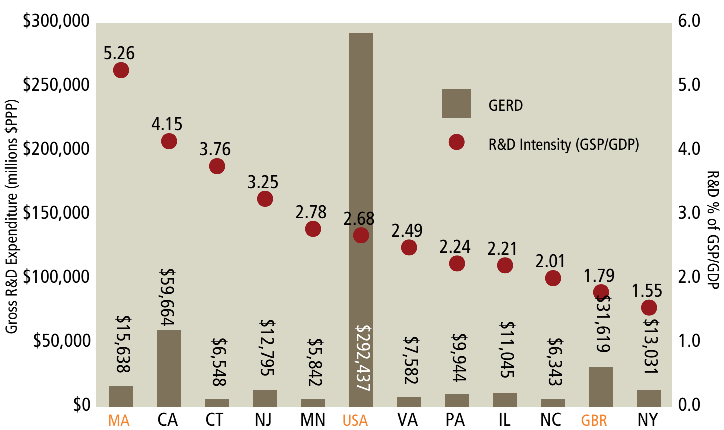
UNITED KINGDOM (GBR)

Gross R&D Expenditures and R&D Intensity in the United Kingdom

The share of the United Kingdom's GDP traced to R&D spending is surprisingly limited, given the overall sophistication of its university system and its commercial and industrial sectors. Less than 2% of the UK's GDP is derived from R&D, not only trailing most of the LTS, but almost all of Western Europe as well (see Figure 35). This may be partly explained as the UK derives the largest share of its GDP from generally non-R&D intensive services, such as financial services and banking, professional consulting, and similar sectors.

FIGURE 35: Great Britain's gross R&D per GDP is lower than most of the LTS and Western Europe

Gross R&D GSP/GDP, GBR and the LTS, 2003



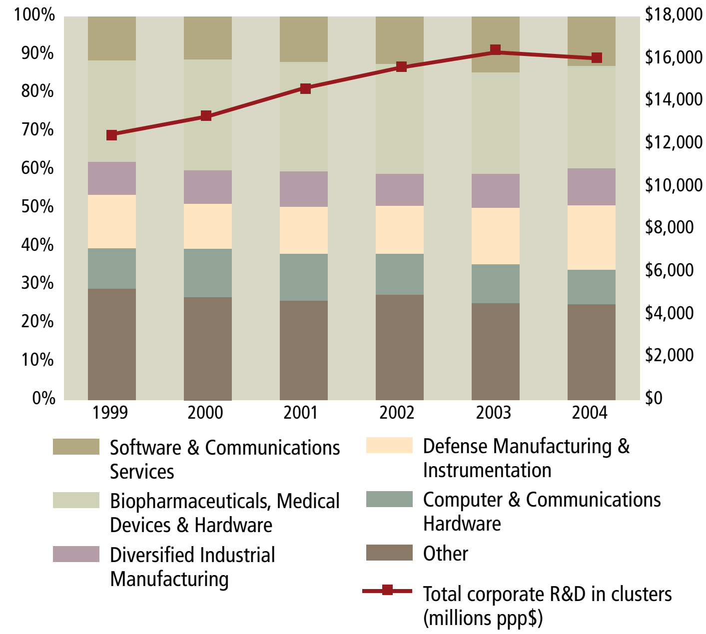
Source: The John Adams Innovation Institute
(Data source(s): OECD MSTI database, NSF)

Privately Funded R&D in the United Kingdom: Cluster Comparisons with US Innovation Economies

As home to healthcare and life sciences stalwarts such as GlaxoSmithKline and Smith & Nephew, not surprisingly, the bulk corporate R&D expenditures in the United Kingdom are found in life sciences related clusters. In addition, as the headquarters location of some of the largest defense contractors in the world in BAE Systems and Rolls Royce, a significant share of corporate R&D investments are made in aircraft and spacecraft sectors as part of the larger Defense Manufacturing & Instrumentation cluster. Other sectors exhibiting the greatest average growth between 1999 and 2004 with rates exceeding 10% include the transportation and marine related industries (see Figure 36).

FIGURE 36: The Biopharmaceuticals and Defense clusters account for most of the UK's corporate R&D expenditures

GBR: Distribution of corporate R&D expenditure within five clusters, 1999-2003



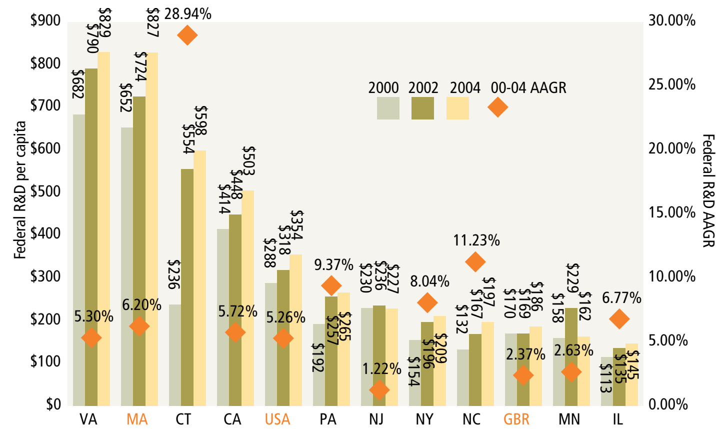
Source: The John Adams Innovation Institute
(Data source(s): OECD ANBERD database)

Publicly Funded R&D in the United Kingdom: Comparisons with US Innovation Economies

The Government of the United Kingdom published a comprehensive ten-year investment framework for science and innovation in 2005. This framework outlines the goals for UK science and innovation through the year 2014, to better understand the contribution of these investments to economic growth and public services. Another stated goal is to illuminate the attributes of funding arrangements and research systems most capable of fostering sustainable economic growth. The UK's primary aim is to create prosperity through the attraction of highly skilled scientists, engineers and technologists and the complementary companies having the greatest potential to innovate and to turn their innovations into commercial opportunity. The UK has committed to raising science spending faster than overall economic growth, aiming to increase its R&D investment as a proportion of GDP from 1.8% to 2.5% by 2014.[23] These aggressive policies and targets for growth result from a consensus that the UK must do more to publicly-fund R&D and better fuel their system of innovation to generate the products, services, companies, and employment opportunities to grow the economy. For example, as of 2004, federal R&D per capita in Great Britain amounted to only $186 per capita and growing at an average rate of 2.4% per year since 2000 (see Figure 37).

FIGURE 37: Federal R&D per capita trails most of Western Europe and the LTS

Federal R&D per capita, GBR, US, and the LTS, 2000-2004



Source: The John Adams Innovation Institute
(Data source(s): OECD MSTI database)

INVESTMENT IN THE R&D ENTERPRISE:

What it means for Massachusetts

The emerging competitive threats to Massachusetts' vibrant R&D infrastructure, capacity, and outputs

- **As a region, Massachusetts is the global leader in terms of R&D intensity.**
- **The most rapidly growing innovation hubs worldwide are predominantly fueled with corporate R&D dollars, intensifying global competition for private resources, with significant pressures from Asia-Pacific.**
- **Key clusters in Massachusetts are increasingly threatened by specialized Advanced Economies like the United Kingdom and Ireland and lower-cost innovation hubs in Asia.**
- *Software & Communications Services:* As a share of total corporate R&D, Ireland's Innovation Economy continues to demonstrate significant specialization in software and related services.
- *Computer & Communications Hardware:* Most developed economies in Europe and in parts of Asia appear to be ceding ground in the Hardware clusters, presumably to China, India and other lower-cost centers in Asia. With the exception of Finland, corporate R&D investment in this cluster has declined overall in these regions.
- *Biopharmaceuticals, Medical Devices, & Hardware:* The United States continues to dominate global investment in the life sciences from both a public and corporate standpoint, and as noted elsewhere in the *Index*, Massachusetts attracts a disproportionate share of such investment within the US. Compared to its global competitors, Massachusetts has the highest proportion of total corporate R&D expenditures—a relatively high 56% of total corporate R&D expenditures in Massachusetts support life sciences-related activities. Outside of the United States, Great Britain, Germany, and Japan dominate the life sciences cluster with more than one-quarter of its total corporate R&D investment dedicated to pharmaceuticals, medical devices, medical hardware, and related firms. There is also ample evidence of mounting competitive pressures from Asia as Japan demonstrates a robust average annual growth rate of 8% with corporate R&D expenditures in life sciences approaching $10 billion (PPP).

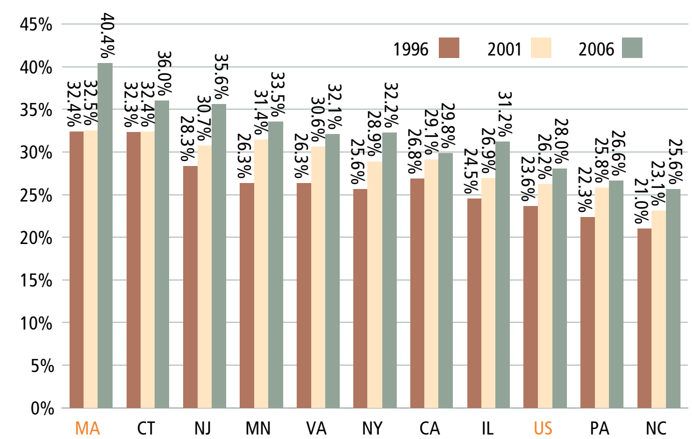
II. Human Capital & Workforce Readiness

Global Overview

The capacity of an economy to produce workers with the skills demanded by innovative companies is a critical measure of the potential for that economy to grow and its people to prosper. The US, Massachusetts, and the LTS collectively have always been at the forefront of centralizing a highly educated and skilled workforce (see Figure 38). While developing economies in other world regions have historically been locales of choice due to lower costs of labor, these same international regions today can boast significantly higher levels of educational attainment and highly skilled workers than the US and the Commonwealth. Regrettably, this is especially true in the more coveted Innovation Economy disciplines of mathematics, science and engineering.

FIGURE 38: Most LTS exceed the US national average in educational attainment

Persons 25 years old and over with a bachelor's degree or higher, LTS and US, 1996, 2001, and 2006



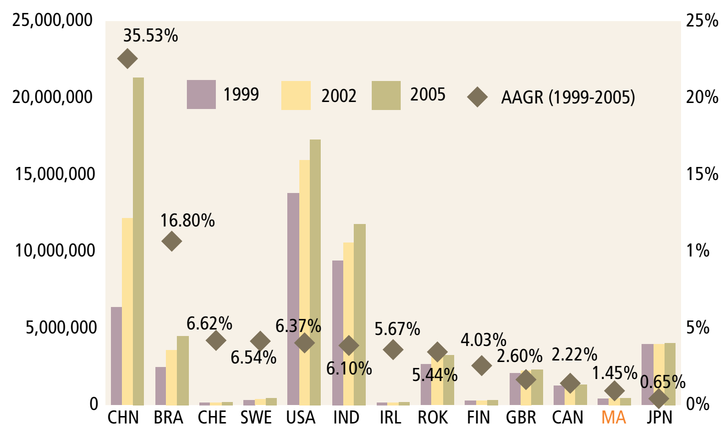
Source: US Census Bureau

Educational attainment is widely accepted as a strong measure of a region's capacity to adapt to and fuel economic growth. In innovative economies, high levels of educational attainment, particularly in the scientific disciplines, enables robust research, development, commercialization and industrial activity. The US has traditionally shown high education attainment levels, although its rate of growth in mathematics, science and engineering enrollments and graduates is not nearly as robust as in other developing economies of the world, particularly in Asia and Brazil.

An examination of the rates of growth in tertiary education enrollments between developing international economies and Massachusetts, as an example, shows a striking disparity. The rather anemic growth rate of less than 1% in university enrollments in Massachusetts might be explained in part by the long standing and highly developed system of colleges and universities here and the high pace of development and smaller base for measuring rates of growth in Asia. This explanation weakens, however, as the data disclose that Massachusetts also trails the more similarly constituted systems of Great Britain and Western Europe (see Figure 39).

FIGURE 39: Massachusetts growth in enrollments trails countries of similar size

Total tertiary enrollment and AAGR (1999-2005)



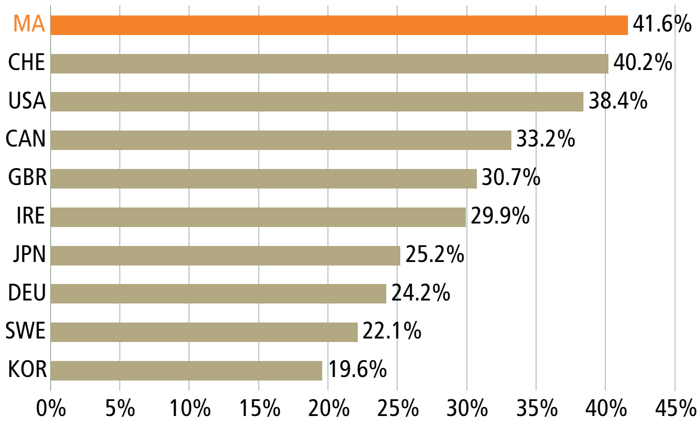
Source: The John Adams Innovation Institute
(Data source(s): US National Center for Education Statistics (NCES) and UNESCO, World Education Indicators)

Comparing the fields of study for tertiary graduates reinforces the conclusion that the US and the strong Innovation Economies of Massachusetts and the LTS face stiffer competition for talent and industry firms from these developing economies. While Massachusetts produces the highest level of graduates from tertiary institutions in the social sciences, trailed by Switzerland, its performance in the sciences and engineering is weak when compared to many of its international competitors (Figures 40, 41, 42).

Even adjusting for significant differences in populations, at a minimum these data reflect the maturation of these developing economies and the likely increases in worldwide competition for students and scientific talent and, in turn, corporate investments in R&D and manufacturing. Countries that are aggressively building a science and engineering infrastructure are increasingly able to compete for higher-level research talent and faculty.

FIGURE 40:

Percent of tertiary graduates with a major in social sciences, business and law, 2003.



Source for Figures 40-41:
Source: The John Adams Innovation Institute
(Data source(s): US National Center for Education Statistics (NCES) and UNESCO, World Education Indicators)

In considering overall educational attainment levels in Massachusetts, it is instructive to examine the data for the educational attainment levels of foreign born residents. This provides a clearer picture of workforce capacity for a number of reasons. First, growth in the Massachusetts population and its workforce would be flat or negative but for international immigration. Second, international students and scientists have consistently populated the state's colleges, universities, and academic medical centers, as well as provided professional and technical talent to the Commonwealth's technology companies. Figure 43 provides a glimpse into the countries of origin of the Massachusetts population and the variations in educational attainment levels for these foreign born residents. While these data are interesting standing alone, they also provide a measure of the impact that national immigration policy can have on the Commonwealth's labor pool.

FIGURE 41:

Percent of tertiary graduates with a major in Science, 2003

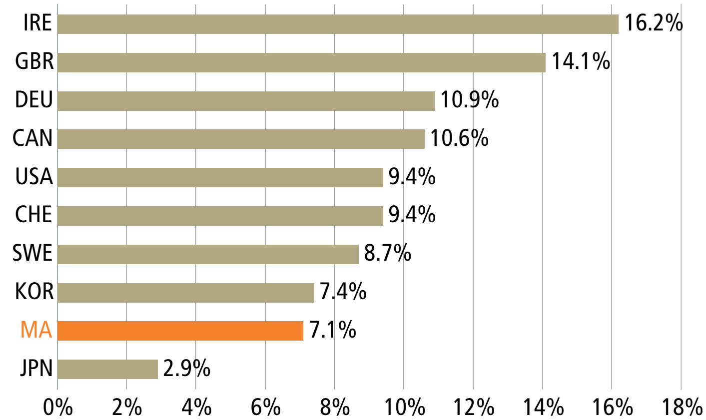


FIGURE 42:

Percent of tertiary graduates with a major in engineering, construction and manufacturing, 2003

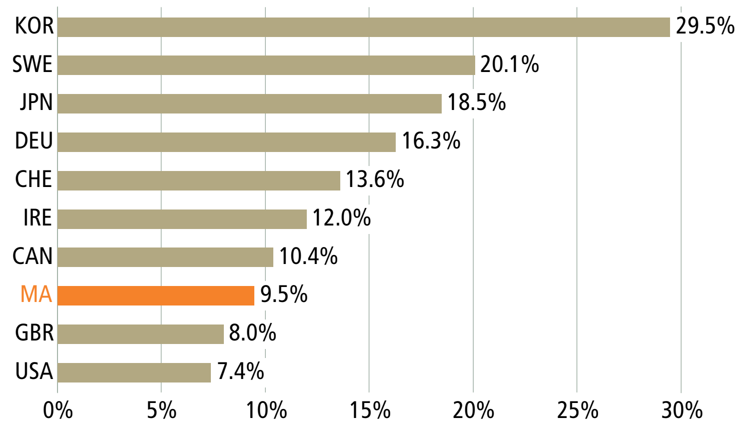
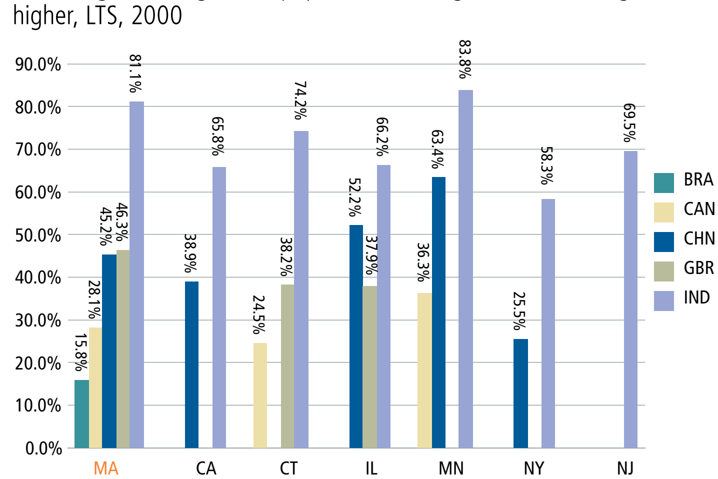


FIGURE 43

Percentage of foreign-born population holding a bachelor's degree or higher, LTS, 2000



** Data not available for all states

HUMAN CAPITAL & WORKFORCE READINESS

What it means for Massachusetts

The challenges to Massachusetts' leadership position in producing and centralizing talent

- **Massachusetts' K-12 system fails to foster necessary interest in science and mathematics.** Massachusetts retains its substantial lead among the LTS in persons over 25 years old with a bachelor's degree or higher and in engineering degrees awarded per 100,000 residents. The Commonwealth, however, trails all LTS except for Pennsylvania and Connecticut in the percentage of high school seniors planning to major in computer/information science or engineering and all LTS except Connecticut in percentage of high school seniors planning to major in health and allied services or biological sciences. Further, when the distribution of intended college majors of high school seniors in the Commonwealth is measured, only 1% indicate mathematics, 2% physical sciences, 4% biological sciences and 4% computer and information sciences. This compares to 26% in humanities and others and 15% in business and commerce. So, while the current percentages of the Massachusetts population with scientific and technological degrees may compare favorably to both the other LTS and international jurisdictions examined, the future supply of workers with competencies in mathematics, science and engineering is uncertain and poses a major workforce challenge for the Commonwealth as it seeks to sustain its position as a leading hub of innovation.

- **Rates of growth in tertiary enrollments and graduates in China, Brazil and India far exceed these same growth rates in both the US and Massachusetts.** The data make it very clear that the developing economies of BRIC nations have invested substantial funds in the development of new industrial clusters that compete directly with those at the core of the Massachusetts economy. Moreover, they have also underscored the critical importance of science, mathematics and engineering education at the highest levels to challenge the developed economies of Western Europe and the United States. It is not particularly useful to compare the raw numbers of the economies of emerging nations with Massachusetts, both because of the massive differences in population and concern about the validity of some of the reported data. Nevertheless, the trend lines and growth rates make the conclusion inescapable that these countries are challenging both the LTS and the United States as a whole in what have been fundamental strengths to the innovation ecosystem.

- **Massachusetts school age children must not only be better prepared for careers in science, engineering, and related disciplines, but skilled graduates in these disciplines must be retained.** There is increasing competition for talent and industry from the developing countries of Asia compounded by decreasing enrollments and graduates from tertiary level schools, particularly in scientific fields, in Massachusetts and the US. As a result, it is critical to not only improve the number of secondary school students who pursue scientific and technical disciplines in college, but also to take steps to retain more skilled foreign-born students after graduation from our institutions. Shortsighted policies when combined with growing economies and opportunities in their native countries could have a significant negative impact. Massachusetts risks the loss of some of the best and brightest talent to fuel our innovative companies, and in turn, risks encouraging those companies to look elsewhere for the skilled workers they demand.

III. Growth in Key Industry Clusters

The growth of the global Innovation Economy is driven by a complex system of knowledge creation, market and product development and commercialization, and various other production activities. A snapshot in time of any regional cluster reflects the integration of the product life cycle across the companies and other organizations that comprise the cluster. It also reflects the relative maturity of the markets served by products in the particular cluster. At the early stages of product life cycles, the ability to create knowledge, attract investment, and transform technology into products that address new market opportunities and create competitive advantages will drive cluster growth. In the latter stages of the product life cycle, as markets mature, the ability to penetrate new markets and achieve manufacturing efficiencies is a more important factor in the fostering of competitive advantage that drives ongoing company and cluster growth. As shown elsewhere in the *Index*, Massachusetts' competitive advantage has generally been shown to be at the earlier stages of product life cycles and during the development of new markets based on emerging technologies.

Using a variety of public sources and a proprietary database developed by the Monitor Group, the 2007 *Index* examines economic profiles and growth trends in regional clusters of innovation in order to gain insight into the Commonwealth's competitive place and the extent to which global innovation clusters are maturing or otherwise evolving.

Global Overview

Massachusetts can be compared with the countries profiled in the global analysis based on growth in GDP; GDP per capita; the relative proportion of GDP resulting from each major sector (agriculture, general industry and services); the distribution of the workforce across sectors; and the relative productivity ($GPD/# workforce) of each sector. Massachusetts would be grouped with Japan, Canada, Germany, Switzerland, and Great Britain as having low growth in GDP (<3%). However, it has higher GDP per capita than any of the countries profiled, suggesting that Massachusetts produces relatively high value products and services with relatively low labor input.

Like most of the non-BRIC countries, Massachusetts creates relatively little of its economic output from agriculture, and has a relatively small proportion of its workforce employed in the agricultural sector. However, the proportion of GDP derived from general industry and the proportion of the workforce employed by that sector is markedly different from most of the other non-BRIC countries profiled. Massachusetts has the lowest proportion of its GDP derived from the general industry sector and the highest proportion derived from services. Its productivity in the agricultural and services sectors is greater than any of the countries profiled, and its general industry productivity is exceeded only by Ireland. This positioning suggests that Massachusetts has unique competencies—and unique challenges—in maintaining its competitive position in the global economy.

Global Sector Analysis

A sector-by-sector analysis of key industry clusters using Monitor Group's global database and the *Index*'s analysis of the Leading Technology States shines light on emerging hubs of innovation and concurrent competitive pressures. The Monitor database is segmented into forty traded clusters that are defined using proprietary correlation algorithms. As such, this analysis is organized into groupings of clusters that are representative of important segments of the key industry clusters as traditionally defined by the *Index*.

The *Index* definition of key clusters can be approximated to comparable Monitor Group clusters:

- Postsecondary Education (*Index*)
  - Education & Knowledge Creation (Monitor Group)
- Financial Services (*Index*)
  - Financial Services (Monitor Group)
- Biopharmaceuticals, Medical Devices, & Hardware (*Index*)
  - Biopharmaceuticals (Monitor Group)
  - Medical Devices (Monitor Group)
- Defense Manufacturing & Instrumentation (*Index*)
  - Analytical Instrumentation (Monitor Group)

These mappings are approximations and do not represent direct equivalencies. Growth trends, however, can be sufficiently illustrative to indicate how Massachusetts clusters are positioned in the world economy and where there exists competitive strength.

Postsecondary Education—Overview

Postsecondary Education is one of the largest, and historically strongest, clusters tracked in the *Index*. This cluster attracts some of the "best and brightest" students from around world, and the research enterprise that is embedded in our leading academic institutions forms the basis for both the Commonwealth's workforce and technology pipelines. The Postsecondary Education key industry cluster has the highest domestic Location Quotient (LQ) among the LTS, indicative of its competitive strength. This cluster ranked fourth behind California, New York and Pennsylvania in overall employment and fourth behind North Carolina, Connecticut, and Illinois in employment growth between 2005 and 2006.

Education & Knowledge Creation—In Global Context

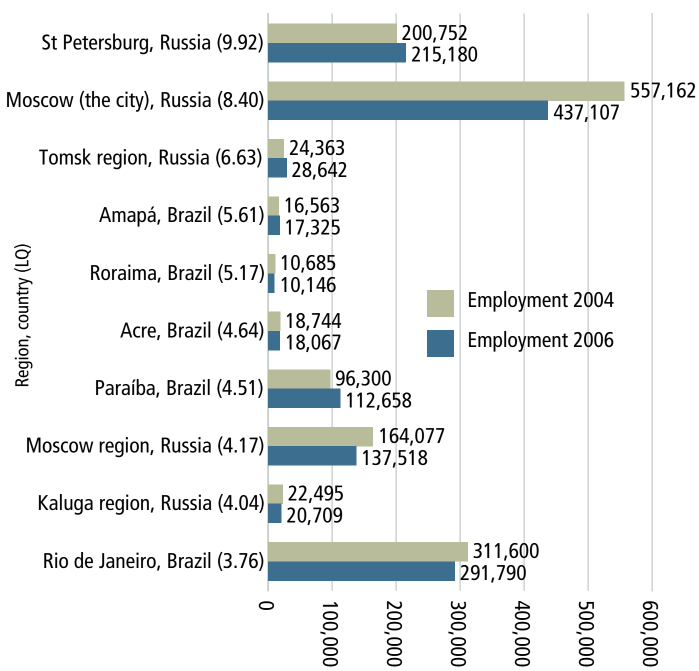
Among the top 20 Advanced Economy regions according to LQ, Massachusetts has the largest overall employment in the Education & Knowledge Creation cluster. Massachusetts employment growth ranked third behind Austria and the District of Columbia among those top ranked clusters with more than 50,000 employed.

The BRIC regions exhibit significant Education & Knowledge Creation clusters in the Russian Federation and Brazil, when ranked by LQ. The data also show that many of these regions have much larger employment than in comparable Advanced Economy regions. Eight of the top twenty BRIC regions employed more than 100,000 when compared to four of the top Advanced Economy regions. The data for Russian regions suggests an overall contraction of the Education & Knowledge Creation cluster in that country, particularly in and around the city of Moscow. Cluster employment in the top regions decreased by over 130,000 between 2004 and 2006. The regional clusters in Brazil show mixed growth trends, but overall have grown by approximately 10%. The largest regional cluster among the BRIC countries, Minas Gerais, Brazil, grew by an impressive 14.8% between 2004 and 2006 (see Figures 44 and 45).

Massachusetts' strong competitive position in the Education & Knowledge Creation cluster is encouraging on several fronts. The direct economic impact of the jobs created in this sector in Massachusetts is significant. Moreover, the sheer size and employment growth of this sector is indicative of the competitive strength of our research and educational enterprises as important drivers of our Innovation Economy. The lack of strong employment in India and China, combined with the contraction in Russia, create important competitive advantages for Massachusetts in the global competition for talent.

FIGURE 44: Education and knowledge creation in the BRIC countries

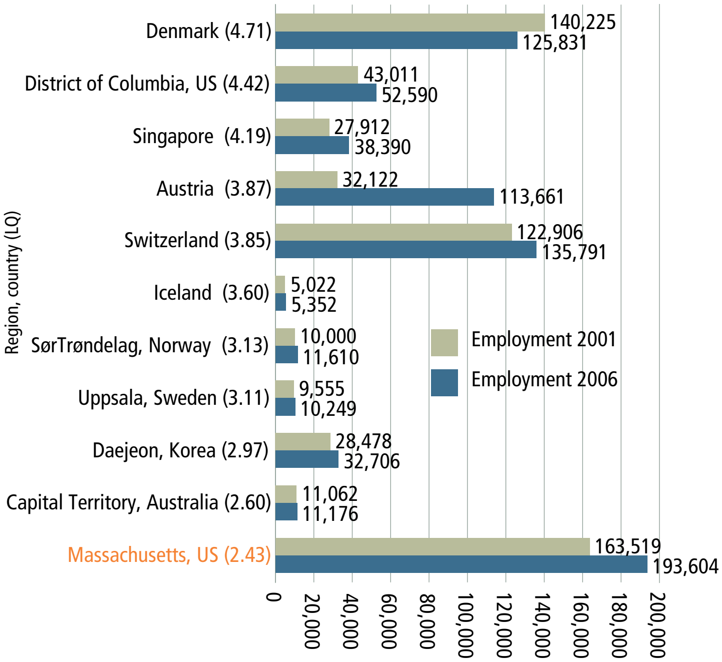
Top ten BRIC regions ranked by LQ, 2004 and 2006



Source: The Monitor Group, Global Cluster Mapping Initiative

FIGURE 45: Education and knowledge creation in the Advanced Economies

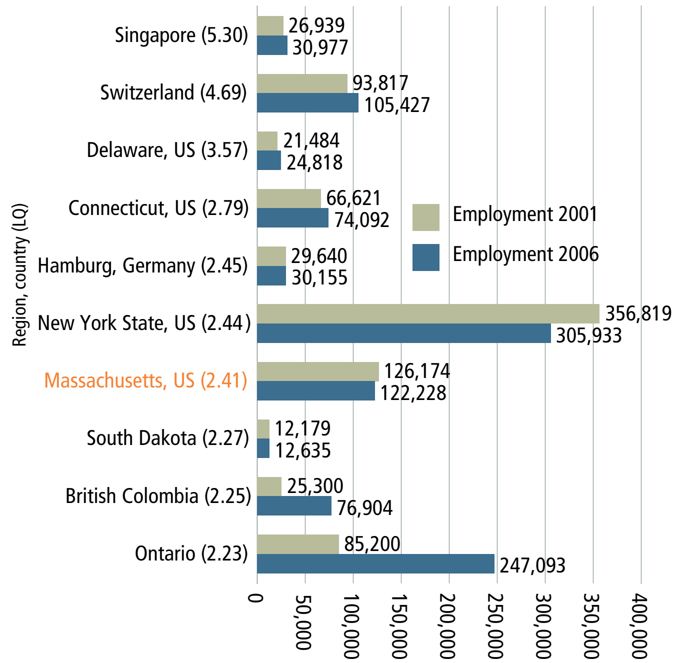
Top ten Advanced Economy regions ranked by LQ and Massachusetts, 2001 and 2006



Source: The Monitor Group, Global Cluster Mapping Initiative

FIGURE 46: Financial services in the Advanced Economies

Top ten Advanced Economy regions ranked by LQ, 2001 and 2006



Source: The Monitor Group, Global Cluster Mapping Initiative

Financial Services—Overview

Financial Services is the second largest Massachusetts key industry cluster tracked by the *Index*. It is the fifth largest such cluster among the LTS, and has the third highest concentration of employment (after Connecticut and New York) as measured by LQ. It includes one of the largest venture capital communities in the country and many of the institutional investors who finance the growth of the state's innovation economy. It ranked third among the LTS in employment growth between 2005 and 2006, after North Carolina and New York.

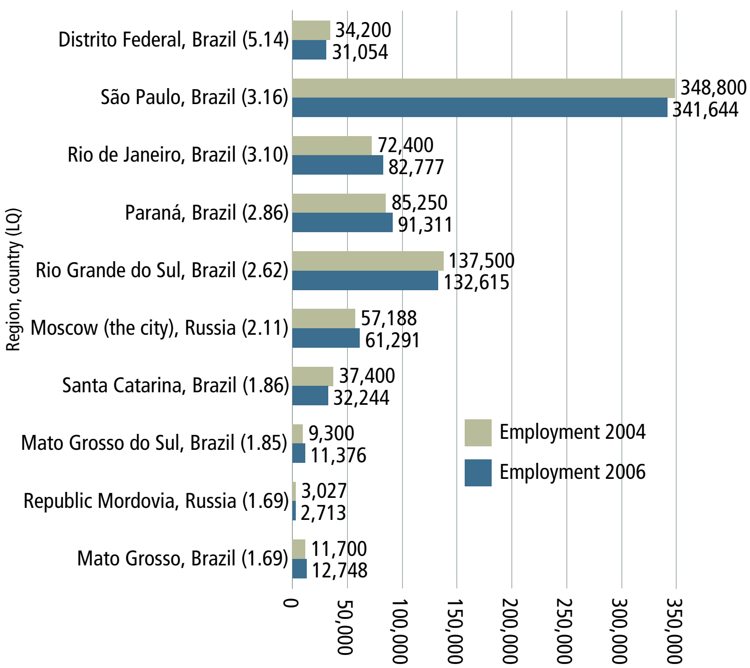
Financial Services—In Global Context

Data for the Advanced Economies indicate there is a transformation occurring in the global financial services industry. In 2001, Massachusetts ranked fourth among the top 20 clusters in total employment, after New York, Illinois, and Pennsylvania. Four of the ten US regions in the top 20 lost employment between 2001 and 2006, including Massachusetts. By 2006, Massachusetts had slipped to fifth overall, as Ontario and London grew by 190% and 37% respectively. Of the top 20 regions, only the LTS of New York and Illinois exhibited slower growth in employment in the cluster (see Figure 46).

Data for the BRIC countries show that the Financial Services clusters in these regions tend to be significantly smaller than their counterparts in the Advanced Economies. Seven of the top twenty Advanced Economy regions had cluster employment in excess of 100,000 in 2006. Only two of the BRIC regions—Rio de Janeiro and Rio Grand do Sul in Brazil—had employment in excess of 100,000. Ten of the top 20 BRIC regions lost employment in this cluster between 2004 and 2006 (see Figure 47).

FIGURE 47: Financial Services in the BRIC countries

Top ten BRIC regions ranked by LQ, 2004 and 2006



Source: The Monitor Group, Global Cluster Mapping Initiative

Acquisitions and consolidations have had a demonstrable negative impact on the employment growth of the Financial Services cluster in Massachusetts, particularly on the retail banking segment. The impact of the growth of Ontario and London as major financial centers in the Advanced Economies is unknown, particularly with respect to changes in the availability of investment capital to support new business formation and growth. However, data from the National Venture Capital Association (NVCA) suggest that total venture capital under management in the US has declined by approximately 7% between 2001 and 2006.

Biopharmaceuticals, Medical Devices, & Hardware—Overview

The production of biopharmaceuticals and medical devices represents one of the strongest growth opportunities for the Massachusetts Innovation Economy, and is considered to be an area where Massachusetts continues to enjoy a competitive edge in manufacturing. This key industry sector, however, experienced a 1.6% decline in employment in Massachusetts between 2002 and 2006. Moreover, the 2.2% growth experienced in this cluster in Massachusetts between 2005 and 2006 was exceeded by California (2.41%), Minnesota (4.47%), North Carolina (5.45%), and Virginia (2.93%) among the LTS.

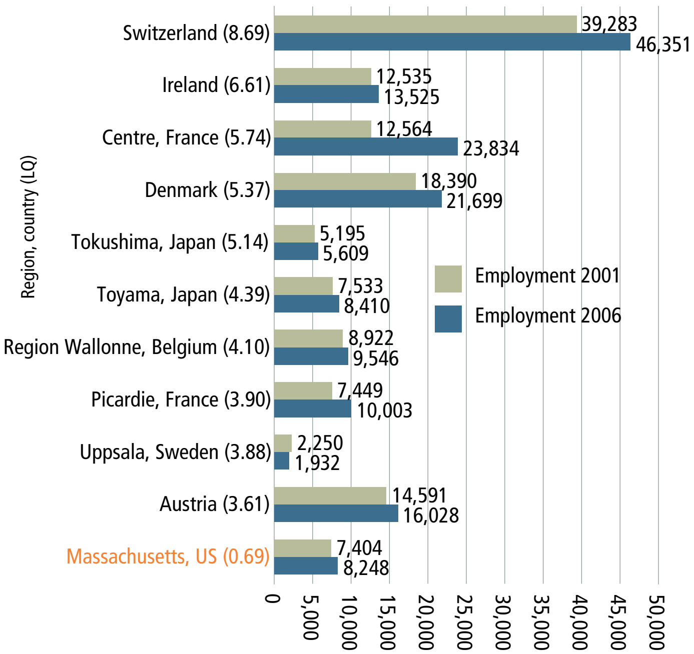
Biopharmaceuticals—In Global Context

The production of biopharmaceuticals in Massachusetts is still a nascent enterprise. In Massachusetts, this sector is focused almost exclusively on the production of biologicals, rather than small molecule drugs. Many of the biotechnology companies in Massachusetts are still at the developmental stage (from both a business and product standpoint). These businesses are only now developing to the point at which establishing manufacturing locations is a subject of interest. Using data from the *Index* indicators and the Monitor Group, Massachusetts present and near-term position and trends of growth may be assessed, illuminating how competitive Massachusetts has been in capturing the manufacturing output from life sciences R&D.

Figure 48 identifies the top ten Advanced Economy regions of the world for bio-pharmaceutical manufacturing, ranked by the Monitor Group according to LQ. As shown, none of the LTS have bio-pharmaceutical clusters that rank in the top ten globally by this measure, reflecting the relatively diverse economies of most of the LTS. In fact, the concentration of employment in the biopharmaceutical industry in the Advanced Economies appears to be approximately twice that in the United States overall. Based on these data and the *Index* analysis of the LTS, only Connecticut, New Jersey, and North Carolina would have a global LQ greater than 1.0, and all would rank considerably below the top 20 Advanced Economy regions identified by Monitor data. This suggests that the US as a whole faces competitiveness issues in the global biopharmaceutical cluster. Key competitors among the Advanced Economies include Germany (89,663), France (53,671), and Switzerland (46,351), all of which have much higher employment in this cluster than does Massachusetts. Growth in employment in the top ranked German (12.09%) and Swiss (17.99%) clusters is slightly higher than in Massachusetts, but growth in France (43.34%) is significantly higher (see Figure 48).

FIGURE 48: Biopharmaceuticals in the Advanced Economies

Top ten Advanced Economy regions ranked by LQ and Massachusetts, 2001 and 2006

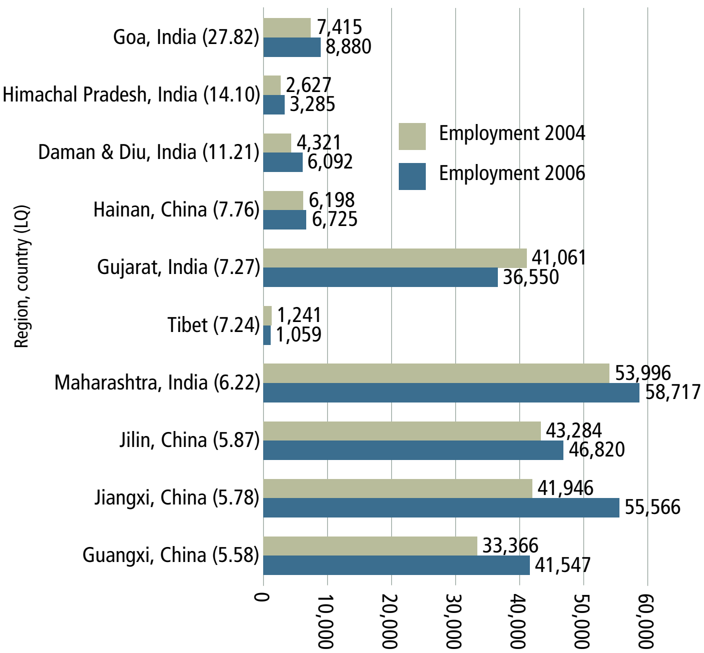


Source: The Monitor Group, Global Cluster Mapping Initiative

Data on regions within the BRIC countries show that there are important bio-pharmaceutical clusters in the emerging economies. Large biopharmaceutical clusters are developing in India and China. Both their size and rate of growth outstrips those of comparable regions in the Advanced Economies. Both countries represent major domestic markets for biopharmaceuticals and have less restrictive regulatory environments the developed Innovation Economies of the US and Europe (see Figure 49).

FIGURE 49: Biopharmaceuticals in the BRIC countries

Top ten BRIC regions ranked by LQ, 2004 and 2006



Source: The Monitor Group, Global Cluster Mapping Initiative

Growth for this cluster in Massachusetts will continue to depend on the extent to which the state's companies move new biological products through the regulatory and adoption pipelines. Traditional drug manufacturing is a mature industry and moving in the direction of lower-cost global regions and regions with more favorable regulatory climates.

Medical Devices—In Global Context

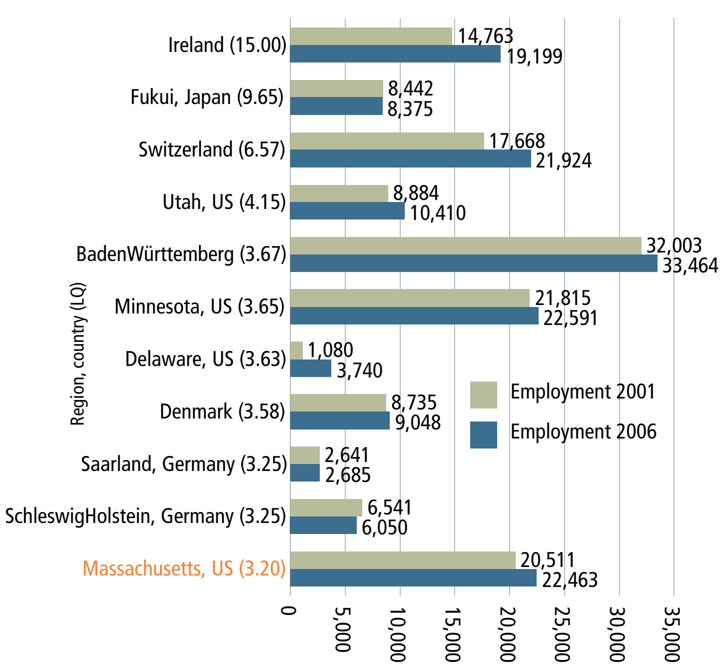
The Medical Device industry in Massachusetts has historically been among the top-ranking Medical Device clusters in the US based on total employment. Yet employment in this cluster in the US has remained relatively flat for almost thirty years, suggesting that this is a mature industry where advances in productivity and technology have kept pace with expanding markets. Massachusetts continues to enjoy a strong competitive position in this global market.

Nine states in the US, including Massachusetts, rank among the top twenty regions among the Advanced Economies, based on LQ (see Figure 50 and Appendix B). The US as a whole has an LQ approximately 20% higher than that for the Advanced Economies, suggesting a relatively strong competitive position. According to Monitor Group research, Massachusetts appears to be well-positioned both nationally and globally in the Medical Devices industry. Clusters in Germany, Switzerland, and Ireland are key global competitors, based on employment, and generally have a higher LQ, indicating stronger regional competitiveness. The medical device clusters in Switzerland and Ireland are growing at a significantly higher rate than in Massachusetts.

An analysis of comparable data for Medical Device clusters in the BRIC countries suggest Massachusetts remains well-positioned relative to these emerging competitors. Only a cluster concentration in Shanghai shows comparable employment levels, and that declined by 35% between 2004 and 2006. In fact, employment among the top Chinese medical device clusters as a whole lost employment between 2004 and 2006. The top ranked clusters in India, on the other hand, grew by an aggregate 25% during that period, but are still much smaller than the cluster in Massachusetts. The Sverdlov region of Russia appears to be growing rapidly and is the third largest medical device cluster among the leading BRIC regions (see Figure 51).

FIGURE 50: Medical Devices in the Advanced Economies

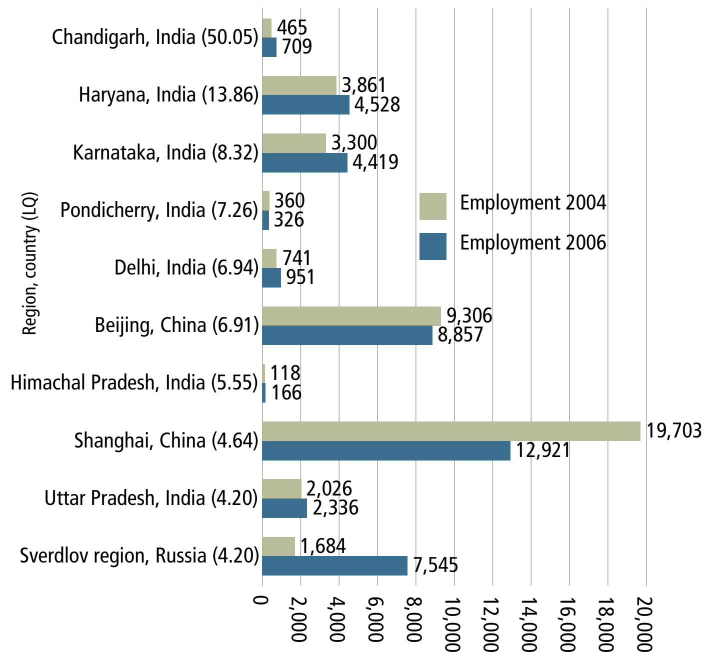
Top ten Advanced Economy regions ranked by LQ and Massachusetts, 2001 and 2006



Source: The Monitor Group, Global Cluster Mapping Initiative

FIGURE 51: Medical Devices in the BRIC Countries

Top ten BRIC regions ranked by LQ, 2004 and 2006



Source: The Monitor Group, Global Cluster Mapping Initiative

Defense Manufacturing & Instrumentation—Overview

The Defense Manufacturing & Instrumentation key industry cluster, as defined in the *Index* has seen flat to declining growth in employment for most of the past ten years, at both the national level and in Massachusetts. Eight of the LTS, including Massachusetts, experienced a decline in employment in this cluster between 2002 and 2006. More recently, the sector has stabilized and all but two states saw increases in employment between 2004 and 2006. Employment concentrations have shifted significantly. In 1983, this sector employed 1.8% of the workforce. In 2006, only 0.88% of the workforce was employed in this sector. In 1983, 71% of US employment in this sector was found in the LTS compared to only 56% in 2006. In 1983, 23% of the LTS employment in this sector was concentrated in Massachusetts, compared to only 19% in 2006.

Analytical Instruments—Overview

This cluster reached its peak employment in the US in 1979, and has declined by 40% since. Recent trends show a decline in the number of large establishments/companies at both the state and national level. These trends suggest that Analytical Instruments is a maturing cluster where the impact on employment of increased productivity and advanced technology has more than offset expansions in markets. Prospects for growth in the analytical instruments cluster in Massachusetts will depend in large part on the extent to which emerging fields, such as nanotechnology, can expand viable markets for this cluster and the extent to which Massachusetts companies can establish competitive advantage from these developments.

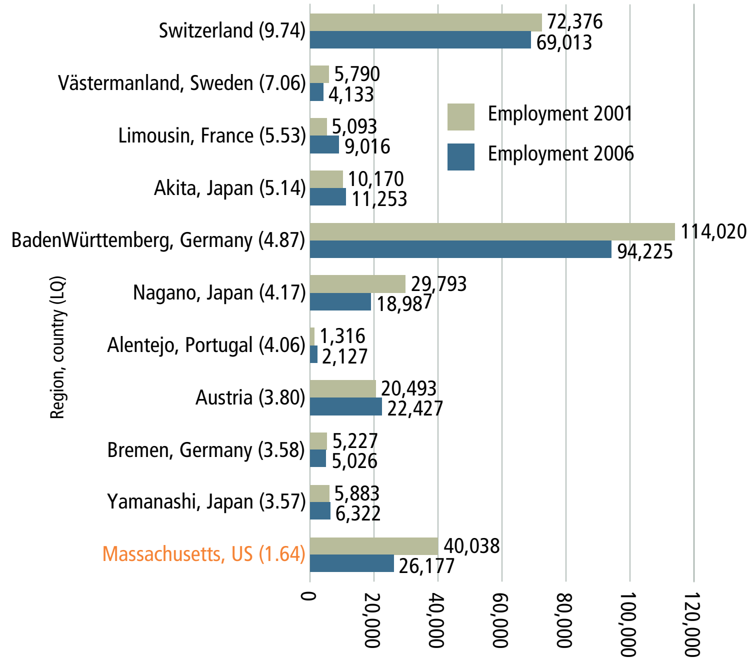
Analytical Instruments—In Global Context

Analytical Instruments has historically been an important component of this key industry cluster and, as defined by the Monitor Group, overlaps other clusters (e.g. Medical Devices) as well. California and Massachusetts have dominated this cluster in the US, consistently ranking number one and two respectively in terms of cluster employment. Between 2001 and 2006, employment in this sector declined by approximately 13% nationally, and by 16% in the LTS. Of the 14 states with employment in excess of 10,000, ten experienced declines in employment in this sector during that period. Of those ten states, only Washington (-65%) exceeded Massachusetts (-34%) employment loss.

The Monitor Group's findings for the top ranked regional clusters show similar patterns. Ten of the top twenty regions experienced a decline in employment between 2001 and 2006, and total employment among the top 20 regions (excluding Massachusetts) declined by 5%. Six of the ten regions with greater than 10,000 employment experienced declines. However, only Nagano (Japan) experienced a greater loss in employment than Massachusetts. The largest competitor countries in 2006 among the top ten regions are Germany (214,846), Switzerland (69,013) and Japan (66,953). The cluster employment in each of those countries declined. The French analytical instruments cluster exhibited the largest overall growth in employment (7,569) among the top 20 regions (see Figure 52).

FIGURE 52: Analytical Instruments in the Advanced Economies

Top ten BRIC regions ranked by LQ, 2004 and 2006



Source: The Monitor Group, Global Cluster Mapping Initiative

GROWTH IN KEY INDUSTRY CLUSTERS

What it means for Massachusetts

The impact of increased global competition for firms, business activity, and cluster employment

- **By measures of productivity and output, Massachusetts is in a class by itself.** The Commonwealth has the highest GDP per capita and some of the highest levels of productivity when compared to all regions and countries examined. It also has one of the lowest economic growth rates (only Japan is lower). Massachusetts is the most specialized service economy of all of the geographies examined.
- **Massachusetts advantage and specialization in employment in the knowledge creation and education cluster are reconfirmed when viewed with a global lens.** Massachusetts boasts one of the largest knowledge creation clusters in the Advanced Economies and it is growing at a relatively steady rate. This pays dividends far beyond direct employment and is a key strategic tool in the battle for global talent. By this measure, the BRIC countries do not compare as their institutions and educational infrastructure simply are not as well developed. Nor do India and China have any significant employment concentration in the clusters, and Russia's performance in the cluster is on the decline. Brazil has significant education clusters, but they appear to be in a state of flux.
- Other key cluster findings:
  - **Financial Services:** Acquisitions and consolidations have taken a toll on employment in Massachusetts, New York, and other major US cities and regions. Concurrently, Toronto and London are expanding rapidly as world financial centers. Beyond employment impact, this has significant potential impact on the availability of investment capital to spur new company formation and cluster growth. In a troubling trend, there has been a 7% decline in total venture capital under management in the US since 2001. There are not significant Financial Services clusters seen in the BRIC countries.
  - **Biopharmaceuticals:** Despite being the primary R&D engine for the world in biopharmaceuticals, the US is losing many production plants and jobs to other locations. The US as a whole appears to be at a competitive disadvantage compared to the rest of the world from the standpoint of employment growth in the drug industry, and it is not obvious yet whether the biopharmaceutical industry will operate under a different set of dynamics. The growth in China and to a lesser extent India show that the industry is adding jobs where markets are large and costs (and regulation) are low.
  - **Medical Devices:** This cluster remains an important and stable industry in Massachusetts and in the US, but there are signs that new players, such as Ireland, can and are vigorously entering the market. The BRIC countries have not made any strong inroads here except for the Sverdlov region of the Russian Federation.
  - **Analytical Instruments:** This is a mature cluster in decline, in both the US and globally. Technology and productivity improvements have far outstripped market demands as a driver of employment growth in the cluster.

IV. Trade & Immigrant Links

Moving beyond the individual performance of global economies, to linkages among Innovation Economies is extremely valuable, both in understanding relative competitive positions and also ascertaining potential opportunities and competitive challenges. Two useful means of understanding these linkages are export flows in manufactured commodities from US Innovation Economies to other global centers of innovation and the movement of immigrant populations among these global hubs. These cross-country linkages are analyzed below.

To gain insights into how well Massachusetts is tapping emerging or established export markets, this analysis probes growth in cross-border trade using a sample of business and industrial activities. Massachusetts total exports and average growth in exports of standardized commodity sets is mapped to the average growth in import market size of other innovation hubs. This provides an assessment as to how the Commonwealth is exploiting (or neglecting) trade opportunities and markets. The following product categories and definitions are used as the basis for comparison:[24]

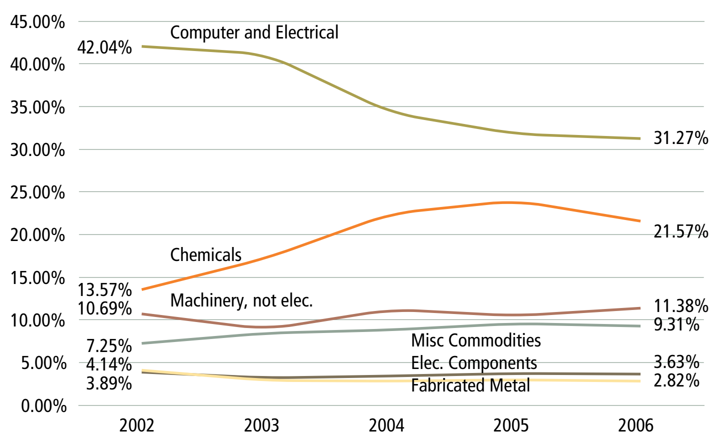
- **Chemicals:** Organic and inorganic raw materials that can be transformed by a chemical process to formulate products, including pharmaceuticals.
- **Computer and Electronics Products:** Computers, computer peripherals, communications equipment, and similar electronic products.
- **Electrical Equipment, Appliances, and Components:** Products that generate, distribute and use electrical power.
- **Fabricated Metal Products:** Intermediate or end products made of metal, other than machinery, computers and electronics, and metal furniture or treating metals and metal formed products fabricated elsewhere.
- **Machinery (excluding electrical):** End products that apply mechanical force, (e.g. the application of gears and levers) to perform work.
- **Miscellaneous Manufactured Commodities:** A wide range of products that cannot otherwise be classified in specific NAICS[25] subsectors in manufacturing. Establishments in this sector manufacture products as diverse as medical equipment and supplies, jewelry, sporting goods, toys, and office supplies.

Global Overview

Massachusetts' historical specialization in IT hardware, analytical instruments, defense industries, and other sectors has led to a relatively high-level of integration in global markets via exports. Total exports from Massachusetts in all product categories equaled $22 billion (US$) in 2005. This represents 12.7% of all US exports, five times what might be expected based on either population or gross domestic product (GDP). Most recently, Massachusetts' distribution of exports has been dominated by computer and electrical components with 31% of total exports and chemicals with 22% of total exports. Although the computer and electrical components export sector remains the largest, the percentage of total exports derived from this cluster has declined more than 10% in the last five years. Conversely, exports in the chemicals cluster, which includes both basic chemicals (such as industrial resins and raw materials) as well as materials used in medicine and pharmaceuticals manufacturing, has grown an additional 8% of total exports in 2006 (see Figure 53).

FIGURE 53:

Computer & Electrical Components and Chemicals are the plurality of Massachusetts exports



Source: The John Adams Innovation Institute
(Data source(s): WISER Trade database)

a) Spotlight: Asia-Pacific

The rapid economic growth in parts of Asia is well-documented, with an overall regional economic growth of rate 8% expected in 2007 and with rates of employment and other outputs of innovation driven business activities rising significantly.[26] This growth not only creates market competition for US firms, but also increases the demand for raw materials, finished goods, and even services from established Innovation Economies in Europe and North America, thereby affording opportunities to build commerce between established and emerging developed economies.

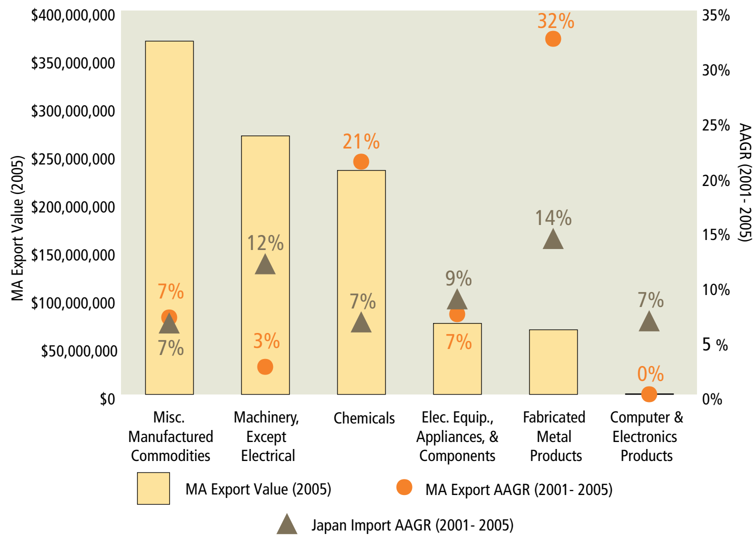
JAPAN (JPN)

Massachusetts' Trade Links to Japan's Innovation Economy

Exports to Japan totaled $1.9 billion (US$) in 2005, making Japan the Commonwealth's fourth largest export partner. Massachusetts' leading export category to Japan was miscellaneous manufactured commodities, encompassing a variety of finished goods, with a value of $367 million (US$). Massachusetts' fastest growing export categories from 2001-2005 were fabricated metal products and chemicals, growing on average 32% and 21% per year, respectively. Massachusetts exported $67 million (US$) worth of product in the fabricated metal products category in 2005, which is also Japan's fastest growing import category, growing more than 14% per year since 2001. Massachusetts exported $233 million (US$) worth of chemicals and related products to Japan in 2005, including raw organic compounds and pharmaceuticals. This too represents one of Japan's fastest growing import sectors, growing at 6% annually. Massachusetts performance was flat or negative, however, in the machinery and computer and electronic products export category, where Japan demonstrated an expanding demand for these product categories with double-digit growth from 2001-2005 (see Figure 54).

FIGURE 54:

JPN import market and Massachusetts' exports by product category, total value (2005) and AAGRs (2001–2005)



Source: The John Adams Innovation Institute
Data source(s): WISER Trade database, International Trade Centre UNCTAD/WTO)

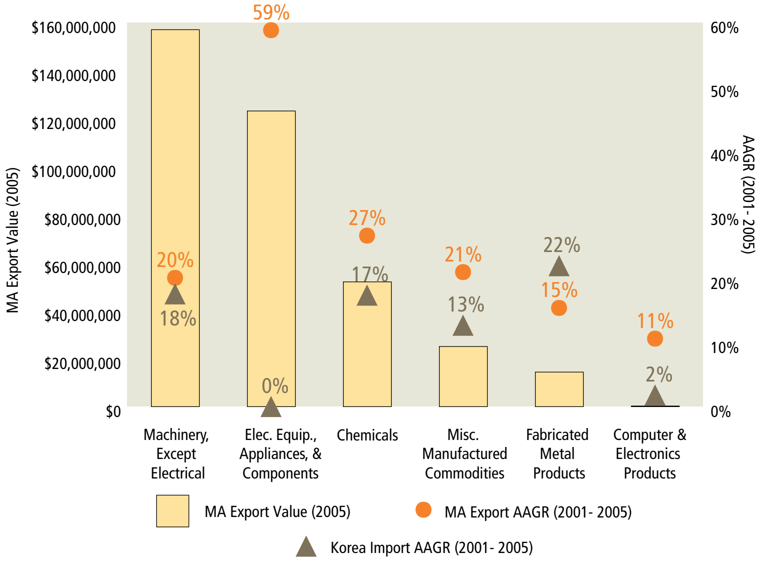
SOUTH KOREA (KOR)

Massachusetts' Trade Links to South Korea's Innovation Economy

South Korea is an important, rapidly expanding export market for Massachusetts goods. The country ranked ninth in total exports at $794 million (US$) in 2005 and the Commonwealth's average growth across all export categories well into the double digits. Machinery is the export category of highest value, accounting for $157 million (US$) in 2005, and growing at more than 20% per year. The electrical equipment and appliances (57%) and chemicals (27%) sectors were the fastest growing product categories from 2001-2005 (see Figure 55).

FIGURE 55:

KOR import market and Massachusetts' exports by product category, total value (2005) and AAGRs (2001–2005)



[NOTE: South Korea's Import AAGR was negative for 2001-2005]
Source: The John Adams Innovation Institute
(Data source(s): WISER Trade database, International Trade Centre UNCTAD/WTO)

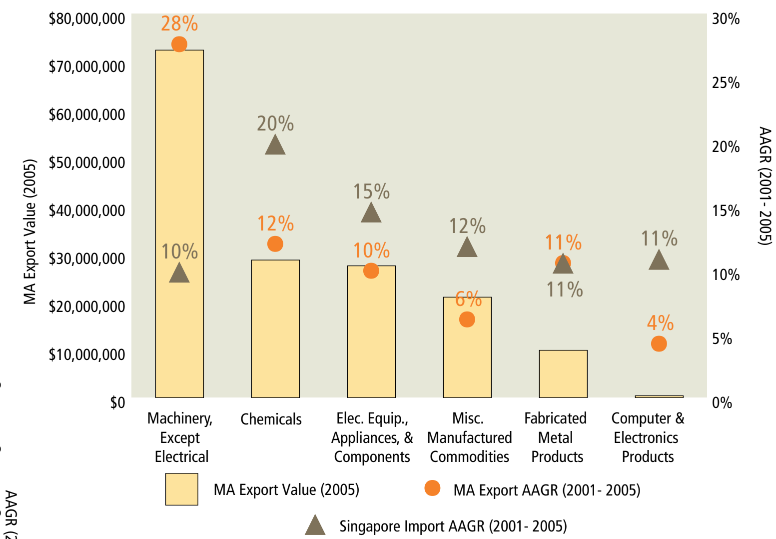
SINGAPORE (SGP)

Massachusetts' Trade Links to Singapore's Innovation Economy

At $529 million (US$), Singapore ranked twelfth in total exports from Massachusetts in 2005. Massachusetts exported $72 million (US$) worth of goods in the machinery sector to Singapore, as the city-state's demand for these products grew an average 10% per year from 2001-2005. Yet as witnessed in Japan's import markets, Singapore's import demand growth for computer and electronic products exceeds 10% per year, Massachusetts exports just $310K (US$) worth of goods coupled with a low rate of growth in this segment—indicating Massachusetts is not well suited or positioned to serve Singapore's expanding market (see Figure 56).

FIGURE 56:

SGP import market and Massachusetts' exports by product category, total value (2005) and AAGRs (2001–2005)



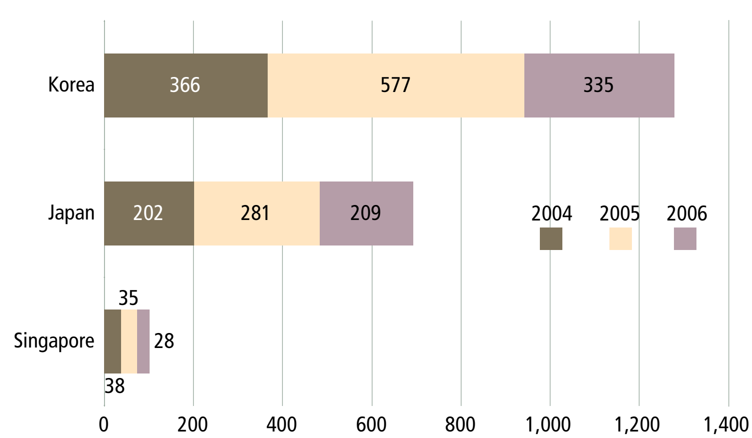
Source: The John Adams Innovation Institute
(Data source(s): WISER Trade database, International Trade Centre UNCTAD/WTO)

Immigrant Links to the Asia-Pacific Region

From 2004 through 2006, Massachusetts attracted more than 1,200 people from South Korea, by far the largest immigrant class from the Asia-Pacific (see Figure 57).

FIGURE 57:

Immigration to MA from Asia-Pacific countries, 2004-2006



Source: The John Adams Innovation Institute
(Data source(s): US Department of Homeland Security)

b) Spotlight: Brazil, Russian Federation, India, China (BRIC)

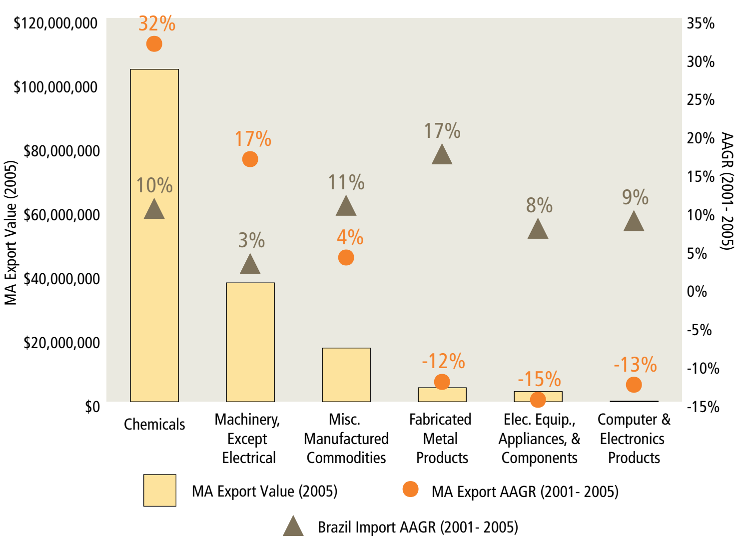
BRAZIL (BRA)

Massachusetts' Trade Links to Brazil's Innovation Economy

Exports to Brazil totaled $283 million (US$) in 2005. Massachusetts leading export to Brazil by category, in terms of both total value and AAGR, is chemicals, equaling more than $104 million (US$) in 2005, and growing an average of 32% per year. Conversely, while Brazil's demand for the fabricated metal products and miscellaneous commodities categories is well into the double-digits, Massachusetts participation in these markets is flat to negative from 2001-2005. In a similar fashion to other rapidly developing economies, Brazil's demand for IT products is growing at nearly 10% per year. Massachusetts' export growth in these sectors, however, is in decline at a rate of more than 10% per year (see Figure 58).

FIGURE 58:

BRA import market and Massachusetts' exports by product category, total value (2005) and AAGRs (2001–2005)



Source: The John Adams Innovation Institute
(Data source(s): WISER Trade database, International Trade Centre UNCTAD/WTO)

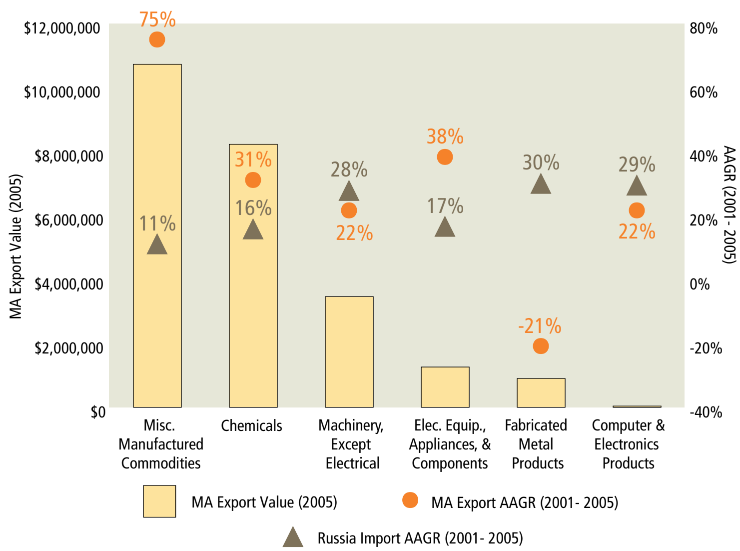
RUSSIAN FEDERATION (RUS)

Massachusetts' Trade Links to the Russian Federation's Innovation Economy

In a relative sense, there is little commerce between the Innovation Economies of Massachusetts and the Russian Federation as the Commonwealth's total exports across all product categories amounted to just $65 million (US$) in 2005, and only $25 million (US$) in the six categories under consideration. That said, Massachusetts accounted for 13.3% of total US exports to the Russian Federation. Although limited in size, there is impressive growth in exports from Massachusetts in product categories that have a minimum value of $5 million (US$), including miscellaneous commodities and chemicals. As is consistent with other Innovation Economies, the demand for Massachusetts exports in chemicals is significant, growing on average 31% per year since 2001, serving an import demand in the Russian Federation of nearly 16% (see Figure 59).

FIGURE 59:

RUS import market and Massachusetts' exports by product category, total value (2005) and AAGRs (2001–2005)



Source: The John Adams Innovation Institute
(Data source(s): WISER Trade database, International Trade Centre UNCTAD/WTO)

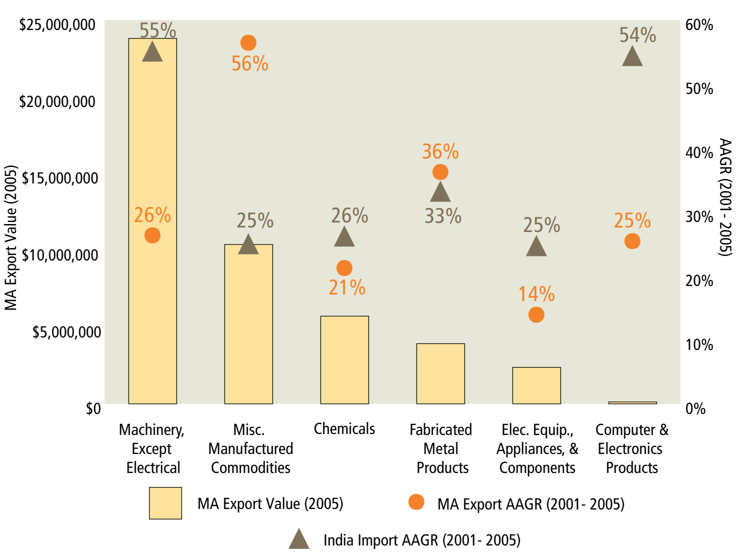
INDIA (IND)

Massachusetts' Trade Links to India's Innovation Economy

India is a rapidly growing trading partner for Massachusetts. Total exports reached $205 million in 2005, up from $86 million in 2001. According to the most recent data, machinery and commodities represented the largest export markets for Massachusetts in India, accounting for $24 million (US$) and $10 million (US$) respectively. Rates of export growth in these key sectors are also impressive, as the average rate of export growth in machinery is approximately 26% and in commodities it exceeds 56%. As is true with many of its Asian counterparts, India's demand for IT hardware and products is extraordinary growing more than 50% per year since 2001. Massachusetts has little penetration into this burgeoning market with few exports and limited growth. The chemicals sector, while a consistent high-performer for Massachusetts across categories and globally, accounted for a modest $6 million (US$) worth of exports to India in 2005 (see Figure 60).

FIGURE 60:

IND import market and Massachusetts' exports by product category, total value (2005) and AAGRs (2001–2005)



Source: The John Adams Innovation Institute
(Data source(s): WISER Trade database, International Trade Centre UNCTAD/WTO)

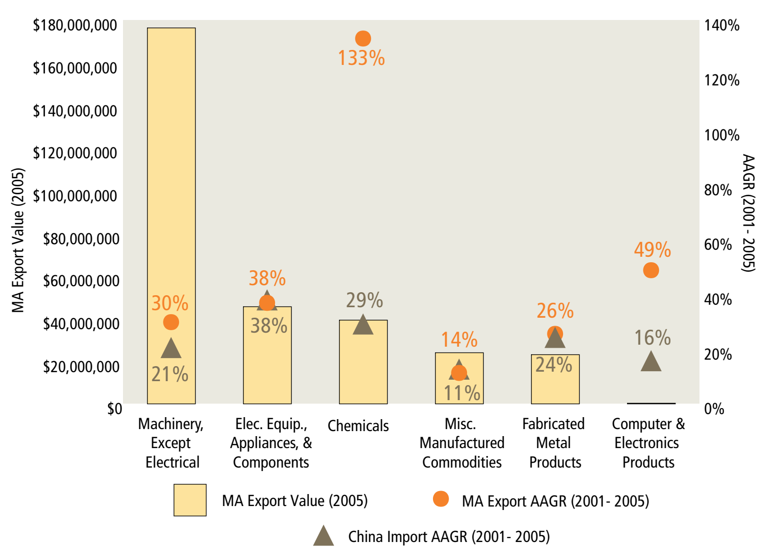
CHINA (CHN)

Massachusetts' Trade Links to China's Innovation Economy

As the most rapidly expanding economy in the last decade, China's demand and markets are coveted for a variety of sectors and industries, especially those Innovation Economies that can satisfy China's booming demand for IT products and services and raw materials. In 2005, the total dollar value of Massachusetts exports to China was more than $880 million in total and with the machinery sector in the lead at more than $176 million. Moreover, Massachusetts exports in this sector are growing an average of 30% since 2001. Chemicals also represent a significant growth opportunity for Massachusetts firms, with China's imports growing at 29% per year and Massachusetts exporting $39 million worth of chemical products in the sector in 2005. Duplicating trends seen in other economies, China's demand for products in the IT sectors exceeds 15% per year, but Massachusetts exported less than $400k in the sector in 2005 (see Figure 61).

FIGURE 61:

CHN import market and Massachusetts' exports by product category, total value (2005) and AAGRs (2001–2005)



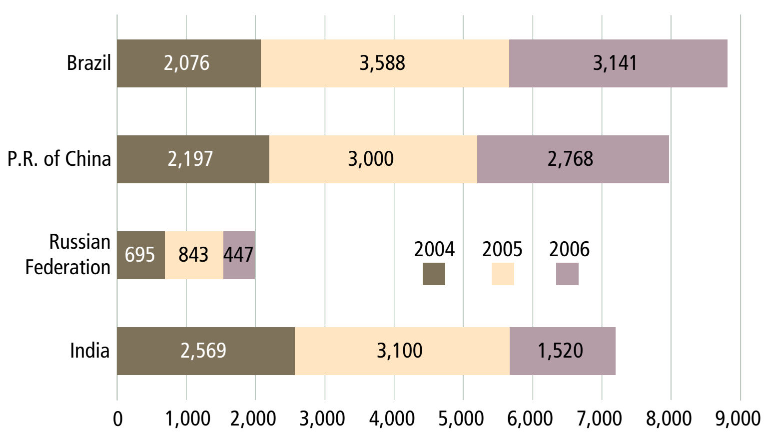
Source: The John Adams Innovation Institute
(Data source(s): WISER Trade database, International Trade Centre UNCTAD/WTO)

Massachusetts' Immigrant Links to the BRIC countries

The BRIC nations accounted for more than 25,000 immigrants to Massachusetts between 2004 and 2006, the highest total of any other grouping. Levels of immigration traced to Brazil exceed those of all other BRIC nations with nearly 9,000 newly arrived in Massachusetts since 2004. Immigration from China is also consistently high, with more than 2,700 Chinese immigrants arriving in 2006, and almost 8,000 total arriving since 2004. Russia accounts for a relatively small proportion of Massachusetts immigrants. India, whose immigrant totals were comparable to both Brazil and China in 2004 and 2005, has seen the number of its immigrants to Massachusetts decline by more than one-half in 2006 compared to 2005 (see Figure 62).

FIGURE 62:

Immigration to Massachusetts from BRIC countries, 2004–2006



Source: The John Adams Innovation Institute
(Data source(s): US Department of Homeland Security)

c) Spotlight: North America

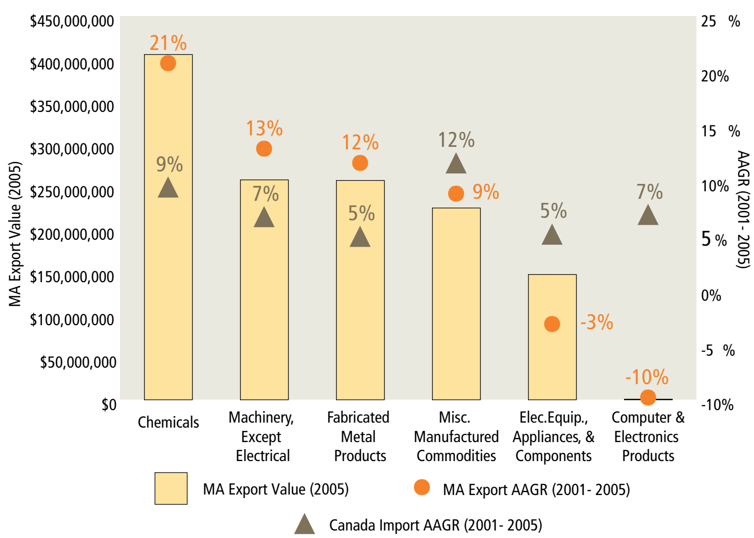
CANADA (CAN)

Massachusetts' Trade Links to Canada's Innovation Economy

Canada is the largest trading partner of the United States; it is also the largest market for Massachusetts exports, approaching $3 billion (US$) in total trade in 2005. The chemicals category represents the largest export sector, accounting for more than $400 million (US$) in exports in 2005, with an average annual rate of growth of 21% since 2001. Chemicals also posts the second best rate of growth among Canada's largest import sectors at nearly 10%. Canada's greatest demand as indicated by its import growth is represented in the miscellaneous manufactured commodities sectors which are growing at 12% per year. Massachusetts is responding with exports in the sector growing at approximately 9% per year (see Figure 63).

FIGURE 63:

CAN import market and Massachusetts' exports by product category, total value (2005) and AAGRs (2001–2005)



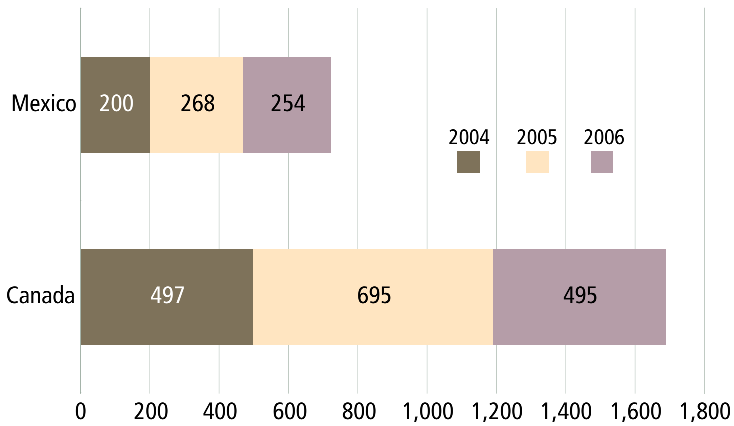
Source: The John Adams Innovation Institute
(Data source(s): WISER Trade database, International Trade Centre UNCTAD/WTO)

Immigrant Links to North American Countries

Canadian immigration accounted for 1,700 people from 2004-2006, quite small in comparison to immigration from the BRIC and many European countries as well. Massachusetts' immigration from Mexico totaled only 700 people during the three-year span.

FIGURE 64:

Immigration to Massachusetts from North American countries, 2004-2006



Source: The John Adams Innovation Institute
(Data source(s): US Department of Homeland Security)

d) Spotlight: Western Europe

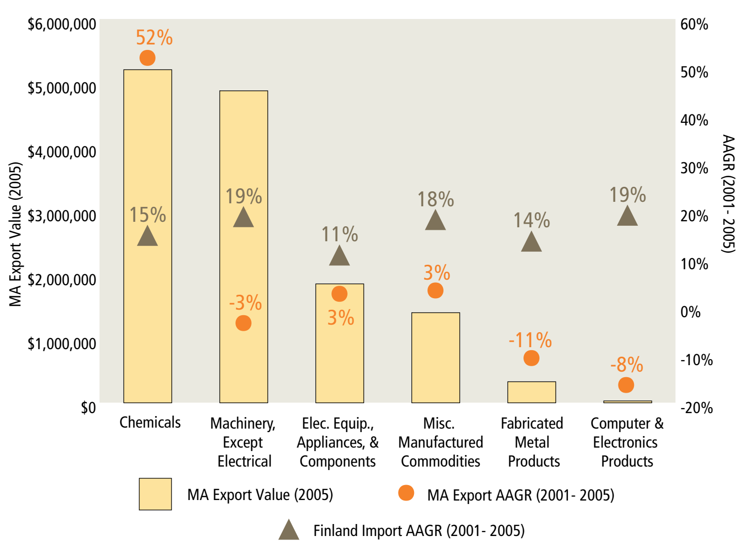
FINLAND (FIN)

Massachusetts' Trade Links to Finland's Innovation Economy

Massachusetts exports to Finland totaled approximately $56 million (US$) in 2005. But the Commonwealth's trade relationship with Finland is somewhat limited, with the largest export sector accounting for approximately $5 million (US$) in products in 2005. This largest export sector is chemicals and leads in growth among Massachusetts export categories growing at an average rate of 52% per year. Finland's total imports in chemicals from all other regions are growing at 15% per year since 2001. Finland also posts impressive growth in the machinery sector with 19% growth in total imports since 2001. Massachusetts growth in this sector is negative. Fabricated metal products and computer and electronic products also demonstrate double digit import growth since 2001, yet Massachusetts growth in exports in these sectors is in the red by more than 10% on both accounts (see Figure 65).

FIGURE 65:

FIN import market and Massachusetts' exports by product category, total value (2005) and AAGRs (2001–2005)



Source: The John Adams Innovation Institute
(Data source(s): WISER Trade database, International Trade Centre UNCTAD/WTO)

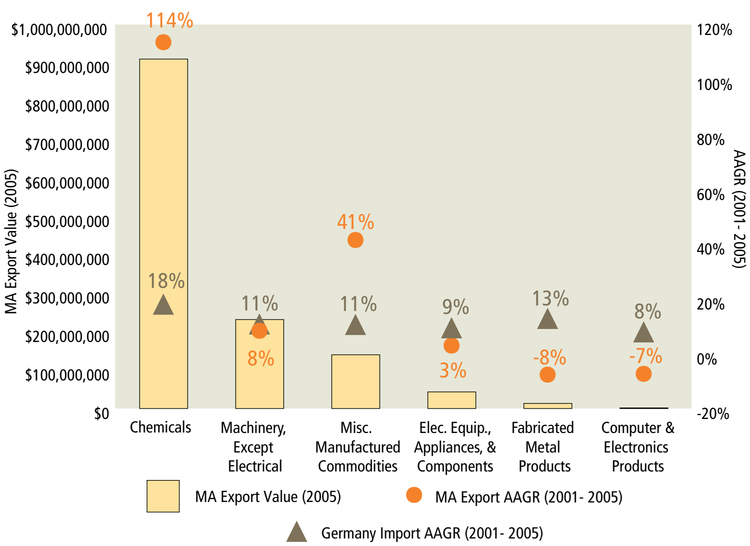
GERMANY (DEU)

Massachusetts' Trade Links to Germany's Innovation Economy

Germany is Massachusetts' third largest trading partner, with total exports of $2.1 billion (US$) in 2005. In Germany, as seen in most other hubs of innovation, demand for Massachusetts exports in chemicals consistently leads all other product categories in both total value (more than $900 million) and a growth rate that has more than doubled since 2001. Both Massachusetts exports and Germany's demand for product in the machinery and miscellaneous commodities sectors are on pace. Germany's demand is growing at more than 10% per year and Massachusetts exporting more than $300 million worth of machinery and miscellaneous products (see Figure 66).

FIGURE 66:

DEU import market and Massachusetts' exports by product category, total value (2005) and AAGRs (2001–2005)



Source: The John Adams Innovation Institute
(Data source(s): WISER Trade database, International Trade Centre UNCTAD/WTO)

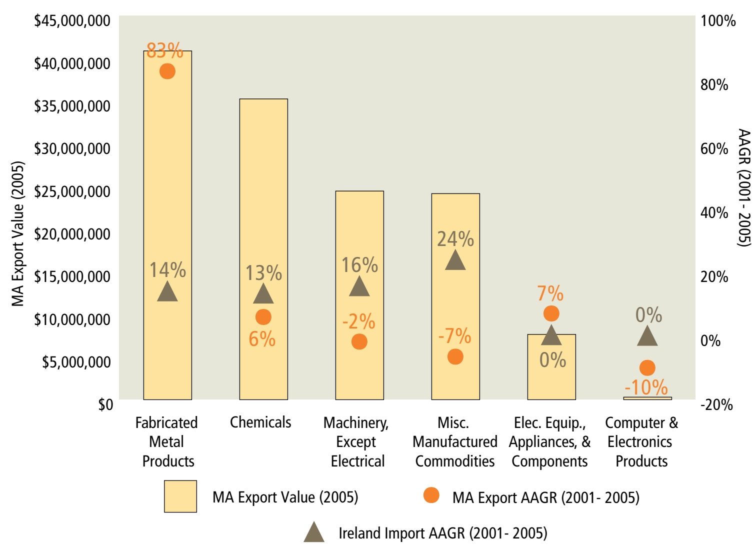
IRELAND (IRL)

Massachusetts' Trade Links to Ireland's Innovation Economy

Massachusetts' trade interaction with the Innovation Economy of Ireland is significant, amounting to approximately $450 million (US$) in exports across all product categories in 2005. Fabricated metal products and chemicals led the roster of Massachusetts exports, with $41 million (US$) and $35 million (US$) worth of products exported in these sectors respectively. Ireland's demand for these sectors is also showing healthy growth of more than 10% per year in both sectors as well and Massachusetts firms are combining to account for positive export growth. Conversely, Ireland's growth in imports in the miscellaneous commodities category is growing by approximately 25% per year since 2005; Massachusetts exhibits negative growth in miscellaneous commodity exports for the same period (see Figure 67).

FIGURE 67:

IRL import market and Massachusetts' exports by product category, total value (2005) and AAGRs (2001–2005)



Source: The John Adams Innovation Institute
(Data source(s): WISER Trade database, International Trade Centre UNCTAD/WTO)

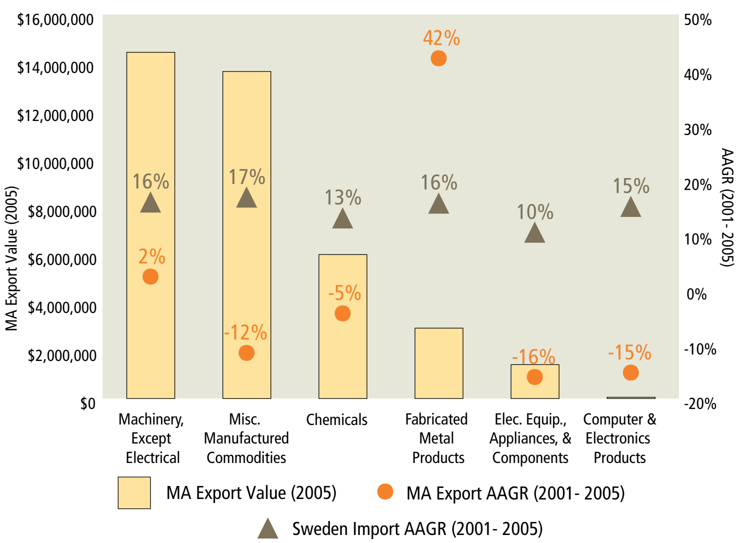
SWEDEN (SWE)

Massachusetts' Trade Links to Sweden's Innovation Economy

Total Massachusetts exports to Sweden were $133 million (US$) in 2005. Machinery and commodities are the two largest export categories from Massachusetts to Sweden, with the latter category showing a negative growth rate of 12% per year while the demand in Sweden grew steadily. While Massachusetts' export performance in the chemicals sector demonstrates consistently strong growth in most global regions, it posts negative growth in exports to Sweden while that country's demand has risen 13% since 2001. Sweden also demonstrates considerable demand in electrical and IT products since 2001. Massachusetts is not competing in this market, however showing negative rates of export growth in these sectors from 2001-2005 (see Figure 68).

FIGURE 68:

SWE import market and Massachusetts' exports by product category, total value (2005) and AAGRs (2001–2005)



Source: The John Adams Innovation Institute
(Data source(s): WISER Trade database, International Trade Centre UNCTAD/WTO)

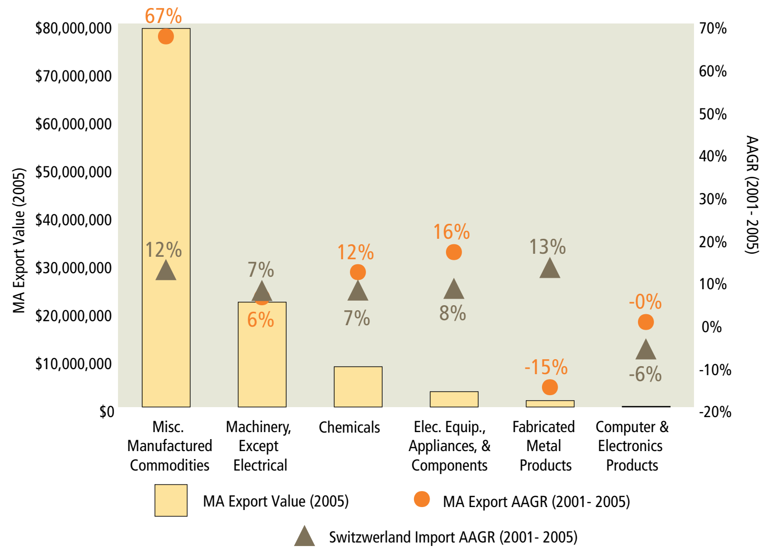
SWITZERLAND (CHE)

Massachusetts' Trade Links to Switzerland's Innovation Economy

Switzerland is a significant trading partner of Massachusetts, accounting for total exports of $269 million in 2005, with manufactured commodities representing the largest product segment valued at $79 million. Export growth in both machinery and chemicals is robust, matching Switzerland's growing demand for products in these sectors. Switzerland's imports in the fabricated metal products category show impressive growth since 2001, yet Massachusetts' growth in exports in this category to the Swiss market has declined more than 15% (see Figure 69).

FIGURE 69:

CHE import market and Massachusetts' exports by product category, total value (2005) and AAGRs (2001–2005)



Source: The John Adams Innovation Institute
(Data source(s): WISER Trade database, International Trade Centre UNCTAD/WTO)

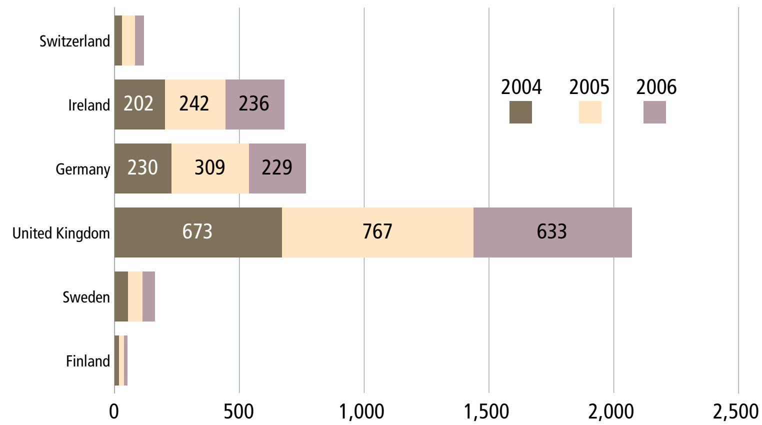
[Import/Export data for the United Kingdom (GBR) is unavailable from UNCTAD/WTO]

Immigrant links to other Western European countries

The United Kingdom accounts for the vast majority of immigrants to Massachusetts originating from Western Europe, exceeding 2,000 people. All other Western European countries account for few immigrants to Massachusetts and growth rates are effectively unchanged on an annual basis (see Figure 70).

FIGURE 70

Immigration to Massachusetts from Western European countries, 2004-2006



Source: The John Adams Innovation Institute
(Data source(s): US Department of Homeland Security)

TRADE AND IMMIGRANT LINKS

What it means for Massachusetts

The penetration of export markets by Massachusetts companies and Massachusetts' immigrant links to other regions

- **Massachusetts companies are strong participants in most export markets around the world, particularly in Western Europe and Asia.** The Computer and electronic products (31.8%) and Chemical (24%) sectors accounted for almost 55% of worldwide exports in 2005.
- **Massachusetts demonstrates significant export growth in the life sciences-related chemicals sector.** In most global regions, the chemicals sector accounts for the highest total dollar value of Massachusetts exports and one of the most significant rates of growth since 2001. As this sector encompasses pharmaceuticals and many other sub-sectors that are the foundation of the life sciences cluster, it's indicative of Massachusetts lead in meeting demand in global markets.
- **The growing demand in Asia for IT and other electronic products represents an emerging, but unexploited, opportunity for Massachusetts companies.** There is growing demand for IT products such as computer hardware, consumer electronics, and networking equipment in the booming Innovation Economies of Asia. Despite the fact that 50% of Massachusetts exports to Asia (including China) were computer hardware and electronic products, the fact remains that imports in this region are growing faster than Massachusetts exports to the region.
- **The BRIC countries combine to account for the largest share of immigrants since 2004.** The BRIC countries as a bloc represent the highest immigrant flows to Massachusetts, with Brazil at the forefront. Immigration from both Western Europe and other North American countries is negligible.

The Framework for Innovation

The 2007 *Index* adopts the National Science Foundation (NSF) definition of the term "innovation":

"The transformation of scientific or technological knowledge into the products, processes, systems and services that fuel economic development, create wealth, and generate improvements in the state's standard of living."

This "transformation" is described in the *Index* as an Innovation Framework. The Framework identifies a region's capacity and potential for innovation, the components of which then fuel the Innovation Process. That process is the mechanism by which an economy creates new inventions, products, services and applications and results in beneficial economic outcomes.

The Innovation Process is the dynamic interaction among three components:

- **Research:** The central element of the Innovation Process is the basic research conducted at academic institutions, teaching hospitals and government and industry laboratories. This research is driven by academic curiosity and technological/ business development needs. The knowledge created in research is largely exploratory, and often at this stage not yet directed at a specific technical or business application. Therefore, even while it is presented at this early stage of the cycle, it can occur at any point of the Process.

- **Technology Development:** The process by which the outcomes of basic research are refined and/or redesigned for a specific application or use.

- **Business Development:** The mechanisms through which the business viability of the invention or innovation is assessed and the product or service is commercialized.

To more fully assess both the societal impacts and other outcomes of the Innovation Economy, the *Index* examines the overall Economic Impact of the Innovation Process. The Economic Impact is considered at both the Cluster Level and at the State Level. In both, the impact of the Innovation Process is measured by reviewing changes in employment and wages, and by various measures of business output.

In addition to Research, Technology Development, and Business Development, the Framework also identifies the impact of a number of external factors on the overall success of the Commonwealth's Innovation Economy.

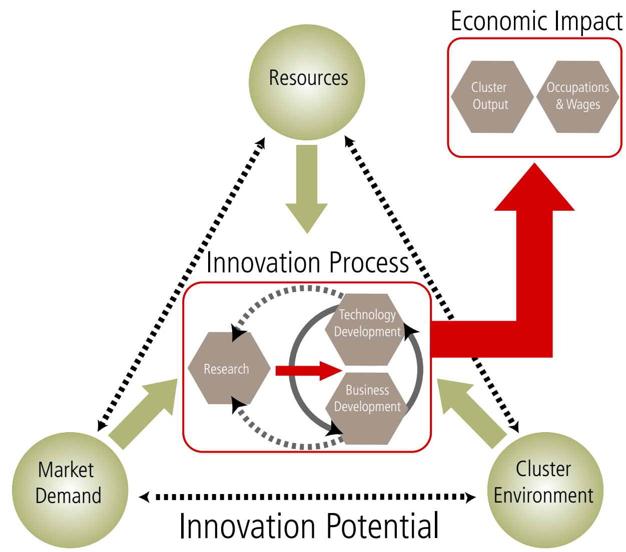
These external factors, collectively the Innovation Potential of a cluster or region, include:

Resources: The various sources of capital and financing available in a cluster, the size and skills of the workforce, and other infrastructure-specific components.

Market Demand: The strength of demand for cluster products and services, which is the collective sum of all the constituent industry demands. This Market Demand is one of the strongest drivers of the Innovation Process.

Cluster Environment: The relationships among the industries that comprise the cluster.

FIGURE: The Framework for Innovation



Indicator Selection

Indicators are quantitative measures that illustrate how well a particular state on the roster of the *Index*'s Leading Technology States (LTS) is performing. Rigorous criteria were applied to all potential indicators, resulting in the selection of twenty indicators that are:

- Derived from objective and reliable data sources
- Statistically measurable on an on-going basis
- Bellwethers that reflect the fundamentals of economic vitality
- Easily understood and accepted by the community
- Measuring conditions of an active public interest

Benchmark Comparisons: Leading Technology States

Tracking the Massachusetts Innovation Economy over time is crucial to continually assessing its strength and resilience. For similar reasons, benchmark comparisons can provide an important context for understanding how Massachusetts is performing in a relative sense. Thus, in some cases, performance indicators for Massachusetts are compared with another Leading Technology State (LTS), in others with the national average or with a composite measure of the other nine LTS. The nine LTS chosen for comparison throughout the 2007 *Index* are California, Connecticut, Illinois, Minnesota, New Jersey, New York, North Carolina, Pennsylvania and Virginia. Appendix A describes the methodology utilized for selecting the LTS.

Eleven Key Industry Clusters

The 2007 *Index* monitors the impact of innovation through eleven industry clusters that are critical to the state's economy and that are linked uniquely to the Innovation Process. These industry clusters are:

- Advanced Materials
- Biopharmaceuticals, Medical Devices, & Hardware

- Business Services
- Computer & Communications Hardware
- Defense Manufacturing & Instrumentation
- Diversified Industrial Manufacturing
- Financial Services
- Healthcare Delivery
- Postsecondary Education
- Scientific, Technical, & Management Services
- Software & Communications Services

The portfolio of key industry clusters differs from prior editions of the *Index* in an attempt to reduce ambiguity and offer more accurate insights into the performance of clusters and their component parts. In particular, the former "Healthcare Technology" cluster has been reordered and augmented into two new and distinct clusters: "Biopharmaceuticals, Medical Devices, & Hardware" and "Healthcare Delivery." In addition, the former "Textiles & Apparel" cluster has been eliminated. In its place, the 2007 *Index* considers a new cluster "Advanced Materials." Appendix B provides a detailed definition for each of these clusters.

By conservative measures, these eleven clusters combined account for approximately 37% of non-government (private) employment in Massachusetts. If direct and indirect jobs, including local suppliers and re-spending effects, are counted, then these innovation clusters support employment of more than half of all state employment.[27] For purposes of the *Index* analysis, however, indirect employment effects are not considered.

Analysis of the 2007 Indicators of the Innovation Economy

The Framework for Innovation underscores both the levers for innovation-based economic growth and also the economic and social conditions that nurture the potential for innovation-fueled growth. This Framework also provides an overall understanding of the economic impact and its underlying drivers, thus identifying potential threats and opportunities. The following section summarizes the 20 indicators that comprise the *2007 Index* and highlights a number of critical factors that might provide insight into the drivers of the Commonwealth's economic performance.

This section is organized as follows:

ECONOMIC IMPACT
- Indicator #1: Industry Cluster Employment & Wages
- Indicator #2: Corporate Sales, Publicly Traded Companies
- Indicator #3: Occupations and Wages
- Indicator #4: Median Household Income
- Indicator #5: Manufacturing Exports

INNOVATION PROCESS
Business Development
- Indicator #6: New Business Incorporations and Business Incubators
- Indicator #7: Initial Public Offerings (IPOs) and Mergers & Acquisitions (M&As)
- Indicator #8: Technology Fast 500 Firms and Inc. 500 Firms

Technology Development
- Indicator #9: Small Business Innovation Research (SBIR) Awards
- Indicator #10: Regulatory Approval of Medical Devices and Biotechnology Drugs

Research
- Indicator #11: Corporate R&D Expenditures, Publicly Traded Companies
- Indicator #12: Patent Applications, Patent Awards, and Invention Disclosures
- Indicator #13: Technology Licenses and Royalties

INNOVATION POTENTIAL
Resources
- Indicator #14: Investment Capital
- Indicator #15: Federal Academic and Health R&D Expenditures
- Indicator #16: Intended College Major of High School Seniors and High School Dropout Rates
- Indicator #17: Public Secondary & Higher Education Expenditures
- Indicator #18: Educational Attainment and Engineering Degrees Awarded
- Indicator #19: Population Growth Rate and Migration
- Indicator #20: Median Price of Single-Family Homes, Home Ownership Rates, and Housing Starts

Industry Cluster Employment and Wages

Why Is It Significant?

Each of the eleven key industry clusters consists of geographic concentrations of interdependent industries and each generally has an employment concentration above the national average. Together they form an ecosystem of commerce, comprising approximately 37% of all non-government jobs in Massachusetts. They produce most of the highest paying jobs in the Commonwealth, and have a positive indirect impact on other sectors of the state's economy. When these impacts are considered in the aggregate, they account for over half of Massachusetts total employment. These industry clusters are the principal drivers of economic prosperity and innovation, underscoring the competitive advantages of Massachusetts and holding the brightest promise for substantial future growth.

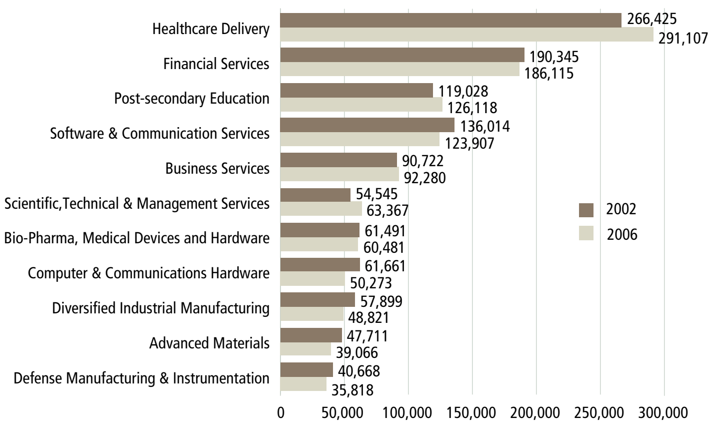
How Does Massachusetts Perform?

Data indicate that the rebound in employment figures in the post-dot-com era continues in 2006, with notable job gains across most industry clusters, predominantly in the last two years. A "Healthcare Delivery" cluster has been added to the 2007 edition of the *Index* and it represents by far Massachusetts' largest cluster (291,000+ jobs). This cluster also shows robust historical growth, growing by more than 3% between 2005 and 2006. The Financial Services cluster remains a substantial segment of Massachusetts' cluster employment ranking second, accounting for more than 186,000 employees in 2006 with impressive year-to-year growth of more than 2.5% annually. The cluster, however, still falls short of its 2002 level. The Postsecondary Education and Scientific, Technical, & Management clusters posted the strongest annual growth between 2005 and 2006 at 4%.

Indicator #1 Key Takeaways:

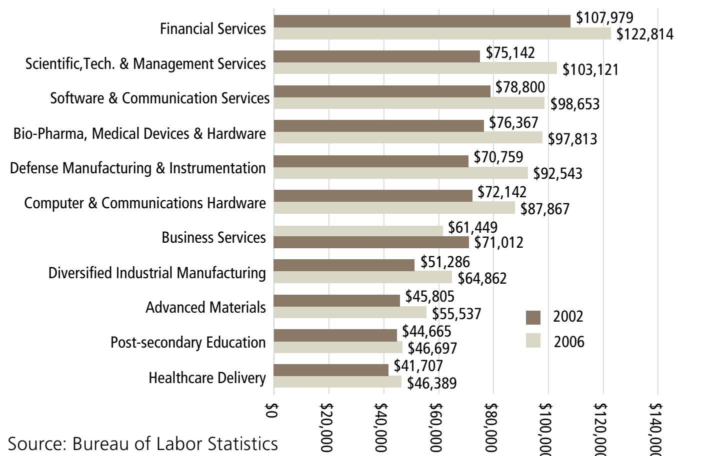
- Three industry clusters, Advanced Materials, Diversified Industrial Manufacturing, and Computer & Communications Hardware, all post above average annual wages, but show negative rates of growth in employment from 2004–2006.
- The Postsecondary Education cluster continues to demonstrate its vital importance to the larger Innovation Economy in Massachusetts. The cluster posted the highest gain in average annual wage at more than 8% and is also showing the fastest growth between 2005 and 2006.
- Although the Scientific, Technical, & Management Services cluster is one of Massachusetts fastest growing clusters at approximately 4%, this rate of growth is outpaced by the majority of other LTS.
- With the exception of Postsecondary Education; Biopharmaceuticals, Medical Devices, & Hardware; and Healthcare Delivery, Massachusetts continues to lag behind many of the LTS and the US as a whole in employment growth in the key industry clusters.

Total employment by industry cluster, Massachusetts, 2002 and 2006



Source: Moody's Economy.com

Average annual wage by cluster, Massachusetts, 2002 and 2006



Source: Bureau of Labor Statistics

Percentage change in cluster employment, 2005-2006

	CA	CT	IL	MA	MN	NC	NJ	NY	PA	VA	US
Advanced Materials	-1.01%	-3.96%	-2.39%	-5.39%	-1.15%	-2.38%	-3.33%	-4.32%	-3.16%	-3.91%	-1.46%
Bio-Pharma, Med Dev & Hdwe	2.41%	-0.39%	-0.33%	2.21%	4.47%	5.45%	2.10%	0.41%	2.18%	2.93%	1.88%
Business Services	3.01%	0.52%	2.08%	2.24%	1.78%	6.07%	0.94%	2.26%	1.51%	3.75%	3.18%
Computer & Comm Hdwe	-0.94%	-3.51%	-0.82%	-1.37%	-1.43%	2.05%	1.31%	-1.33%	0.15%	6.00%	-0.09%
Def Mfg & Instrumentation	-1.25%	1.56%	0.48%	1.12%	3.07%	7.45%	2.54%	0.85%	6.29%	-3.87%	2.23%
Div Ind Mfg	-0.82%	-1.29%	9.49%	-4.07%	2.16%	-0.63%	-3.99%	-2.57%	-0.02%	2.39%	0.14%
Financial Services	2.13%	1.24%	0.93%	2.59%	1.86%	5.12%	-0.42%	3.13%	0.41%	2.48%	2.77%
Healthcare Delivery	2.14%	1.54%	2.17%	3.29%	4.68%	4.82%	1.29%	1.89%	2.52%	2.45%	2.66%
Postsecondary Education	2.93%	4.29%	4.23%	4.08%	3.01%	5.36%	2.82%	3.75%	0.66%	2.56%	3.55%
Scientific, Tech & Mgmt Svcs	9.38%	2.43%	4.25%	3.97%	12.89%	9.97%	5.86%	3.90%	4.64%	8.73%	5.33%
Software & Comm Services	2.09%	1.76%	0.66%	1.97%	-0.91%	3.32%	3.42%	0.97%	0.16%	3.45%	1.98%
Total State Employment	1.88%	0.88%	0.84%	1.00%	1.40%	2.70%	0.89%	0.96%	0.90%	1.68%	1.85%

Corporate Sales, Publicly Traded Companies

Why Is It Significant?

The volume of, and growth in, corporate sales by publicly traded companies are indicators of the vitality of an industry cluster. Examining corporate sales data across both the LTS and the US provides insight into the patterns of a cluster's market demand as well as the competitiveness of industry players within a particular cluster. While highly affected by productivity changes, corporate sales are nevertheless an early indicator of potential employment change and the potential of a cluster to create and/or maintain jobs.

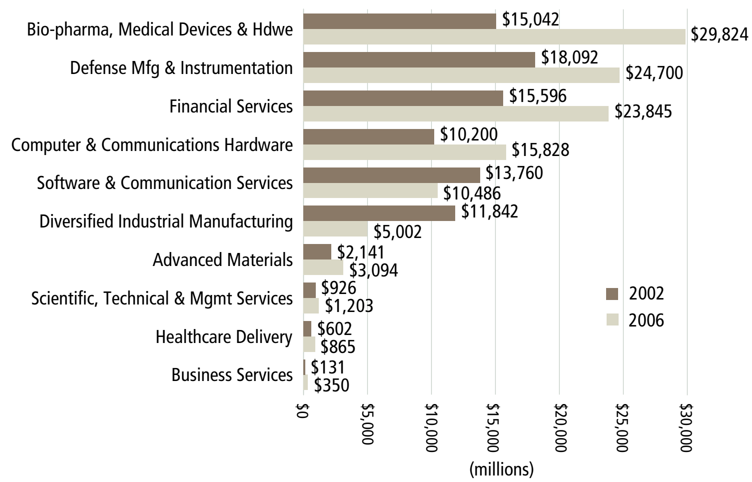
How Does Massachusetts Perform?

As corporate sales figures are ascribed to location of corporate headquarters, much of the economic activity in Massachusetts is not captured by this measure as the state lacks many such corporate anchors. However, in some key clusters, the growth rate of Massachusetts-headquartered companies compares exceedingly well with those of the other LTS. In Massachusetts, for example, four key clusters (Business Services; Computer & Communications Hardware; Financial Services; and Biopharmaceuticals, Medical Devices, & Hardware) all exhibit double-digit sales growth on an average annual basis between 2002 and 2006. The Diversified Industrial Manufacturing and Software clusters in Massachusetts, however post negative growth of 5% to 7% in sales, although this average includes atypically underperforming years of 2002-2004.

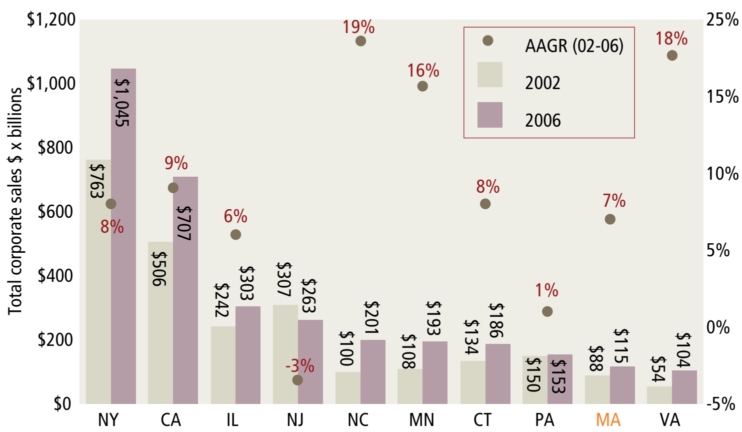
Indicator #2 Key Takeaways:

- Eight of the ten key industry clusters showed growth in corporate sales of publicly traded companies between 2002 and 2006.
- Massachusetts demonstrates a 19% average annual growth rate (AAGR) in corporate sales between 2002 and 2006 for the Life Sciences sub-cluster Biopharmaceuticals, Medical Devices, & Hardware. This performance rivals Minnesota's for the best among the LTS.
- The Biopharmaceuticals, Medical Devices, & Hardware cluster shows the highest corporate sales of any of the key industry clusters in Massachusetts.
- The LTS of Minnesota, North Carolina, and Virginia all post double-digit AAGR in corporate sales for all clusters between 2004 and 2006, with Massachusetts showing only 7% AAGR for the same period.

Corporate sales by cluster, Massachusetts, 2002 and 2006



Corporate sales (all clusters), LTS, 2002 and 2006



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

Occupations and Wages

Why Is It Significant?

Occupational employment and wages are critical factors in understanding both the types of job opportunities being created and also the financial benefits those jobs contribute to a state's economy and its labor force. The mix of occupations in a state can be indicative of the diversity of its industrial base, the educational attainment level of its workforce, and the skills and competencies required by its businesses.

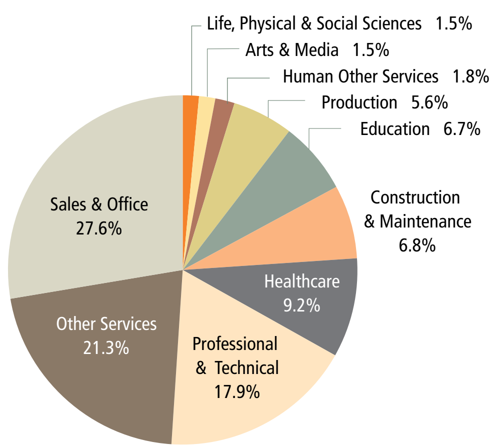
How Does Massachusetts Perform?

While 49% of the workforce in Massachusetts is seen in occupations in Sales & Office and Other Services categories combined, a significant share of workers can be seen in higher paid occupations in the Professional & Technical; Healthcare; and Life, Physical, & Social Sciences categories. In fact, nearly 30% of the workforce can be found in these occupations, with a greater concentration of employment, higher growth in employment, and wages greater than the state average.

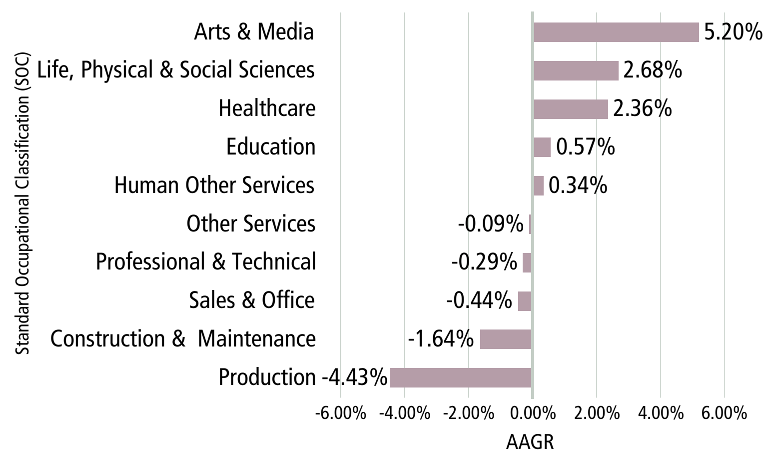
Indicator #3 Key Takeaways:

- The Arts & Media occupational category shows the strongest growth in the past five years at more than 5% growth This signifies the importance of the "creative economy," public relations, and offline and online content industries to the greater Massachusetts Innovation Economy.
- Massachusetts has the highest concentration of employment in the Professional & Technical and Life, Physical, & Social Sciences occupations among the LTS.
- Among the LTS, Massachusetts, Pennsylvania, and New York continue to rank atop the LTS in the Healthcare occupational category.
- The concentration of Massachusetts employment in Production occupations is among the lowest of the LTS.

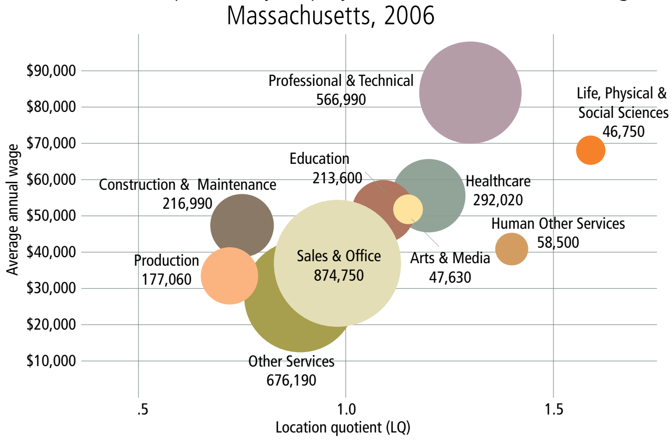
Distribution of occupations by standard occupational classification (SOC), Massachusetts, 2006



Occupational average annual growth rate (AAGR), Massachusetts, 2002-2006



Portfolio of occupations by employment concentration and wage, Massachusetts, 2006



LTS employment by sector as a percentage of total state employment, 2006

	MA	CA	CT	IL	MN	NJ	NY	NC	PA	VA	US
Professional & Technical	17.9%	15.6%	16.2%	14.1%	15.9%	15.0%	14.1%	12.1%	12.3%	16.9%	13.7%
Life, Physical & Social Sciences	1.5%	1.0%	1.0%	0.8%	1.1%	1.1%	1.0%	1.0%	1.0%	1.1%	0.9%
Human Other Services	1.8%	1.2%	1.8%	1.1%	1.8%	1.4%	2.1%	1.2%	1.8%	1.2%	1.3%
Education	6.7%	6.4%	7.4%	6.4%	5.5%	6.7%	7.8%	6.4%	6.1%	6.0%	6.2%
Arts & Media	1.5%	2.0%	1.2%	1.1%	1.3%	1.1%	2.0%	0.9%	1.1%	1.3%	1.3%
Healthcare	9.2%	6.2%	8.5%	7.5%	8.2%	7.8%	9.0%	8.4%	9.2%	6.4%	7.7%
Other Services	21.3%	23.7%	21.4%	24.1%	22.8%	24.1%	21.8%	23.8%	23.8%	23.1%	24.0%
Sales & Office	27.6%	28.4%	28.6%	27.9%	26.6%	29.8%	29.8%	26.4%	28.2%	27.9%	28.0%
Construct. & Maintenance	6.8%	8.9%	6.7%	7.8%	7.8%	7.4%	7.4%	9.4%	8.4%	10.3%	9.1%
Production	5.6%	6.5%	7.2%	9.1%	8.8%	5.6%	5.0%	10.5%	8.3%	5.8%	7.7%

Source of all data for this indicator: US Bureau of Labor Statistics

Median Household Income

Why Is It Significant?

Rising incomes reflect a region's ability to provide wages that outpace inflation, thereby resulting in an increase in a region's overall standard of living. The median household income provides a snapshot of the financial conditions and general economic prosperity of the typical household in Massachusetts.

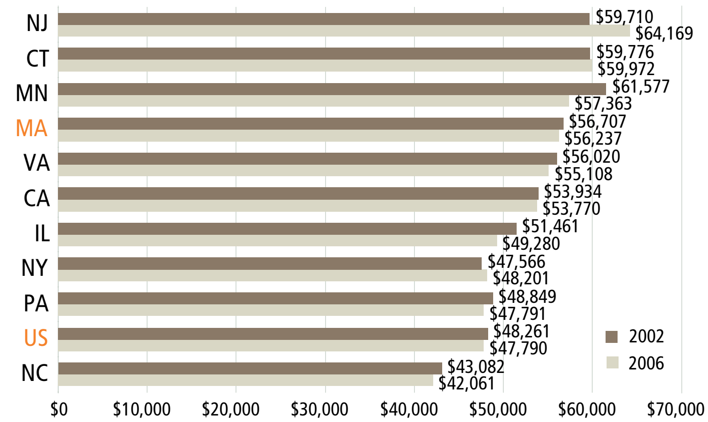
How Does Massachusetts Perform?

Three-year median household income between 2005 and 2006 was down in fully half of the LTS, including Massachusetts. The Commonwealth is in the second quartile among the LTS, behind New Jersey, Connecticut, and Minnesota. While Massachusetts income recorded a marginal drop and remains essentially static, wages in Minnesota and Virginia saw the biggest decreases and dropped 1% or more in both states. Increases in median income were most pronounced in New Jersey, with an increase of 4%.

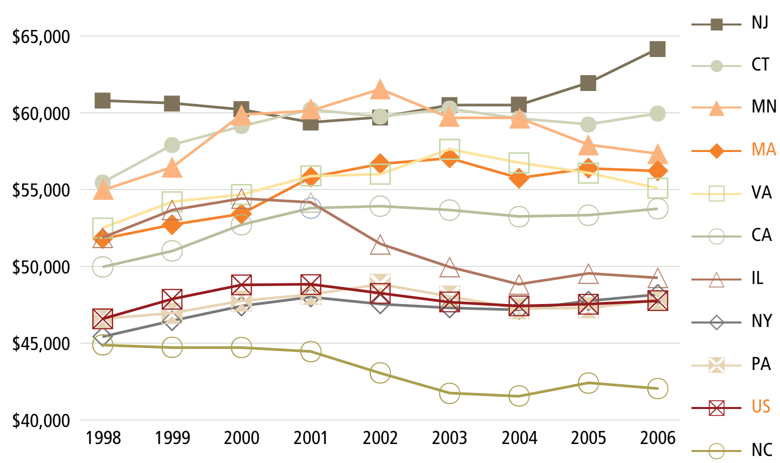
Indicator #4 Key Takeaways:

- Median household income in Massachusetts remained stagnant for the last two years and has yet to rebound to income levels seen in 2002.
- Massachusetts median household income exceeds the US average by 18%

Three-year average median household income, in 2006 dollars, LTS and US, 2002 and 2006



Three-year average median household income, in 2006 dollars, LTS and US, 1998-2006



Source of all data for this indicator: US Census Bureau

Manufacturing Exports

Why Is It Significant?

Exports are an important indicator of the Commonwealth's global competitiveness. Supplying emerging global markets can bolster growth in employment, sales, and increase market share for innovation-intensive companies. Moreover, a diversity of markets and product categories creates a countercyclical hedge against an economic downturn or recession in any particular international region.

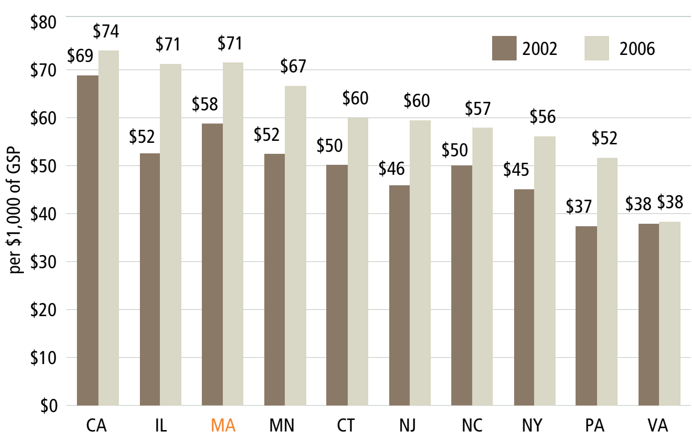
How Does Massachusetts Perform?

Massachusetts continues to post good performance in exports of manufactured goods at approximately 10% per year, signifying a healthy and ongoing integration into the larger global economy, but still lagging other LTS. In terms of export value, only California and Illinois among the LTS can claim better export performance per gross state product (GSP), with $74.0 and $71.4 per $1,000 of GSP, respectively.

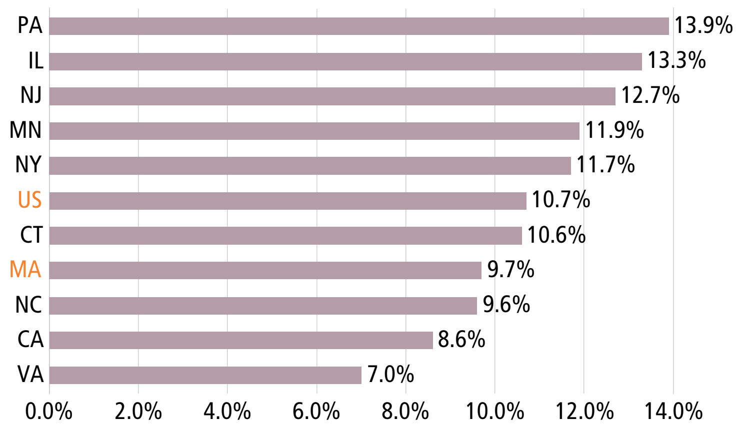
Indicator #5 Key Takeaways:

- Massachusetts exports in the categories of Computer & Electronic Products, Machinery, and Miscellaneous Manufactured Commodities remained stagnant from 2004-2006. In the Computer & Electronics Products sector, exports have decreased more than 10% since 2002.
- The largest sector of Massachusetts exports is Computer & Electronic Products, which includes many information technology products, analytical instruments, and electronic medical devices.
- After four years of growth in the Chemicals sector, which includes key industries such as pharmaceuticals, there has been nearly a 4 point drop in the percentage of exports in this sector between 2005 and 2006.

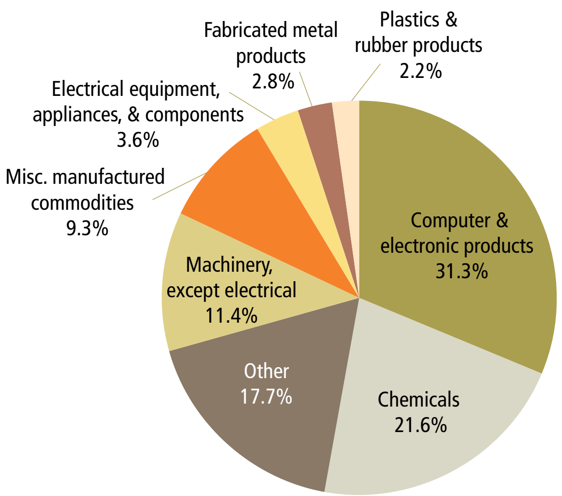
Manufacturing exports per $1,000 GSP, LTS, 2002 and 2006



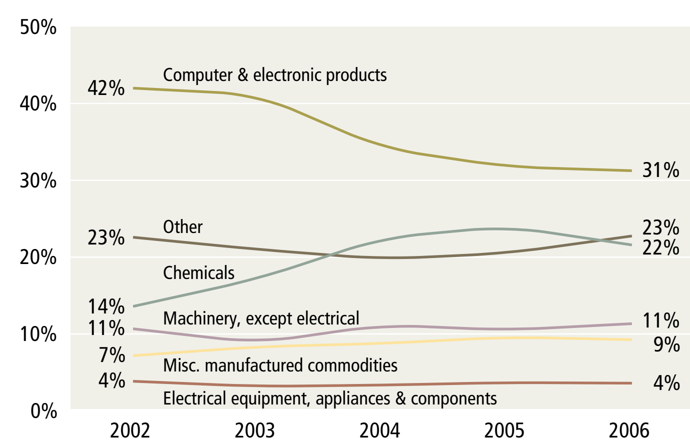
Average annual growth rate (AAGR) of manufacturing exports, LTS and US, 2002–2006



Distribution of manufacturing exports, Massachusetts, 2006



Manufacturing exports as a percentage of total state exports, Massachusetts, 2002–2006



Source of all data for this indicator: US Census Bureau, Foreign Trade Division

New Business Incorporations and Business Incubators

Why Is It Significant?

The number of new business incorporations per year is a fundamental indicator of a vigorous economy. A high number of new business starts typically indicates an economic environment with the capacity to support entrepreneurial ventures and nurture risky and innovative ideas. Successful new companies not only produce their own jobs, goods, and services, but also create an increased demand for new ideas, products, and services. This demand comes from other companies in related spheres of activity, such as suppliers, partners, and the state's academic and research institutions.

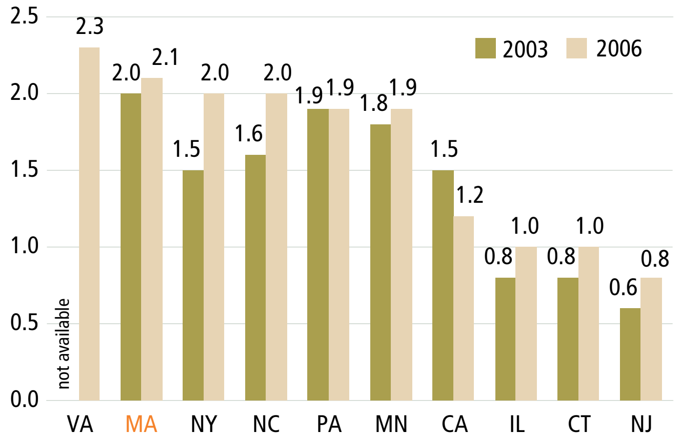
How Does Massachusetts Perform?

Massachusetts continues to post growth in new business incorporations year-over-year, with well over 31,000 new incorporations in 2006, nearly 2,000 more than the number in 2004. Of all categories of new businesses, private-sector, for-profit enterprises showed the strongest average annual growth rate between 2002 and 2006 at nearly 6%. Massachusetts continues to post a healthy ratio of business incubators to establishments, trailing only Virginia among the LTS. Incubators play a key role in a healthy Innovation Economy to support and foster innovative ideas and nascent firms spun out of universities and research centers to nurture them along the continuum to more developed, profitable, and self-sustaining firms.

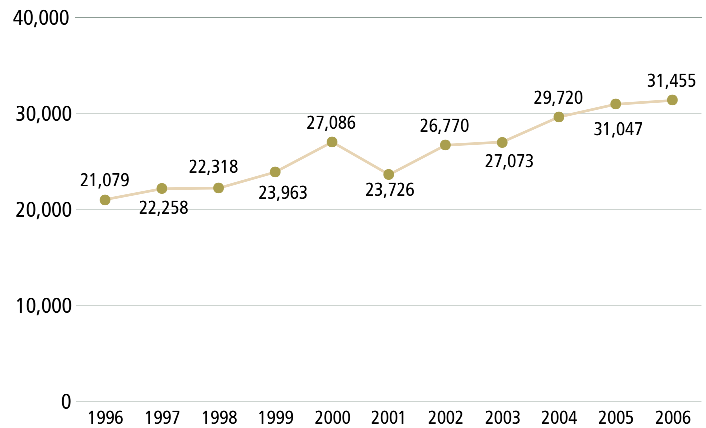
Indicator #6 Key Takeaways:

- Massachusetts has the most business incubators per establishment of any LTS, except Virginia.
- Across most of the LTS in 2006, numbers of business incubators per establishment have grown when compared with 2003.
- Since the economic downturn of 2001, Massachusetts has seen increases in the number of new business incorporations year-to-year, with almost 2,000 more incorporations last year as compared to 2004. The rate of growth, however, of for-profit new business incorporations has slowed significantly from 2005 to 2006.

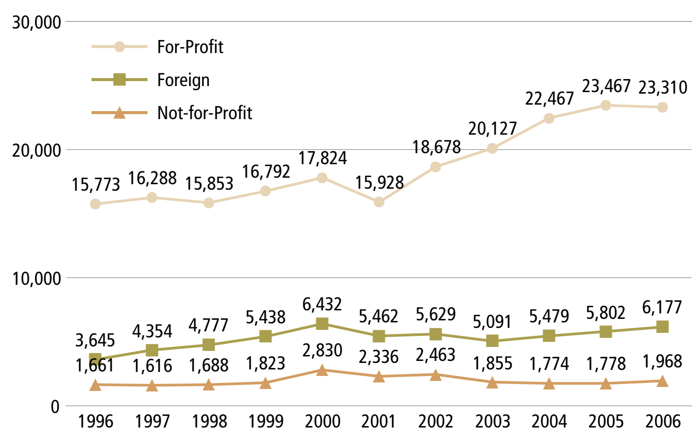
Business incubators per 10,000 business establishments, LTS, 2003 and 2006



Total new business incorporations, Massachusetts, 1996–2006



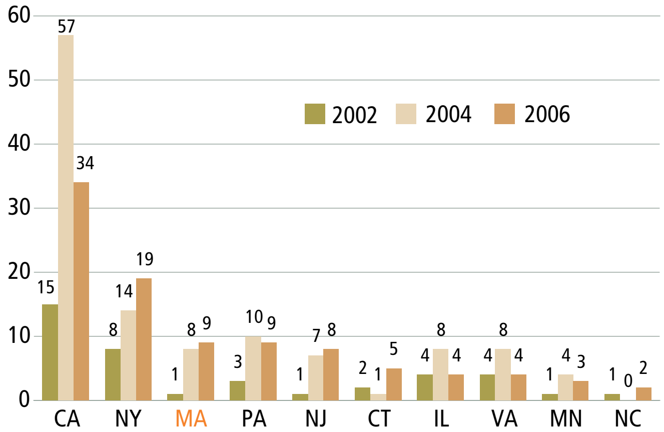
New business incorporations by category, Massachusetts, 1996–2006



Source: Commonwealth of Massachusetts

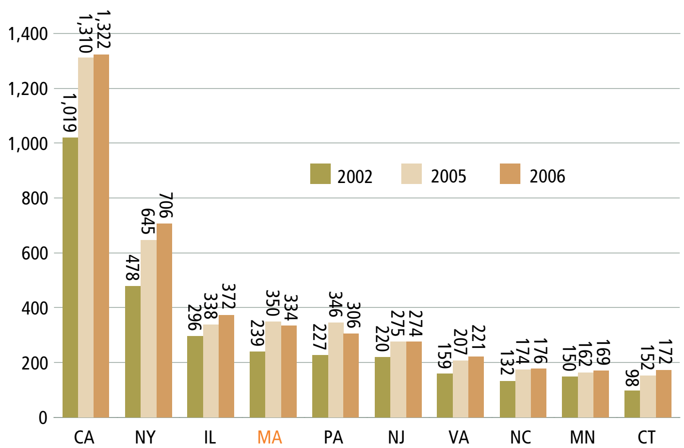
Initial Public Offerings (IPOs) and Mergers & Acquisitions (M&As)

Initial public offerings, LTS, 2002, 2004, 2006



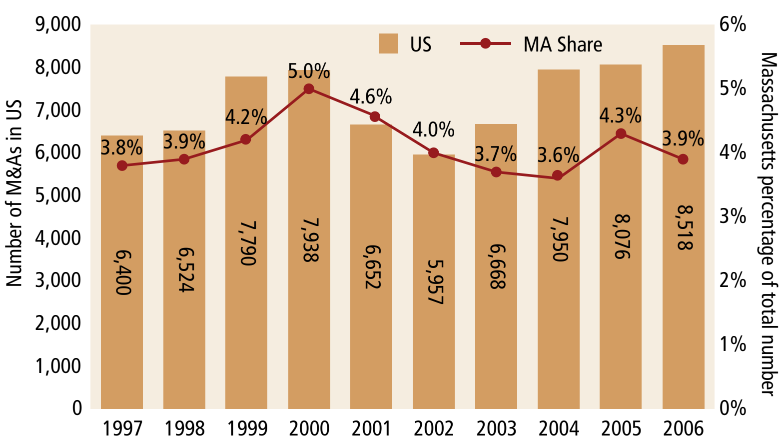
Source: Renaissance Capital, IPO Home

Mergers and acquisition by location of acquired company, LTS, 2002, 2005, 2006



Source: FactSet Mergerstat, LLC

Mergers and acquisitions and Massachusetts share of total US, 1997-2006



Source: FactSet Mergerstat, LLC

Why Is It Significant?

The number of initial public offerings (IPOs) is an indicator of companies with the potential for high-growth. "Going public" via an IPO raises significant capital to stimulate next-stage growth whether in the form of investments in R&D, new employee hiring, or the marketing and launching of new products. A successful IPO reflects investor confidence that a company can increase in value, sustain growth, and produce satisfactory returns on investment (ROI). Mergers and acquisitions (M&As) are another critical avenue to liquidity for entrepreneurs and investors in rapidly growing firms seeking to diversify, accelerate new product development, or expand sales or market share. However, in an environment of numerous M&As, there exists the risk of significant job losses as the result of the elimination and/or consolidation of redundant functions and the relocation of offices or operations, especially if the acquiring company is an out-of-state firm.

How Does Massachusetts Perform?

For 2006, Massachusetts ranks third among the LTS in IPOs, trailing California and New York. While in 2005 Massachusetts posted the largest number of IPOs since 2001, the number of IPOs in 2006 moderated to just nine.

Indicator #7 Key Takeaways:

- IPOs in Massachusetts are down from the recent high seen in 2005, but remain higher than most competing LTS, only behind the performance of California and New York.
- Although total US M&A activity reached record levels, fewer Massachusetts companies were acquired in 2006 than in 2005. Mergers & acquisitions in Massachusetts account for 3.9% of the US total, down from an historical high of 5% in the year 2000.

Technology Fast 500 Firms and Inc. 500 Firms

Why Is It Significant?

The Technology Fast 500 list compiled by Deloitte and Touche, LLP and the Inc. 500 firm list compiled by *Inc. Magazine* provide insight into the number of rapidly growing "gazelle" firms in a region.[28] The Technology Fast 500 list identifies companies spending large proportions of their revenues on R&D. The Inc. 500 list measures all rapidly growing privately held companies, and is not limited to technology sectors.

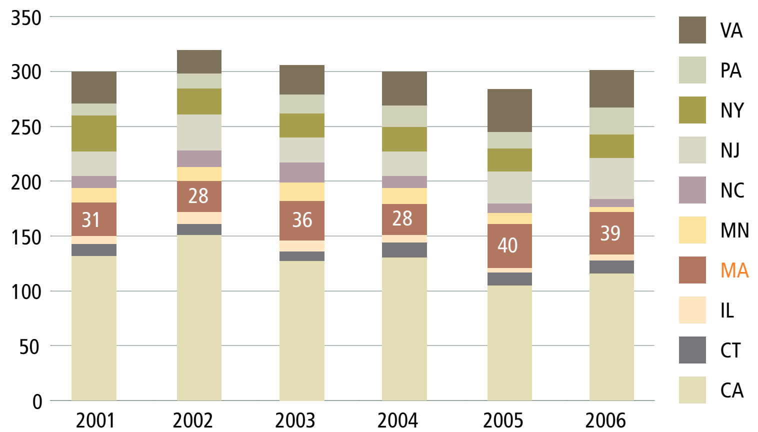
How Does Massachusetts Perform?

Massachusetts continues to account for significant numbers of these types of hyper-growth and high potential firms. Massachusetts now counts numbers of these types of growth-oriented firms comparable to those seen in the high growth era of 1999-2001. In states with 20 or more firms fitting the profile of the Inc. 500 list in 2005, all have shown positive growth to 2006, with the exception of Virginia and Massachusetts.

Indicator #8 Key Takeaways:

- Massachusetts number of Technology Fast 500 firms continues posting strong numbers, significantly higher than those seen early in this decade.
- Massachusetts continues to account for increasing numbers of Inc. 500 firms on an annual basis, approaching the pre-downturn high reached in the 2001.

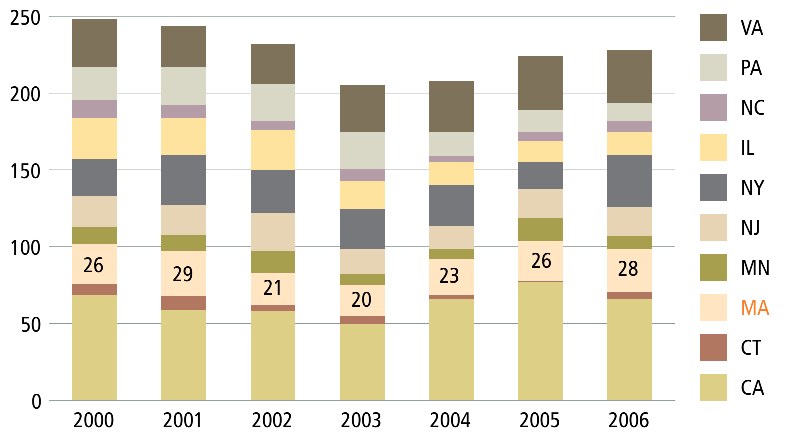
Technology Fast 500 firms, LTS, 2001-2006



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

Source: Deloitte & Touche LLP

Total number of Inc. 500 firms, LTS, 2000-2006

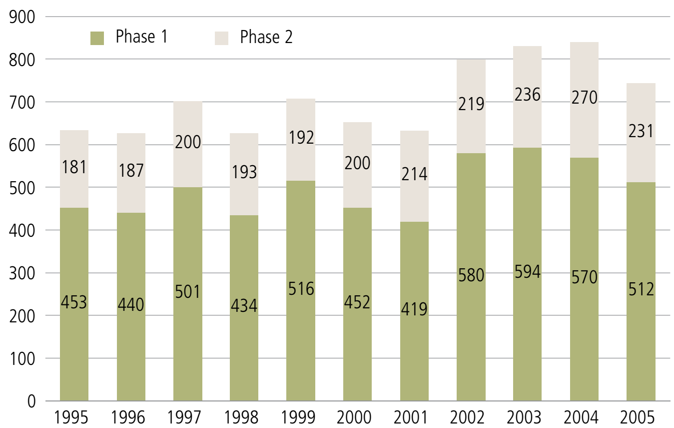


	2000	2001	2002	2003	2004	2005	2006
CA	69	59	58	50	66	77	66
CT	7	9	4	5	3	1	5
MA	26	29	21	20	23	26	28
MN	11	11	14	7	7	15	8
NJ	20	19	25	17	15	19	19
NY	24	33	28	26	26	17	34
IL	27	24	26	18	15	14	15
NC	12	8	6	8	4	6	7
PA	21	25	24	24	16	14	12
VA	31	27	26	30	33	35	34

Source: *Inc. Magazine*

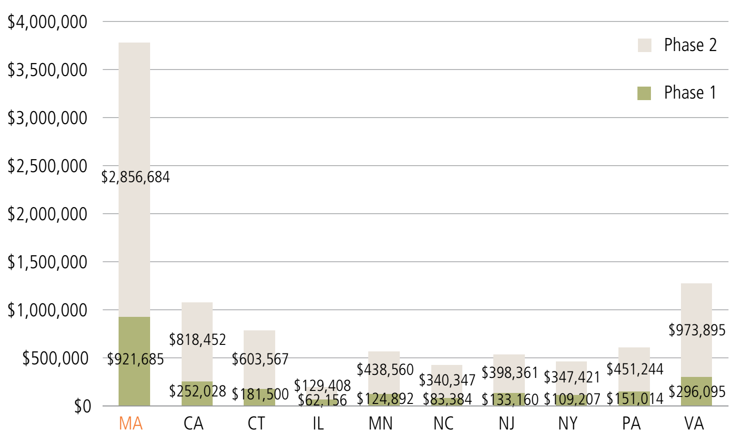
Small Business Innovation Research (SBIR) Awards

SBIR awards to companies by phase, Massachusetts, 1995–2005*

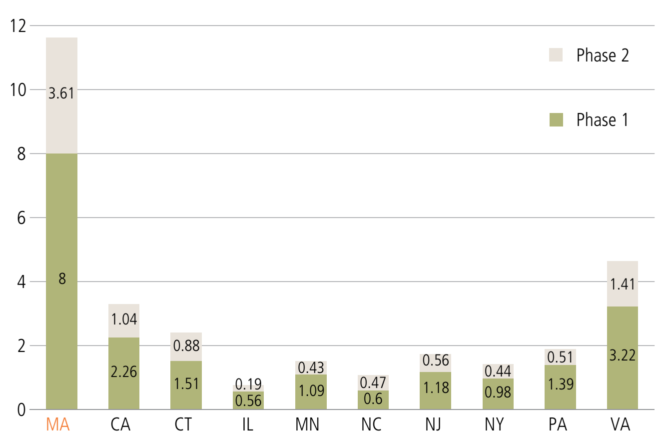


*More recent data was unavailable for this indicator at time of publication.

Dollar value of SBIR awards, per 100,000 people, LTS, 2005



SBIR awards to companies by phase, per 100,000 people, LTS, 2005



Source of all data for this indicator: US Small Business Administration (SBA)

Why Is It Significant?

The Small Business Innovation Research (SBIR) Program provides competitive grants to entrepreneurs seeking to conduct "Phase I" proof-of-concept research on technical merit and idea feasibility and "Phase II" prototype development building on Phase I findings. The federal SBIR program is a preeminent seed capital fund for development of new products and processes, and often provides the initial source of financing for some start-up companies. Participants in the SBIR program are often able to use the credibility and experimental data developed through their research to attract strategic partners and outside capital investment.

How Does Massachusetts Perform?

The state experienced a sharp decline in the number of awards in 2005 relative to 2004, dropping from 840 to 743. To some extent, this decline can be attributed to the acquisition of Waltham-based Foster-Miller Inc. by UK-based QinetiQ in September 2004, making this company unable to compete for awards as a Massachusetts small business. However, despite the yearly decline in the number of awards, Massachusetts continues to attract a major share of the R&D funding available from the SBIR program. Massachusetts has ranked second, after California, in the absolute number and dollar amount of SBIR awards every year since the inception of the program. In 2005, Massachusetts technology entrepreneurs and small businesses received $242M, second only to California, and far ahead of third-ranked Virginia. This performance is even more impressive when measured on a per capita basis. In total number of awards, Massachusetts outperformed its closest competitor, Virginia, by a factor of 2.5 and outperformed California by a factor of 3.5. Despite this success, Massachusetts continues to lose market share in the SBIR program, dropping from 15.3% in 2000 to 13.8% in 2004, with another decline to 12.5% recorded in 2005.

Indicator #9 Key Takeaways:

- SBIR awards to Massachusetts firms in 2005 are down significantly from 2004, declining more than 13%.
- Per capita, Massachusetts maintains its lead in SBIR awards compared to all other LTS, ahead of second place, Virginia.
- For 2005, Massachusetts experiences a reversal of a ten year growth trend in Phase 2 awards.

FDA Approval of Medical Devices and Biotechnology Drugs

Why Is It Significant?

The US Food and Drug Administration (FDA) classifies medical devices into two categories for purposes of the approval process: pre-market approvals (PMAs) and pre-market notifications, known as 510(k)s. PMA is the designation for the more sophisticated, developed devices, while 510(k) is a classification for less sophisticated instruments or simple improvements to existing products or functional equivalents. Approval rates reflect innovation in medical device design and manufacturing as well as important relationships with the teaching and research hospitals where many of these instruments undergo clinical investigation and trial.

The FDA's Center for Drug Evaluation and Research (CDER) approves all drugs bound for the US market. The new drug approval (NDA) process is thorough and comprehensive, involving clinical trials and an extensive review process. Drug approvals generally reflect innovation in health research and pharmaceutical manufacturing.

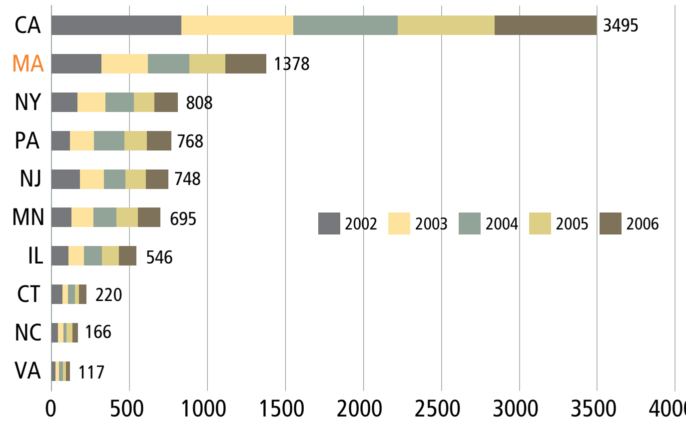
How Does Massachusetts Perform?

Massachusetts maintained its strong performance in the number of 510(k) submissions in 2006 with 264, reversing a downturn in 2005 which resulted in a ten year low of only 227 approvals. Among states with at least one hundred 510(k) submissions last year (70% of the LTS), Massachusetts demonstrated the greatest growth in submissions from 2005 to 2006, more than 16%.

Indicator #10 Key Takeaways

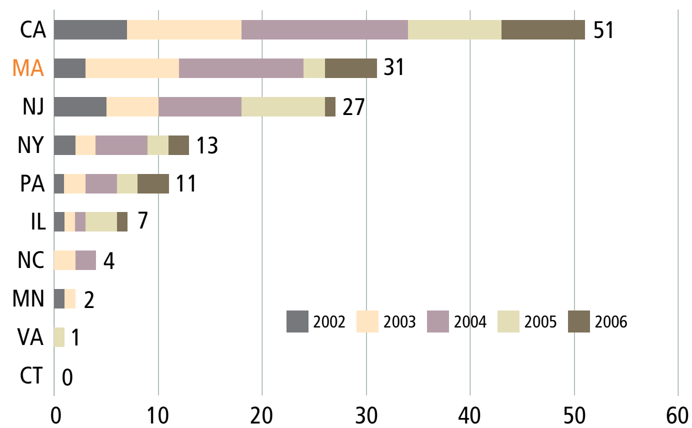
- The number of 510(k) submissions increased more than 16% between 2005 and 2006, reversing a three-year decline and highlighting the cyclical nature of the federal regulatory approvals process.
- Massachusetts trails only California in the number of biotechnology drug approvals in the five year span of 2002 through 2006. Among the LTS, there were only 20 biotechnology drug approvals in total in 2006—of which Massachusetts counted five, or 25%.
- On a three-year average basis (2004-2006), California, Massachusetts, Minnesota, and Illinois lead the LTS in the number of PMAs.

Releasable 510(k)s, LTS, 2002-2006



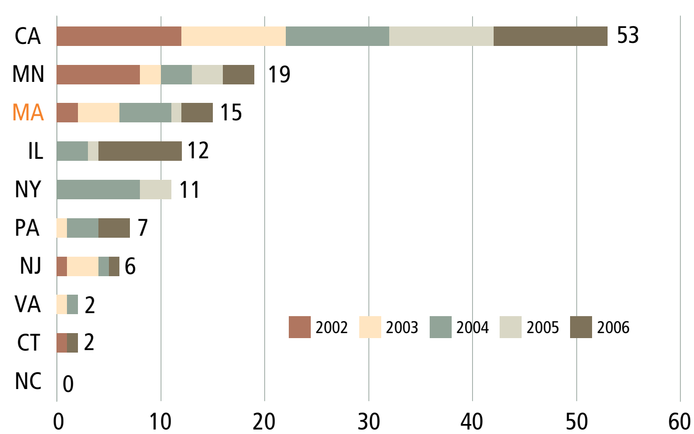
Source: US Food and Drug Administration

FDA approvals of biotechnology drugs, LTS, 2002-2006



Source: Biotechnology Industry Organization

Premarket approvals, LTS 2002-2006



Source: US Food and Drug Administration

Corporate Research & Development Expenditures, Publicly Traded Companies

Why Is It Significant?

Corporate research and development (R&D) is an essential ingredient in the formula for producing innovative new products and services that keep Massachusetts companies competitive in the global marketplace. This indicator tracks corporate R&D expenditures at publicly traded companies in their headquarter states. This metric provides solid evidence of company readiness to invest for the long-term, their assessment of market demand for new products, and the level of confidence in the future of their industries.

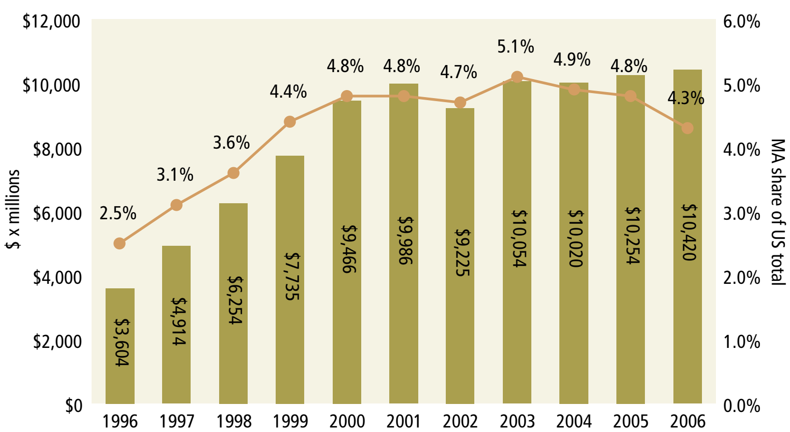
How Does Massachusetts Perform?

Continuing a downward trend first witnessed in 2004, Massachusetts share of total corporate R&D spending in the US has dropped to 4.3%, a low not seen since the late 1990s. Given that corporate R&D nationally continues to rise, it is of concern that Massachusetts share of total continues to recede. This indicates that firms are increasingly diverting their R&D dollars to other locations. Biopharmaceuticals, Medical Devices, & Hardware and the Computer & Communications Hardware clusters post both the greatest ratio of R&D to sales and the greatest average sales growth. This reinforces the understanding that the Massachusetts Innovation Economy excels at translating initial R&D expenditures into downstream revenue for firms in select clusters.

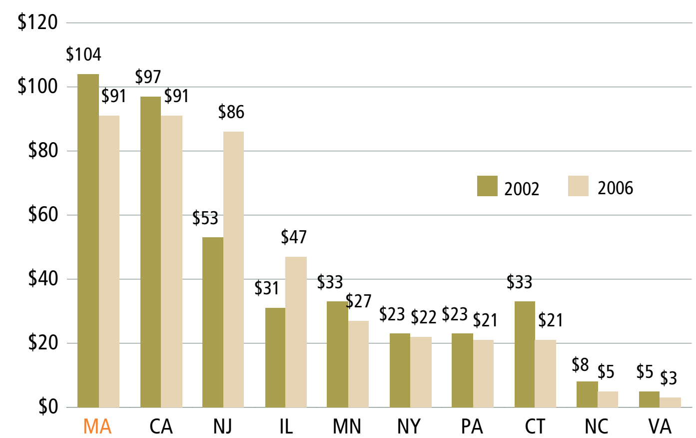
Indicator #11 Key Takeaways:

- Although Corporate R&D expenditures in Massachusetts reached record levels in 2006, corporate R&D expenditures as a share of the US total is at its lowest point since 1998.
- Biopharmaceuticals, Medical Devices, & Hardware and the Computer & Communications Hardware clusters post double digit growth in corporate sales with 19% and 12% respectively and invest a high proportion of their sales in R&D.
- Corporate R&D spending in the Software & Communications Services cluster has yet to return to 2002 levels.

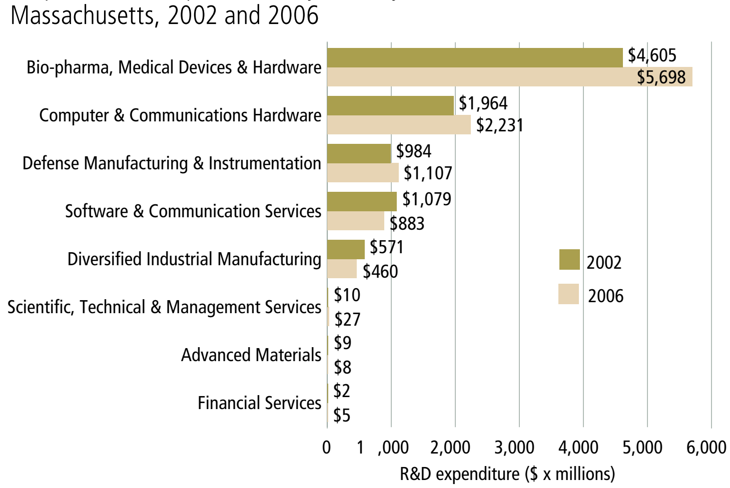
Corporate research and development (R&D) expenditure and as a percent of total US corporate R&D expenditure, publicly traded companies, Massachusetts, 1996-2006



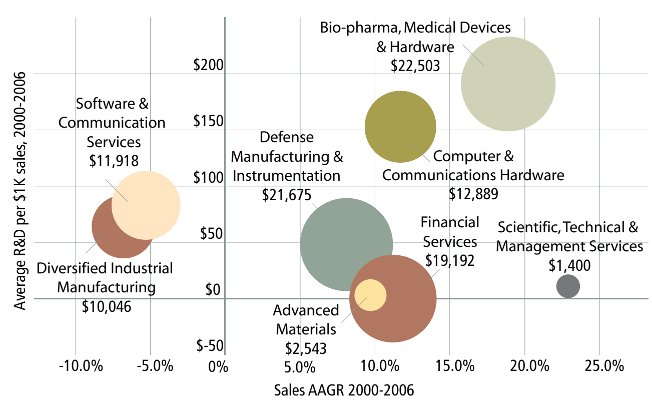
Corporate R&D expenditures, per $1K of corporate sales, LTS, 2002 and 2006



Corporate R&D expenditures by industry cluster, Massachusetts, 2002 and 2006



Corporate sales and R&D expense per $1,000 in sales, and AAGR, 2002-2006



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

Patent Applications, Patent Awards, and Invention Disclosures Applications

Why Is It Significant?

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

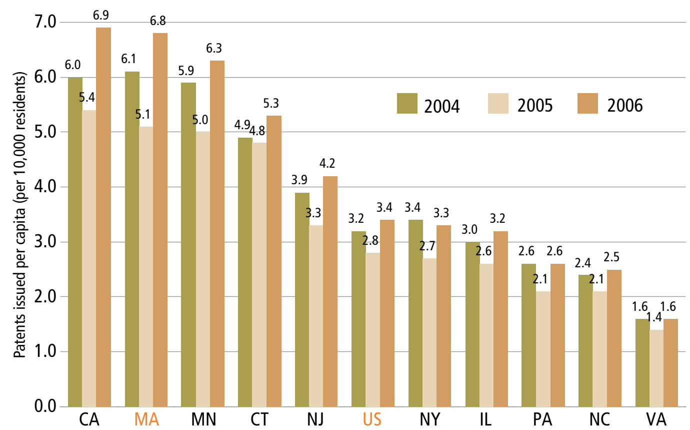
How Does Massachusetts Perform?

Massachusetts remains highly inventive and innovative among the LTS, with patent awards per capita on par with its co-competitors of California and Minnesota. For the period 2002–2006, an up-tick of seven percentage points is seen in the share of total patent awards made in the Computer Hardware & Software sector when compared to the period 1997–2001. But counter-intuitively, given the sophistication, size, and growth in Massachusetts in healthcare R&D spending, the percentage of total patents in healthcare from 2002–2006 declined by approximately six points when compared to the same share in 1997–2001. Patent applications and invention disclosures by universities, hospitals and non-profit institutions declined from historic highs in 2004, but were still significantly higher than in 2001–2003.

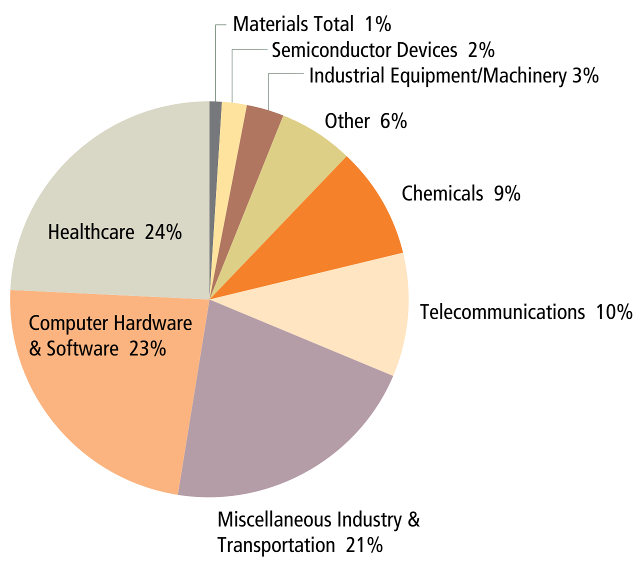
Indicator #12 Key Takeaways:

- Massachusetts entrepreneurs, inventors, research institutions, and companies remain a robust producer of patent applications and issued patents with consistently high rates per capita.
- In terms of the distribution of patents issued, the Computer Hardware & Software sector represents an increasing share of patents awarded, while patents in the Healthcare sectors show modest declines.
- Data for 2005 indicate that total invention disclosures and patent applications from academic and non-profit institutions have declined in Massachusetts since historic highs in 2004.

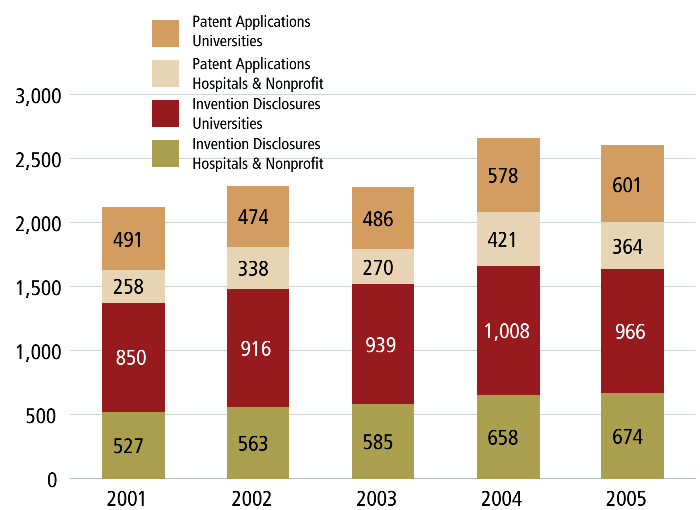
Patents issued per capita, LTS, 2004–2006



Distribution of patents awarded in Massachusetts, 2002–2006



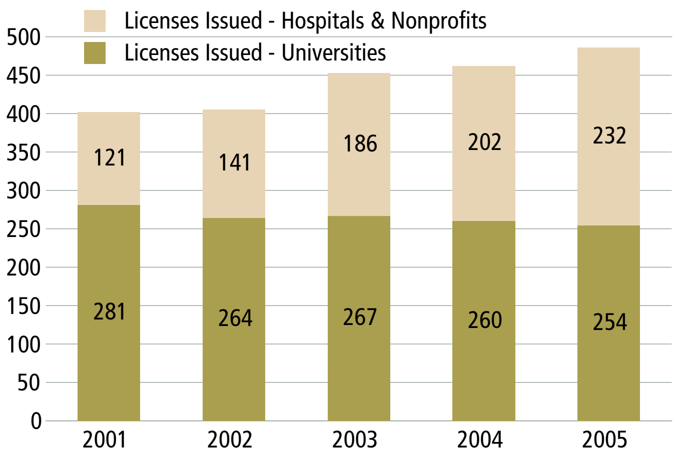
New patent applications and invention disclosures filed by Massachusetts universities, hospitals, and non-profit research institutions, 2001–2005



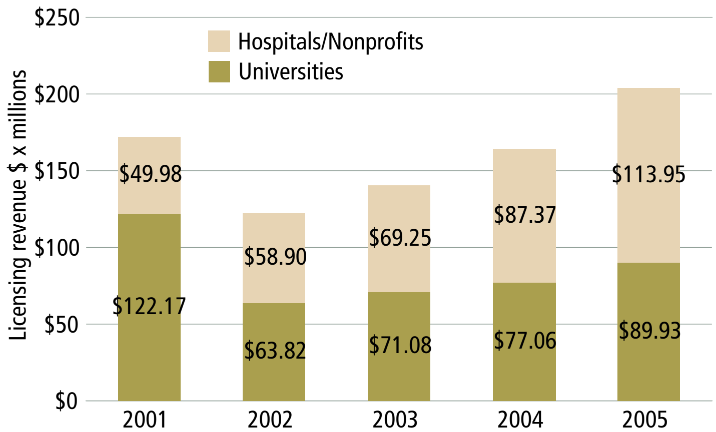
Source of all data for this indicator: US Patent and Trademark Office

Technology Licenses and Royalties

Technology licenses issued by major universities, hospitals, and other nonprofit research institutions, Massachusetts, 2001–2005



Technology licensing revenue for major universities, hospitals, and other nonprofit research institutions, Massachusetts, 2001–2005



Source: Association of University Technology Managers

Why Is It Significant?

Technology licenses provide a vehicle for the transfer of intellectual property (IP), patents and copyrights for example, from universities, hospitals, and other research organizations to companies that will ultimately commercialize the technology. The number of new technology licenses and gross royalties received are measures of the success of these technology transfer efforts. Royalties from these licenses are evidence of both the perceived value of the IP in the commercial marketplace, and also the actual revenues generated by the sales of products and services embodying the licensed intellectual capital. Royalties and license fees may also provide additional support for further research activities at licensing institutions.

How Does Massachusetts Perform?

Massachusetts academic and health infrastructures provide tremendous backend horsepower to the state's Innovation Economy. The number of licenses issued by these institutions continues to rise. The hospitals and non-profits in particular have posted strong growth in licenses issued. Since 2001, licensing revenue for hospitals has increased an average of 23% per year. Licensing revenue for non-profit institutions also has steadily increased since 2002, although not approaching the historical high of $122 million set in 2001.

Indicator #13 Key Takeaways:

- The number of licenses issued by hospitals and non-profits has consistently risen annually since 2001, nearly doubling in the period. Concurrently, the number of licenses issued by universities in 2005 is down almost by 10% compared to levels in 2001.
- Between 2001 and 2005, licensing revenue to hospitals and non-profit institutions has increased 23% on average each year.

Investment Capital

Why Is It Significant?

Venture capital (VC) firms are one of the primary sources of funds for the creation and development of new companies. The amount of and sectors where VC is invested can be predictive of employment, revenue growth, and new products and services in the Innovation Economy. VC firms often fund cutting-edge high-tech companies, many of which are relatively risky investments. Private investment capital derived from sources such as the funds of individual entrepreneurs and other "angel investors" can fill shortfalls that might exist in VC funding.

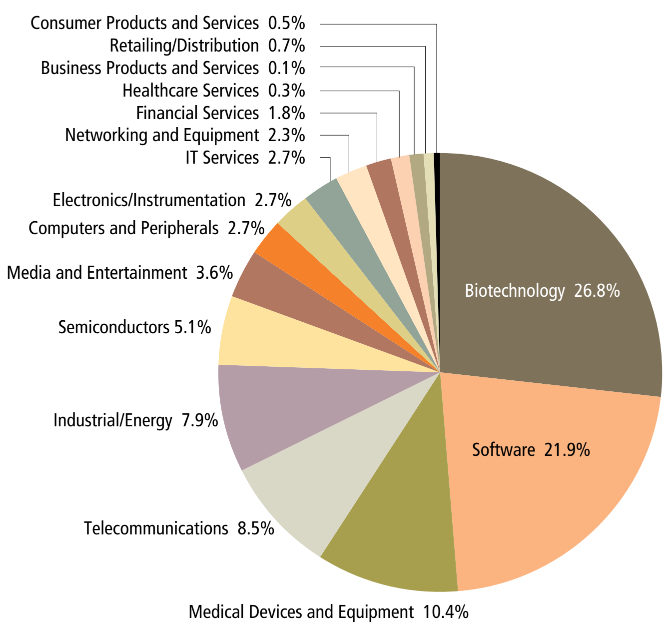
How Does Massachusetts Perform?

Massachusetts firms continue to attract a healthy share of total US VC investment at 11%, a share that has remained predominantly unchanged between 2005 and 2006, but remains below historic highs seen in 2003 of nearly 14%. California, perennially Massachusetts biggest competitor in attracting VC funds, has seen the amount of VC invested increase 7% on an average annual basis between 2002 and 2006, while Massachusetts demonstrates a more modest 3% increase during the period. Seed and start-up investments more than doubled between 2005 and 2006, consistent with trends in many of the other LTS.

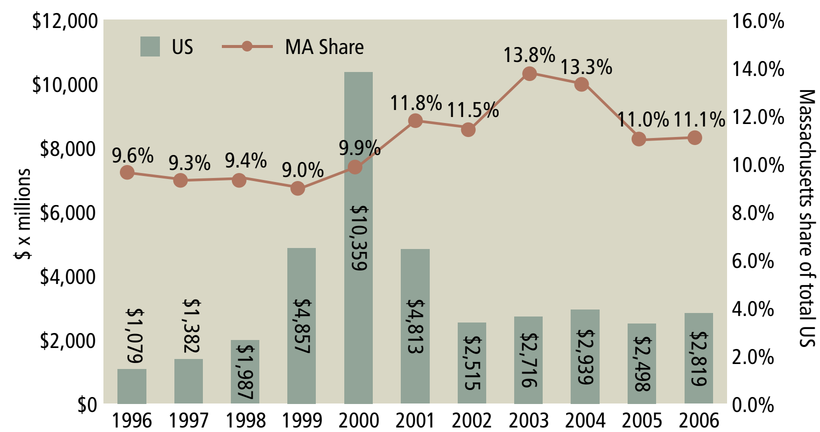
Indicator #14 Key Takeaways:

- Venture capital investment in the medical devices sector has increased by 4% since 2001 and now accounts for fully 10% of all VC invested in Massachusetts.
- Massachusetts retains a healthy 11% share of total US VC investment. Although this represents an approximate 2% decline since the record levels set in 2003 and 2004, it is comparable with levels of VC investment seen in 2001 and 2002 and significantly higher than the levels seen in the late 1990's.
- The biotechnology and software sectors attract the greatest shares of total Massachusetts VC, with 27% and 22% respectively. The state's share of VC attracted to the biotechnology sectors has more than doubled since 2001.

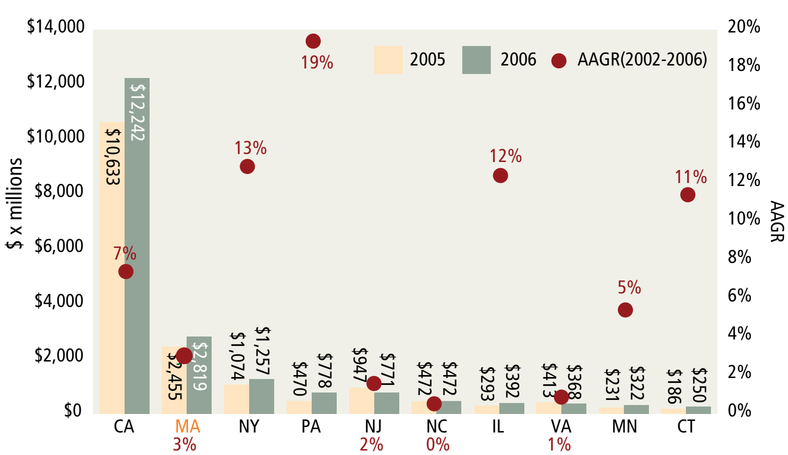
Distribution of venture capital investments in Massachusetts, 2006



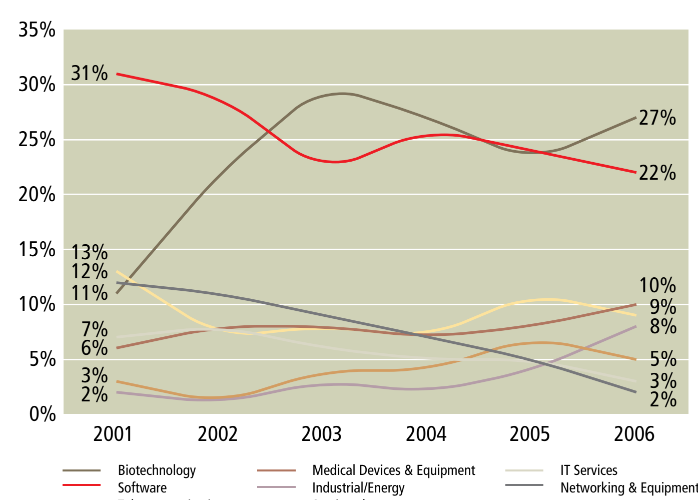
Massachusetts venture capital investment as a share to total US venture capital investment, 1996–2006



Total venture capital investment, LTS, 2002–2006



Top venture capital investment percentage by sector, Massachusetts, 2001–2006



Source of all data for this indicator: PricewaterhouseCoopers MoneyTree Report

Federal Academic and Health R&D Expenditures

Why Is It Significant?

The primary source of funds for academic research in the US is the federal government. Research universities and other academic centers are pivotal in the Massachusetts economy because they create technology that can be licensed to the private sector for development and commercialization. R&D conducted by academic institutions also has a pronounced effect in stimulating private sector R&D investments.

The National Institutes of Health (NIH) is the principal source of funds for health-related research in the US and the largest source of federal funding for non-defense research. NIH-funded research is a critical driver of the Commonwealth's biotechnology, medical device, and health services industries, which together comprise a life sciences super-cluster that is currently at the core of innovation in Massachusetts.

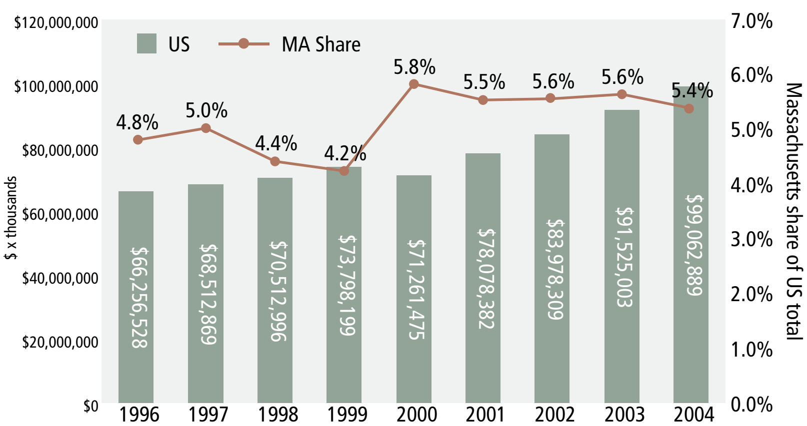
How Does Massachusetts Perform?

In line with historical trends, Massachusetts continues to perform very well in attracting federal R&D monies on a per capita basis. With $827 in federal R&D invested per resident in 2004, Massachusetts trails only Virginia. Focusing on total expenditures in the academic, non-profit, and health-related arenas exclusively, Massachusetts performance is unmatched, outpacing the next nearest LTS by more than two-to-one on both counts. Total federal R&D spending, however, increased 8% between 2003 and 2004, while Massachusetts share of this growing pool of funds remained static.

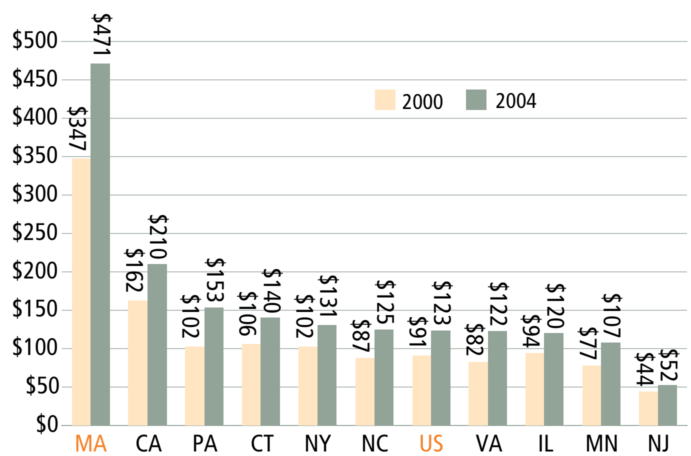
Indicator #15 Key Takeaways:

- Massachusetts attracted $827 per resident in 2004, $176 more per resident than in 2000.
- As is the case with corporate R&D, Massachusetts share of federal R&D has remained stagnant or moderately declined since the year 2000. While total federal R&D in the US increased more than 8% between 2003 and 2004, reaching an all time high of $99 billion, Massachusetts share has remained virtually the same.

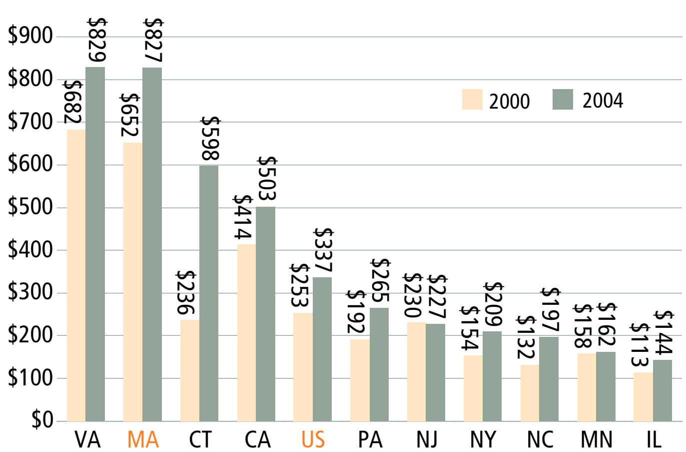
Federal R&D expenditures and Massachusetts share of total expenditure, 1996–2004



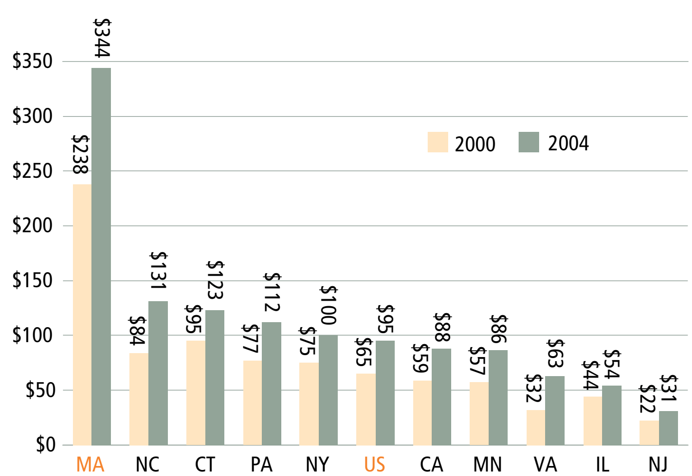
Per capita federal R&D expenditures (academic and nonprofit research), LTS and US, 2000 and 2004



Per capita federal R&D expenditures, LTS and US, 2000 and 2004



Per capita US Department of Health & Human Services (HHS) R&D expenditures, LTS and US, 2000 and 2004



Source of all data for the indicator National Science Foundation

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

Why Is It Significant?

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

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

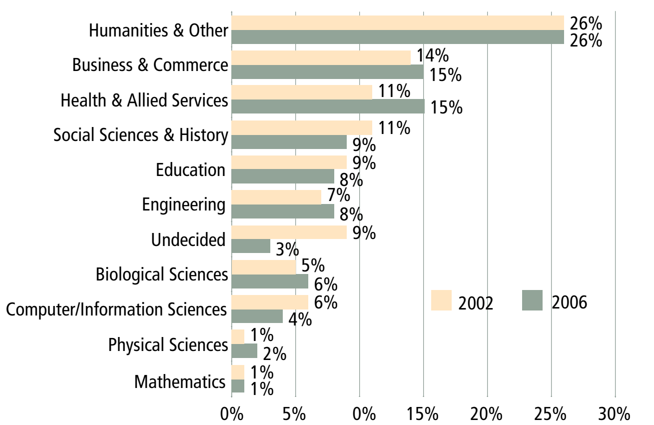
How Does Massachusetts Perform?

Interest on behalf of high school seniors in the humanities, business and management disciplines, and health and allied services remains high in Massachusetts. Unfortunately, the interest of high school seniors in basic science and mathematics remains in the single digits and trails the bulk of the LTS. High school drop-out rates are at their lowest levels in four years and are below the US average rate. The pipeline for talent in the life sciences, especially in health and biological sciences, continues to be a source of concern. A smaller percentage of Massachusetts seniors intend to pursue these disciplines than those in California, Virginia, North Carolina, and other competitor states. In terms of engineering and related disciplines, interest in pursuing this field of study at the college level is decreasing across the LTS. Massachusetts has only 11% of its graduating seniors expressing interest in engineering, trailing not only the US average, but many competitor states as well.

Indicator #16 Key Takeaways:

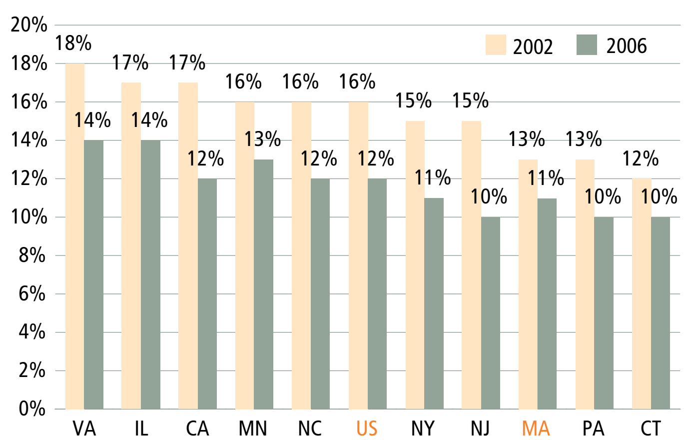
- The interest of high school seniors in allied health or biology majors has increased 5% since 2002 to 21%, but remains significantly less than percentages in other states.
- In line with an LTS-wide trend, Massachusetts high school seniors planning to major in computer or information science or engineering has declined since 2002, to 1% below the US average and fully 3% less than Virginia and Illinois.
- Massachusetts high school drop-out rate is down to 3.3%, which is below the US average of 3.5% and at its lowest point since the 2002-2003 academic year.

Distribution of intended college majors of high school seniors, Massachusetts, 2002 and 2006



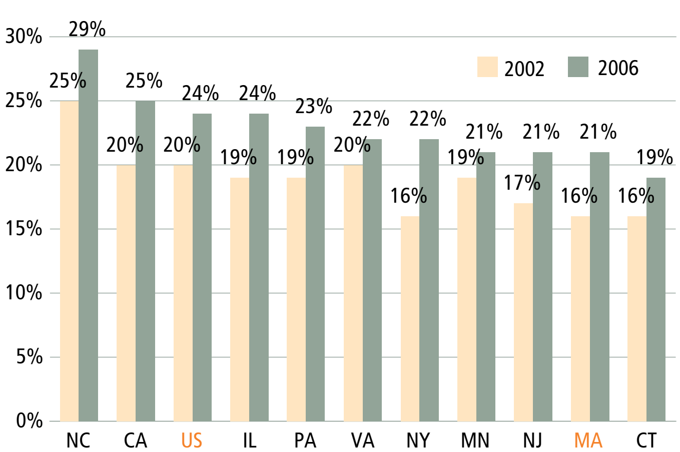
Source: The College Board

Percentage of high school seniors planning to major in Computer, Engineering, or Information Science, LTS and US, 2002 and 2006



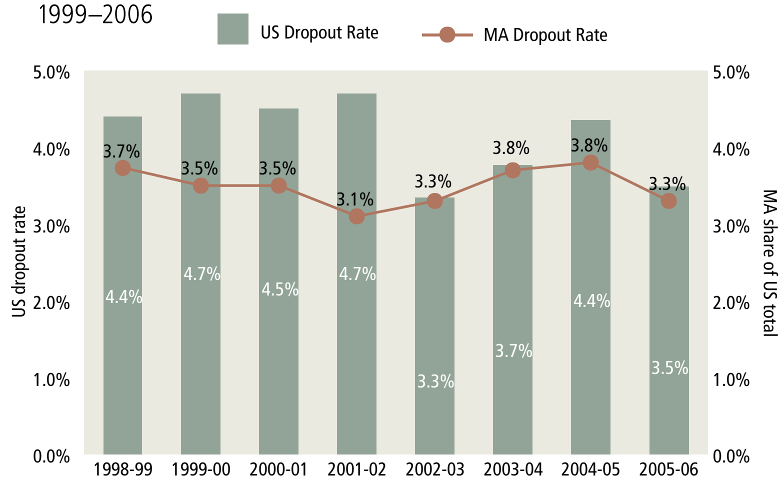
Source: The College Board

Percentage of high school seniors planning to major in Health and Allied Services or Biological Sciences, LTS and US, 2002 and 2006



Source: The College Board

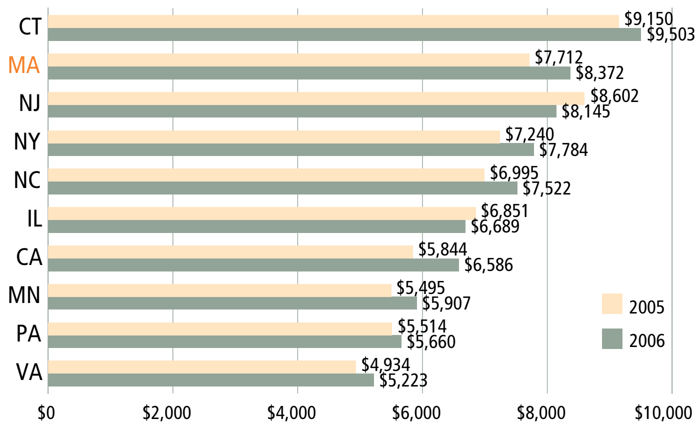
High school dropout rates, grades 10–12, Massachusetts and US, 1999–2006



Source: US Census Bureau and the Massachusetts Department of Education

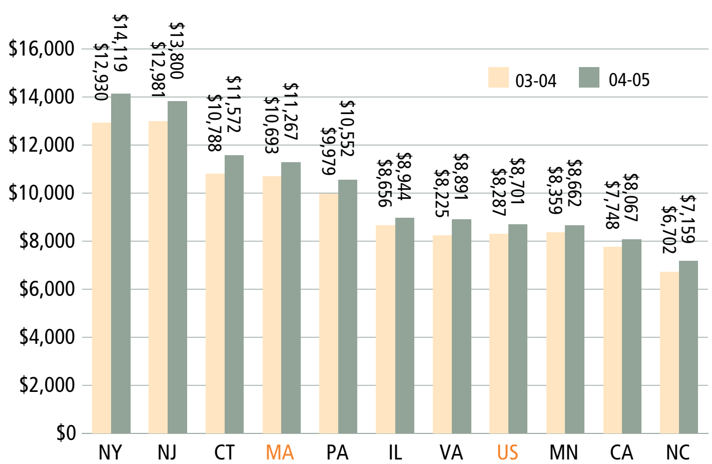
Public Secondary and Higher Education Expenditures

Higher education appropriations per full-time equivalent (FTE) student, LTS, 2005 and 2006



Source: The Grapevine Project, Illinois State University

Per pupil spending of public elementary/secondary school systems, LTS and US, 2003–2005



Source: US Census Bureau

Why Is It Significant?

Quality K-12 programs complemented by local colleges and universities help create a diverse and well-educated population and provide the knowledge and skills required by the businesses and the workforce of the Innovation Economy. Investments in public postsecondary education are important for increasing the capacity of these academic institutions to attract and train talented students from within Massachusetts and beyond. Investments in elementary, middle and high schools and in the state's public colleges and university system are vitally important in generating a broad-based, well-educated workforce, critical for bolstering the region's overall infrastructure for innovation.

How Does Massachusetts Perform?

Per enrolled student, Massachusetts continues to invest in its public higher education system at a relatively high level, more than $8,300 per full-time equivalent (FTE) student trailing only Connecticut in amount invested in 2006. Per pupil spending in Massachusetts at the elementary and secondary school levels exceeded most of the LTS and the US average with more than $11,000 spent per pupil in the 2004-2005 school year, an increase of more than $500 per student from the pervious year.

Indicator #17 Key Takeaways:

- Massachusetts trails only Connecticut among the LTS in terms of public higher education expenditures per enrolled student.
- At the primary and secondary school levels, Massachusetts invests more than $11K per student, but trails New York, New Jersey, and Connecticut.

Educational Attainment and Engineering Degrees Awarded

Why Is It Significant?

The educational attainment of the workforce is a fundamental indicator of how well a region can generate and support innovation-driven economic growth. Regions that are well-served by postsecondary engineering programs have a strong workforce advantage in the creation of new products and ideas. The potential pool of new engineers and scientists for technology and health-related industries offers an indication of future workforce resources for these critical clusters.

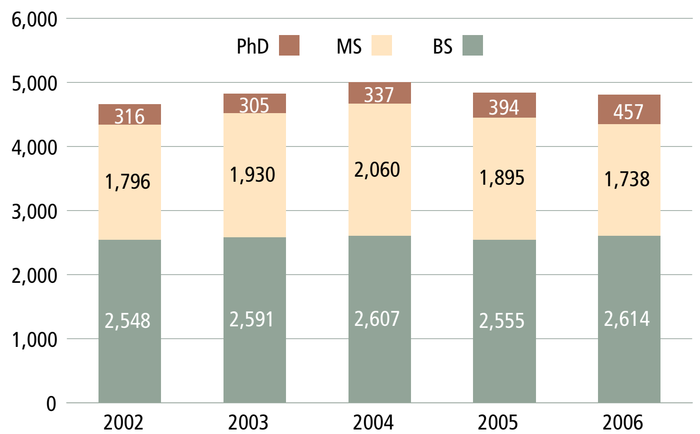
How Does Massachusetts Perform?

In terms of persons 25 years of age and older, Massachusetts remains the most highly educated of the LTS with more than 40% of its population holding a BA or higher. By this measure, Massachusetts exceeds the next highest LTS, Connecticut and New Jersey, by more than 4%. The total number of engineering degrees awarded in Massachusetts, however, is on the decline, with numbers of graduates in the discipline at the lowest level since 2002.

Indicator #18 Key Takeaways:

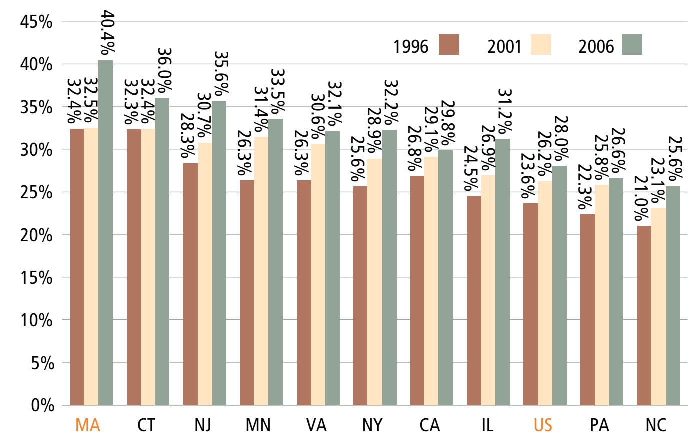
- Massachusetts continues to lead the LTS in educational attainment, with more than 40% of the population with a bachelor's degree or higher.
- Massachusetts graduated a decreasing number of engineering students in 2006 to a level of graduates not seen since 2002.
- The majority of Massachusetts engineers are trained in the electrical, computer, and mechanical disciplines. Surprisingly, barely 3% of Massachusetts engineers are trained in the emerging field of biomedical engineering.
- Massachusetts continues to graduate more engineering students at all thee levels (BS, MS, PhD) than any of the other LTS.

Number of engineering degrees awarded in Massachusetts, 2002–2006



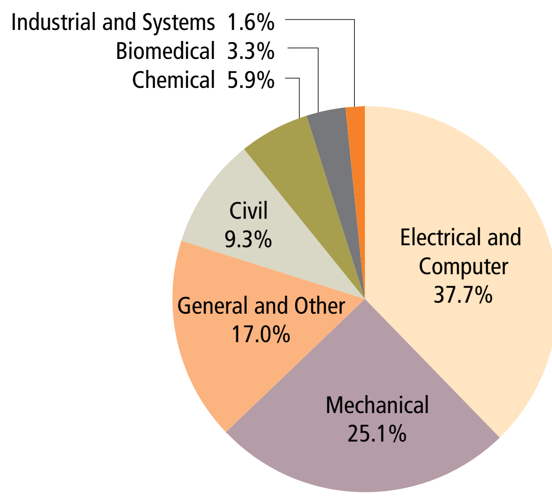
Source: American Association of Engineering Societies

Persons 25 years old and over with a bachelor's degree or higher, LTS and US, 1996, 2001, and 2006



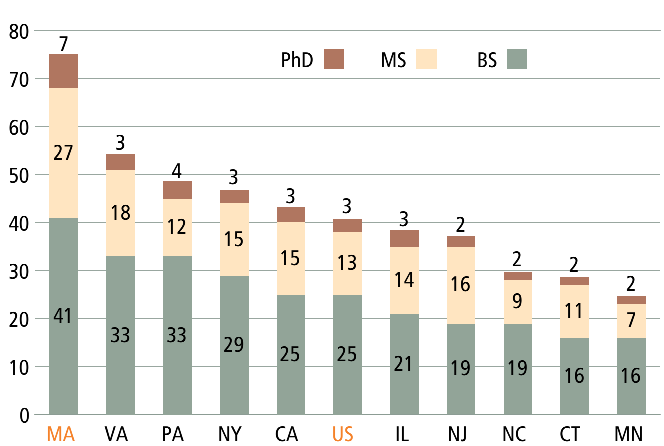
Source: US Census Bureau

Distribution of total higher education engineering degrees by discipline, Massachusetts, 2006



Source: American Association of Engineering Societies

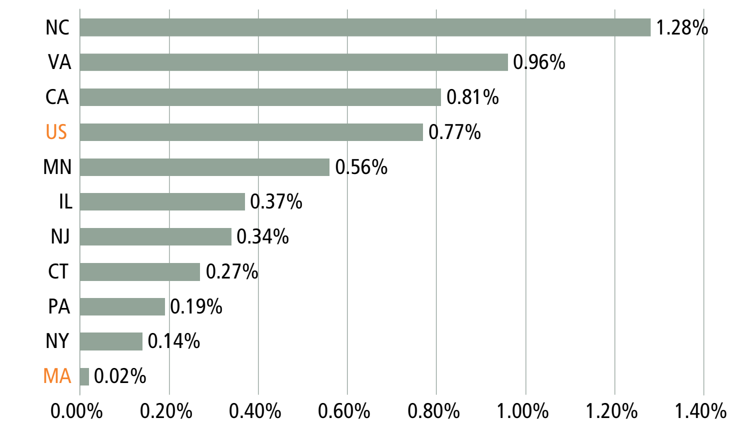
Engineering degrees awarded, per 100,000 residents, LTS and US, 2006



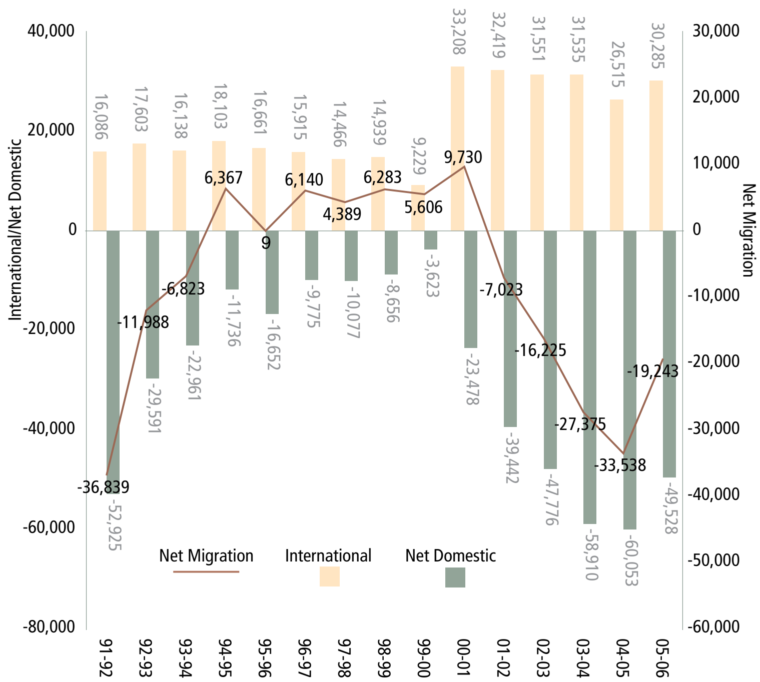
Source: American Association of Engineering Societies

Population Growth Rate and Migration

Average annual growth rate (AAGR) of population, LTS and US, 2001–2006



International and domestic migration, Massachusetts, 1996–2006



Source of all data for this indicator: US Census Bureau

Why Is It Significant?

Low population growth rates can constrain the expansion of a state's workforce and inhibit business growth and economic development. Migration thus becomes a very important indicator of a state's ability to sustain an adequate workforce to sustain the Innovation Economy. In-migration can help brace innovative industries by bringing to the state skill-sets and educational backgrounds that are in demand while out-migration may reflect a state's failure to create the opportunities necessary to retain a skilled population in the face of increasing costs of living and business costs.

How Does Massachusetts Perform?

Massachusetts continued to be the slowest growing state of any of the LTS between 2001 and 2006 with an average annual rate of growth of 0.02%. But in a reversal of historical trends, the Commonwealth attracted greater numbers of international immigrants and lost fewer residents to domestic out-migration. This easing of overall population loss is likely the result of more abundant job opportunities as reflected in growth in cluster employment and by moderating home prices between 2005 and 2006.

Indicator #19 Key Takeaways:

- Massachusetts posts the weakest average annual growth rate in population of any of the LTS, a miniscule 0.02%.
- A multi-year trend of compounding net population losses moderated in Massachusetts in 2006, with less than a 20,000 resident loss last year, compared to a loss of more than 31,000 in 2005. Decreasing domestic out-migration coupled with increasing international migration according to 2005-2006 data has helped to stem the troubling net-migration figures seen in Massachusetts since 2001-2002.

Median Price of Single-Family Homes, Home Ownership Rates, and Housing Starts

Why Is It Significant?

Affordable housing can help to attract and retain the young, highly skilled workforce that has become increasingly mobile in recent years. Home ownership rates and housing starts are also bellwethers for a state's economy. They indicate the willingness of the population to live in the state over the long term and their desire to make an investment in the community and establish personal and career roots in a region.

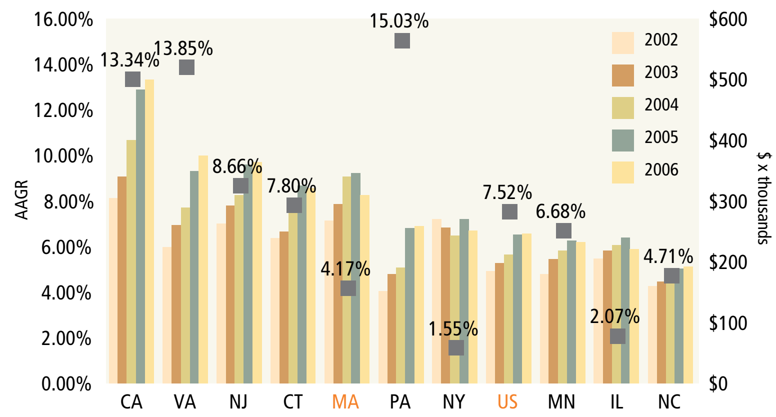
How Does Massachusetts Perform?

A challenge cited by both Massachusetts employers and employees is the chronic lack of affordable starter-housing, suitable for younger workers and their families. Given this dearth of housing options, employees seek housing in other locations and employers are left unable to retain the workers they require. As home prices have fallen since 2005, the median price of Massachusetts homes has tumbled by more than $35k, or 10%, between 2005 and 2006. In 2005, only California had a higher median price than Massachusetts among the LTS. In 2006, however, Virginia, New Jersey, and Connecticut all exceeded the median price in Massachusetts. Average annual growth rate of median price also trails the bulk of the LTS.

Indicator #20 Key Takeaways:

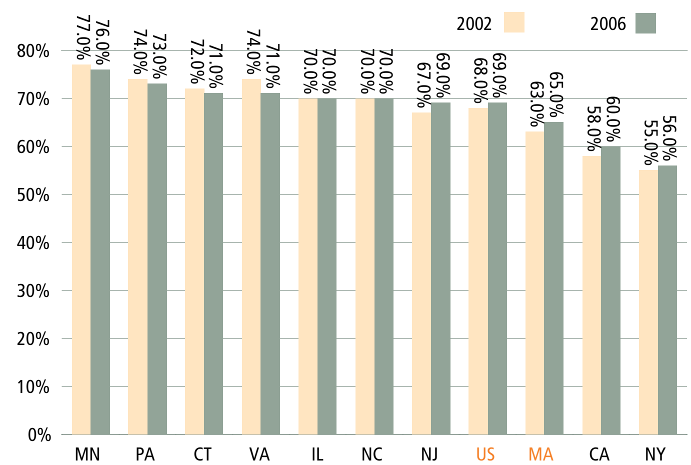
- Mirroring nationwide trends, median home price is moderating across the LTS, with Massachusetts demonstrating one of the lower growth rates between 2002 and 2006 and the sharpest decline between 2005 and 2006.
- Massachusetts' 65% rate of home ownership, while increased over 2002, still trails most LTS
- Massachusetts' number of housing starts (3 starts per 1,000 residents) is among the lowest of the LTS and less than half the number of starts seen in higher growth states such as North Carolina and Virginia.

Median home price and average annual growth rates (AAGR), LTS and US, 2002–2006



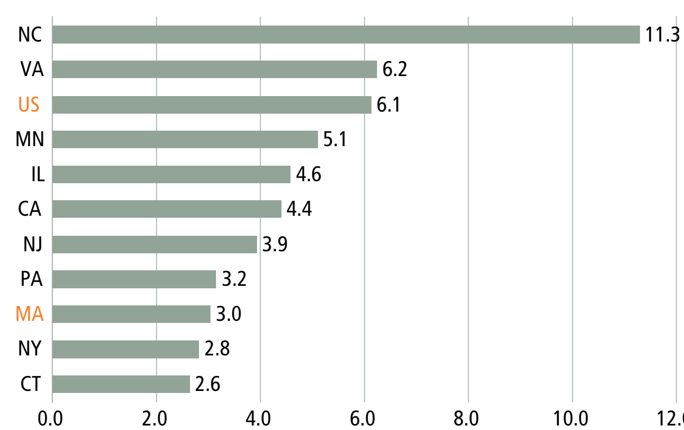
Source: Federal Housing Financing Board

Rate of home ownership, LTS and US, 2002 and 2006



Source: Federal Housing Financing Board

Per capita housing starts, per 1,000 residents, LTS and US, 2006



Source: US Census Bureau

ENDNOTES

1. "Advanced Economies" as defined by the Monitor Group's Global Cluster Mapping Initiative.
2. For global data, the Analytical Business Enterprise Research and Development (ANBERD) database and Main Science & Technology Indicators (MSTI) database, Organization for Economic Co-operation and Development (OECD). For domestic US data, Standard & Poor's Compustat database, the National Science Foundation (NSF), and US Census Bureau.
3. OECD and the United Nations Educational, Scientific, and Cultural Organization (UNESCO).
4. Global Cluster Mapping Initiative, The Monitor Group, 2007.
5. The US Department of Homeland Security (DHS), WISERTrade Export database, International Trade Centre UNCTAD/WTO.
6. The United Nations Standard Country and Area Code Classification system is used to identify countries by three character abbreviation (http://unstats.un.org/unsd/methods/m49/m49alpha.htm#ftna).
7. The top six states in rank order are California, Michigan, New York, New Jersey, Massachusetts, and Illinois. National Science Foundation (NSF), 2000.
8. The Global Innovation 1000, Booz Allen Hamilton, October 2007.
9. Purchasing power parity (PPP): A method of measuring the relative purchasing power of different countries' currencies over the same types of goods and services. Because goods and services may cost more in one country than in another, PPP allows more accurate comparisons of standards of living across countries. (Source: World Bank)
10. Gross domestic expenditure on research and development (GERD) is total intramural expenditure on research and development performed on the national territory during a given period. (Source: OECD)
11. The five clusters chosen for analysis represent the lion share of corporate R&D expenditures. The six clusters excluded from the corporate R&D analysis are generally not R&D intensive in terms of corporate spending. In Massachusetts, for example, these six excluded clusters accounted for just 0.2% of corporate R&D expenditures in 2004.
12. National Science Foundation.
13. Science Research Statistics, NSF, 2004.
14. Agency for Science, Technology, and Research, Singapore.
15. Corporate R&D data for Singapore is unavailable.
16. Dreaming With the BRICs: The Path to 2050, Goldman Sachs, 2003.
17. Office of the United States Trade Representative (USTR).
18. Innovation In Canada, http://www.innovationstrategy.gc.ca.
19. R&D data for Switzerland are not available.
20. Main Science & Technology Indicators (MSTI) database, OECD.
21. Statistics Finland, 2005.
22. Innovation Policy and Performance: A Cross-Country Comparison, OECD, 2005.
23. The Treasury of the United Kingdom's Science & innovation investment framework 2004–2014.
24. The basis for comparison is three-digit NAICS codes and the Harmonized Tariff System (HTS) to the 2-digit level for generalized categories. Exports codes (which the US calls Schedule B) are administered by the US Census Bureau. Import codes are administered by the US International Trade Commission (USITC).
25. NAICS is the North American Industrial Classification System.
26. Regional Economic Outlook Report, International Monetary Fund, October 2007.
27. See studies on employment multipliers published by the Economic Policy Institute and others.
28. A "gazelle" firm is one that has grown at 20% per year or greater for at least a five year period.
29. The percentage of employment ascribed to this cluster is derived from the US Bureau of Labor Statistics occupational categories that are related to the cluster.
30. The percentage of employment ascribed to this cluster is derived from the US Bureau of Labor Statistics occupational categories that are related to the cluster. The remainder of employment for NAICS 5417 is ascribed to the Scientific, Technical, & Management Services cluster.
31. The percentage of employment ascribed to this cluster is derived from the US Bureau of Labor Statistics occupational categories that are related to the cluster.
32. Excluding employment for NAICS 6215 which is ascribed to the Biopharmaceuticals, Medical Devices, & Hardware cluster.

APPENDIX A ECONOMIC OVERVIEWS OF GLOBAL REGIONS

Thumbnail sketches of each of the innovation economies and regions analyzed in the 2007 *Index* of the Massachusetts Innovation Economy (Compiled using data and information from The World Factbook, US Central Intelligence Agency [CIA], 2007)

ECONOMIC OVERVIEW: ASIA-PACIFIC

JAPAN (JPN)
Government-industry cooperation, a strong work ethic, mastery of high technology, and a comparatively small defense allocation (1% of GDP) have helped Japan advance with extraordinary rapidity. Japan ranks as the second most technologically powerful economy in the world after the US and the third-largest economy in the world after the US and China, measured on a purchasing power parity (PPP) basis. For three decades, overall real economic growth had been impressive—a 10% average in the 1960s, a 5% average in the 1970s, and a 4% average in the 1980s. Growth slowed markedly in the 1990s, averaging just 1.7%, largely because of lingering effects of overinvestment and an asset price bubble during the late 1980s that required protracted time for firms to reduce excess debt, capital, and labor. From 2000 to 2001, government efforts to revive economic growth proved short-lived and were hampered by the slowing of the US, European, and other Asian economies. In 2002–06, growth improved and the lingering fears of deflation in prices and economic activity lessened. Japan's enormous government debt, which totals 176% of GDP, and the aging of the population are two major long-term challenges.

GDP – real growth rate	2.2%
GDP – per capita (PPP)	$33,100
GDP – by sector	Agriculture: 1.6%
	General industry: 25.3%
	Services: 73.1%
Labor force	66.4 million
Labor force – by occupation	Agriculture: 4.6%
	General industry: 27.8%
	Services: 67.7%

REPUBLIC OF SOUTH KOREA (KOR)
In the last forty years, South Korea has an incredible record of growth and integration into the high-technology-driven, modern world economy. In the 1960s, GDP per capita was comparable with that of second and third world countries of Africa and Asia. But by 2004, the value of South Korea's economy exceeded one trillion dollars. Today its GDP per capita is equal to the smaller economies of the EU. These successes were achieved out of close government/business cooperation, including import restrictions and sponsorship of specific industries. The government promoted the import of raw materials and technology rather than consumer goods, encouraged a higher savings rate, and focused on investment over consumption. The Asian financial crisis of 1997–98 caused a GDP plunge of 6.9% in 1998, with recovery of 8%–9% by the year 2000. As a result of the global economic downturn and falling exports, growth fell back to 3.3% in 2001. Led by consumer spending and exports, growth in 2002 was an impressive 7%, despite still anemic global growth. Between 2003 and 2006, total growth has moderated to about 4%–5%.

GDP – real growth rate	5%
GDP – per capita (PPP)	$24,500
GDP – by sector	Agriculture: 3%
	General industry: 45%
	Services: 52%
Labor force	23.8 million
Labor force – by occupation	Agriculture: 6.4%
	General industry: 26.4%
	Services: 67.2%

SINGAPORE (SGP)
Singapore has a highly developed and successful free-market economy. This city-state enjoys stable prices, and a per capita GDP equal to that of the four largest West European countries. The economy depends heavily on exports, particularly in consumer electronics and information technology products. It was especially hard hit during 2001–03 by the global recession and the slump in the technology sector. Fiscal stimulus, low interest rates, a surge in exports, and internal flexibility led to vigorous growth in 2004–06 with real GDP growth averaging 7% annually. Current government economic strategy is focused on more diverse growth that will be less vulnerable to the global demand cycle for information technology products. As a result, Singapore has attracted major investments in pharmaceuticals, medical devices and technology production—further establishing Singapore as the epicenter for Southeast Asia's financial and high-technology sectors.

GDP – real growth rate	7.9%
GDP – per capita (PPP)	$31,400
GDP – by sector	Agriculture: 0%
	General industry: 34%
	Services: 66%
Labor force	2.4 million
Labor force – by occupation	Construction: 6%
	Financial, business, and other services: 39%
	Manufacturing: 18%
	Transportation and communication: 11%

ECONOMIC OVERVIEW: BRIC COUNTRIES

BRAZIL (BRA)
Brazil's economy outperforms that of all other South American countries and is expanding its global reach beyond its large and well-developed agricultural, mining, manufacturing, and service sectors. Since 2004, Brazil has enjoyed continued growth that has yielded increases in employment and real wages. While economic management in Brazil is solid, economic weaknesses remain. The most significant are debt-related: the government's largely domestic debt increased steadily from 1994 to 2003—straining government finances—before falling as a percentage of GDP beginning in 2003.

Brazil improved its debt profile in 2006 by shifting its debt burden toward real denominated and domestically held instruments. A significant near-term challenge will be to maintain sufficient growth to generate employment and reduce the government debt burden.

GDP – real growth rate	3.7%
GDP – per capita (PPP)	$8,800
GDP – by sector	Agriculture: 8%
	General industry: 38%
	Services: 54%
Labor force	96.3 million
Labor force – by occupation	Agriculture: 20%
	General industry: 14%
	Services: 66%

RUSSIAN FEDERATION (RUS)

Russia has enjoyed eight straight years of growth, averaging 6.7% annually since the financial crisis of 1998. High oil prices and a relatively cheap ruble initially drove this growth, however, since 2003 consumer demand and, more recently, investment have played a significant role. Over the last five years, fixed capital investments have averaged real gains greater than 10% per year and personal incomes have achieved real gains more than 12% per year. Business and investor confidence in Russia's economy is on the rise, with foreign direct investment rising from $14.6 billion in 2005 to an estimated $30 billion in 2006. In 2006, Russia's GDP grew 6.6%, while inflation was below 10% for the first time in the past 10 years. Despite Russia's recent success, serious problems persist. Oil, natural gas, metals, and timber account for more than 80% of exports and 32% of government revenues, leaving the country vulnerable to swings in world commodity prices. Russia's manufacturing base is dilapidated and must be replaced or modernized if the country is to achieve broad-based economic growth.

GDP – real growth rate	7%
GDP – per capita (PPP)	$12,200
GDP – by sector	Agriculture: 5%
	General industry: 37%
	Services: 58%
Labor force	74 million
Labor force – by occupation	Agriculture: 11%
	General industry: 29%
	Services: 60%

INDIA (IND)

India's diverse economy encompasses traditional village farming, modern agriculture, handicrafts, a wide range of modern industries, and a variety of value-added services. These services are the major source of economic growth, accounting for more than half of India's output with less than one-third of its labor force. The majority of the workforce (approx. 60%) continues to be in agriculture, resulting in an economic reform program that includes developing basic infrastructure to improve the lives of the rural poor and boost economic performance. More recently, higher limits on foreign direct investment were permitted in some key sectors, such as telecommunications. The economy has posted an average growth rate of more than 7% in the decade since 1996, leading to a reduction in the poverty rate of about 10%. India achieved 8.5% GDP growth in 2006, mostly due to a significant expansion in manufacturing. India is capitalizing on a highly educated workforce, comprised of workers with good English language skills, to become a major exporter of software services and software workers. Strong growth (more than 8% in each of the last three years) combined with easy consumer credit and a real estate boom is fueling inflation concerns. The huge and growing population poses economic, and environmental challenges.

GDP – real growth rate	9%
GDP – per capita (PPP)	$3,800
GDP – by sector	Agriculture: 20%
	General industry: 19%
	Services: 61%
Labor force	509 million
Labor force – by occupation	Agriculture: 60%
	General industry: 12%
	Services: 28%

CHINA (CHN)

China's economy during the last quarter century has changed from a centrally planned system that was largely closed to international trade to a more market-oriented economy that has a rapidly growing private sector. It is now a major player in the global economy. Reforms started in the late 1970s with the phasing out of collectivized agriculture, and expanded to include the gradual liberalization of prices, fiscal decentralization, increased autonomy for state enterprises, the foundation of a diversified banking system, the development of stock markets, the rapid growth of the non-state sector, and the opening to foreign trade and investment. The restructuring of the economy and resulting efficiency gains have contributed to a more than tenfold increase in GDP since 1978. Measured on a purchasing power parity (PPP) basis, China in 2006 stood as the second-largest economy in the world after the US. In per capita terms, however, the country is still lower middle-income and 130 million Chinese fall below the international poverty line. Economic development has generally been more rapid in coastal provinces than in the interior, and there are large disparities in per capita income between regions. China has benefited from a huge expansion in computer Internet use, with more than 100 million users at the end of 2005. Foreign investment remains a strong element in China's remarkable expansion in world trade and has been an important factor in the growth of urban jobs.

GDP – real growth rate	11%
GDP – per capita (PPP)	$7,800
GDP – by sector	Agriculture: 12%
	General industry: 48%
	Services: 40%
Labor force	798 million

Labor force – by occupation	Agriculture: 45%
	General industry: 24%
	Services: 31%

ECONOMIC OVERVIEW: NORTH AMERICA

CANADA (CAN)

As an affluent, high-tech industrial society in the trillion-dollar class, Canada resembles the US in its market-oriented economic system, pattern of production, and high standard of living. In the post-World War II era, the impressive growth of the manufacturing, mining, and service sectors has transformed the nation from a largely rural economy into one of primarily industrial and urban character. The 1989 US-Canada Free Trade Agreement (FTA) and the 1994 North American Free Trade Agreement (NAFTA) spurred a dramatic increase in trade and economic integration with the US. Given its great natural resources, skilled labor force, and modern capital plant, Canada enjoys solid economic potential for growth. Prudent fiscal management has produced consecutive balanced budgets since 1997, although debate continues over how to manage the rising cost of the publicly funded healthcare system. Exports account for roughly a third of GDP. Canada enjoys a substantial trade surplus with its principal trading partner, the US, which absorbs about 85% of Canadian exports. Canada is the largest foreign supplier of energy, including oil, gas, uranium, and electric power to the US.

GDP – real growth rate	2.8%
GDP – per capita (PPP)	$35,700
GDP – by sector	Agriculture: 2.3%
	General industry: 29.2%
	Services: 68.5%
Labor force	17.6 million
Labor force – by occupation	Agriculture: 2%
	Manufacturing: 14%
	Construction: 5%
	Services: 75%
	Other: 3%

ECONOMIC OVERVIEW: WESTERN EUROPE

FINLAND (FIN)

Finland is a highly industrialized, largely free-market economy with per capita output roughly that of the UK, France, Germany, and Italy. Its key economic sector is manufacturing—principally the wood, metals, engineering, telecommunications, and electronics industries. Trade is important; exports equal two-fifths of GDP. Finland excels in high-tech exports, most notably in mobile phones. Except for timber and several minerals, Finland depends on imports of raw materials, energy, and some components for manufactured goods.

GDP – real growth rate	4.9%
GDP – per capita (PPP)	$33,500
GDP – by sector	Agriculture: 3%
	General industry: 30%
	Services: 67%
Labor force	2.6 million
Labor force – by occupation	Agriculture: 2%
	Manufacturing: 14%
	Construction: 5%
	Services: 75%
	Other: 3%

GERMANY (DEU)

Germany's affluent and technologically powerful economy—the fifth largest in the world in terms of PPP—showed considerable improvement in 2006 with 2.2% growth. After a period of stagnation with an average growth rate of 0.7% between 2001 and 2005, and chronically high unemployment, stronger growth has led to a considerable fall in unemployment to about 7% at the end of 2006. Among the most important reasons for Germany's high unemployment during the past decade were macroeconomic stagnation, the declining level of investment in plant and equipment, company restructuring, flat domestic consumption, structural rigidities in the labor market, lack of competition in the service sector, and high interest rates. The modernization and integration of the eastern German economy continues to be a costly long-term process, with annual transfers from west to east amounting to roughly $80 billion. Corporate restructuring and growing capital markets are setting the foundations that could help Germany meet the long-term challenges of European economic integration and globalization.

GDP – real growth rate	2.8%
GDP – per capita (PPP)	$31,900
GDP – by sector	Agriculture: 0.9%
	General industry: 29%
	Services: 70%
Labor force	43.7 million
Labor force – by occupation	Agriculture: 3%
	General industry: 33%
	Services: 64%

IRELAND (IRL)

Ireland is a small, modern, trade-dependent economy with growth averaging 6% per year in 1995–2006. Agriculture, once the most important sector, is now dwarfed by industry and services. Industry accounts for 46% of GDP, about 80% of exports, and 29% of the labor force. Although exports remain the primary engine for Ireland's growth, the economy has also benefited from a rise in consumer spending, construction, and business investment. Per capita GDP is 40% above that of the four big European economies and the second highest in the EU behind Luxembourg. Over the past decade, the Irish Government has implemented a series of national economic programs designed to curb price and wage inflation, reduce government spending, increase labor force skills, and promote foreign investment.

GDP – real growth rate	5.7%
GDP – per capita (PPP)	$44,500
GDP – by sector	Agriculture: 5%
	General industry: 46%
	Services: 49%
Labor force	2.1 million
Labor force – by occupation	Agriculture: 8%
	General industry: 29%
	Services: 64%

SWEDEN (SWE)

Aided by peace and neutrality for the entire 20th century, Sweden has achieved an enviable standard of living under a mixed system of high-tech capitalism and extensive welfare benefits. It has a modern distribution system, excellent internal and external communications, and a skilled labor force. Timber, hydropower, and iron ore constitute the resource base of an economy heavily oriented toward foreign trade. Privately owned firms account for about 90% of industrial output, of which the engineering sector accounts for 50% of output and exports. Agriculture accounts for only 1% of GDP and 2% of employment. The government's commitment to fiscal discipline resulted in a substantial budgetary surplus in 2001, which was cut by more than half in 2002 due to the global economic slowdown, declining revenue, and increased spending. The Swedish central bank (the Riksbank) focuses on price stability with its inflation target of 2%. Growth remained sluggish in 2003 but picked up during 2004–06.

GDP – real growth rate	4.5%
GDP – per capita (PPP)	$32,200
GDP – by sector	Agriculture: 1%
	General industry: 28%
	Services: 71
Labor force	4.6 million
Labor force – by occupation	Agriculture: 2%
	General industry: 24%
	Services: 74%

SWITZERLAND (CHE)

Switzerland is a prosperous, and stable modern market economy with low unemployment, a highly skilled labor force, and a per capita GDP larger than that of the big Western European economies. The Swiss in recent years have brought their economic practices largely into conformity with the EU's to enhance their international competitiveness. Switzerland remains a safehaven for investors, because it has maintained a degree of bank secrecy and has kept up the franc's long-term external value. Reflecting the anemic economic conditions of Europe, GDP growth stagnated during the 2001–03 period, improved during 2004–05 to 1.8% annually and to 2.9% in 2006. Unemployment remains at less than half the EU average.

GDP – real growth rate	2.7%
GDP – per capita (PPP)	$34,000
GDP – by sector	Agriculture: 2%
	General industry: 34%
	Services: 65%
Labor force	3.8 million
Labor force – by occupation	Agriculture: 5%
	Industry: 26%
	Services: 69%

UNITED KINGDOM (GBR)

The UK, a leading trading power and financial center, is one of the trillion dollar economies of Western Europe. Over the past two decades, the government has greatly reduced public ownership and contained the growth of social welfare programs. Agriculture is intensive, highly mechanized, and efficient by European standards, producing about 60% of food needs with less than 2% of the labor force. The UK has large coal, natural gas, and oil reserves; primary energy production accounts for 10% of GDP, one of the highest shares of any industrial nation. Services, particularly banking, insurance, and business services, account by far for the largest proportion of GDP while industry continues to decline in importance. GDP growth slipped in 2001–03 as the global downturn, the high value of the pound, and the bursting of the "new economy" bubble hurt manufacturing and exports. Output recovered in 2004, to 3.2% growth, then slowed to 1.7% in 2005 and 2.7% in 2006. The economy is one of the strongest in Europe; inflation, interest rates, and unemployment remain low.

GDP – real growth rate	2.8%
GDP – per capita (PPP)	$31,800
GDP – by sector	Agriculture: 1%
	General industry: 26%
	Services: 73%
Labor force	31.1 million
Labor force – by occupation	Agriculture: 1%
	General industry: 18%
	Services: 80%

APPENDIX B COMPLETE MONITOR GROUP CLUSTER DATA TABLES

TABLE 1 (COMPLETE DATA FOR FIGURE 44)

Education and knowledge creation in the BRIC Countries							
Rank	BRIC Region	Country	LQ (2006)	Employment (2004)	Employment (2006)	Employment Change (2004-2006)	Employment Growth (2004-2006)
1	St Petersburg	Russia	9.92	200,752	215,180	14,428	7.19%
2	Moscow (the city)	Russia	8.40	557,162	437,107	-120,055	-21.55%
3	Tomsk region	Russia	6.63	24,363	28,642	4,279	17.56%
4	Amapá	Brazil	5.61	16,563	17,325	762	4.60%
5	Roraima	Brazil	5.17	10,685	10,146	-539	-5.04%
6	Acre	Brazil	4.64	18,744	18,067	-677	-3.61%
7	Paraíba	Brazil	4.51	96,300	112,658	16,358	16.99%
8	Moscow region	Russia	4.17	164,077	137,518	-26,559	-16.19%
9	Kaluga region	Russia	4.04	22,495	20,709	-1,786	-7.94%
10	Rio de Janeiro	Brazil	3.76	311,600	291,790	-19,810	-6.36%
11	Nizhny-Novgorod region	Russia	3.64	79,371	81,554	2,183	2.75%
12	Distrito Federal	Brazil	3.53	71,400	65,521	-5,879	-8.23%
13	Novosibirsk region	Russia	3.46	57,971	54,210	-3,761	-6.49%
14	Rio Grande do Norte	Brazil	3.44	76,950	82,360	5,410	7.03%
15	Republic North Asetia	Russia	3.30	8,453	8,606	153	1.81%
16	Sergipe	Brazil	3.24	53,400	48,386	-5,014	-9.39%
17	Piauí	Brazil	3.10	84,000	92,053	8,053	9.59%
18	Minas Gerais	Brazil	2.80	520,300	596,695	76,395	14.68%
19	Pernambuco	Brazil	2.80	274,500	330,574	56,074	20.43%
20	Maranhão	Brazil	2.63	132,750	162,899	30,149	22.71%
Source: The Monitor Group, Global Cluster Mapping Initiative							

TABLE 2 (COMPLETE DATA FOR FIGURE 45)

Education and knowledge creation in the Advanced Economies						
Rank	Advanced Economy Region	Country	LQ (2006)	Employment (2001)	Employment (2006)	Employment Growth (2001-2006)
1	Denmark	Denmark	4.71	140,225	125,831	-10.26%
2	District of Columbia	United States	4.42	43,011	52,590	22.27%
3	Singapore	Singapore	4.19	27,912	38,390	37.54%
4	Austria	Austria	3.87	32,122	113,661	253.84%
5	Switzerland	Switzerland	3.85	122,906	135,791	10.48%
6	Iceland	Iceland	3.60	5,022	5,352	6.57%
7	SørTrøndelag	Norway	3.13	10,000	11,610	16.10%
8	Uppsala	Sweden	3.11	9,555	10,249	7.26%
9	Daejeon	South Korea	2.97	28,478	32,706	14.85%
10	Australian Capital Territory & Others	Australia	2.60	11,062	11,176	1.03%
11	Troms	Norway	2.54	4,029	4,921	22.14%
12	Massachusetts	United States	2.43	163,519	193,604	18.40%
13	Svalbard	Norway	2.32	73	74	1.37%
14	Västermbotten	Sweden	2.27	6,593	6,928	5.08%
15	Eastern Finland	Finland	2.19	12,446	13,702	10.09%
16	Northern Finland	Finland	2.13	12,599	13,567	7.68%
17	Mecklenburg Vorpommern	Germany	2.08	29,039	26,996	-7.04%
18	Sachsen Anhalt	Germany	2.00	32,534	37,276	14.58%
19	Oslo	Norway	2.00	16,013	20,407	27.44%
20	Berlin	Germany	1.99	53,848	52,082	-3.28%
Source: The Monitor Group, Global Cluster Mapping Initiative						

TABLE 3 (COMPLETE DATA FOR FIGURE 46)

Financial services in the Advanced Economies							
Rank	Advanced Economy Region	Country	LQ (2006)	Employment (2001)	Employment (2006)	Employment Growth (2001-2006)	Employment Share Change (2001-2006)
1	Singapore	Singapore	5.3	26,939	30,977	14.99%	-0.49%
2	Switzerland	Switzerland	4.69	93,817	105,427	12.38%	14.12%
3	Delaware	United States	3.57	21,484	24,818	15.52%	8.99%
4	Connecticut	United States	2.79	66,621	74,092	11.22%	8.32%
5	Hamburg	Germany	2.45	29,640	30,155	1.74%	6.03%
6	New York	United States	2.44	356,819	305,933	-14.26%	-16.16%
7	Massachusetts	United States	2.41	126,174	122,228	- 3.13%	-1.10%
8	South Dakota	United States	2.27	12,179	12,635	3.75%	0.79%
9	British Colombia	Canada	2.25	25,300	76,904	203.97%	168.70%
10	Ontario	Canada	2.23	85,200	247,093	190.02%	150.20%
11	London	United Kingdom	2.21	111,292	152,314	36.86%	32.06%
12	Pennsylvania	United States	2.08	145,731	178,976	22.81%	20.59%
13	Denmark	Denmark	2.03	32,973	34,537	4.74%	12.24%
14	New Jersey	United States	1.92	118,037	116,997	-0.88%	-3.02%
15	Rhode Island	United States	1.87	10,914	14,315	31.16%	19.39%
16	Illinois	United States	1.86	171,776	164,115	-4.46%	-2.33%
17	Austria	Austria	1.84	34,436	34,452	0.05%	-7.21%
18	District of Columbia	United States	1.82	11,737	13,759	17.23%	9.84%
19	Brussels Hoofdstedelijk Gewest	Belgium	1.79	24,577	33,525	36.41%	-28.20%
20	New South Wales	Australia	1.77	66,670	76,649	14.97%	8.80%
Source: The Monitor Group, Global Cluster Mapping Initiative							

TABLE 4 (COMPLETE DATA FOR FIGURE 47)

Financial services in the BRIC countries							
Rank	BRIC Region	Country	LQ (2006)	Employment (2004)	Employment (2006)	Employment Change (2004-2006)	Employment Growth (2004-2006)
1	Distrito Federal	Brazil	5.14	34,200	31,054	-3,146	-9.20%
2	São Paulo	Brazil	3.46	348,800	341,644	-7,156	-2.05%
3	Rio de Janeiro	Brazil	3.10	72,400	82,777	10,377	14.33%
4	Paraná	Brazil	2.86	85,250	91,311	6,061	7.11%
5	Rio Grande do Sul	Brazil	2.62	137,500	132,615	-4,885	-3.55%
6	Moscow (the city)	Russia	2.11	57,188	61,291	4,103	7.17%
7	Santa Catarina	Brazil	1.86	37,400	32,244	-5,156	-13.79%
8	Mato Grosso do Sul	Brazil	1.85	9,300	11,376	2,076	22.32%
9	Republic Mordovia	Russia	1.69	3,027	2,713	-314	-10.37%
10	Mato Grosso	Brazil	1.69	11,700	12,748	1,048	8.96%
11	Sergipe	Brazil	1.66	5,700	7,799	2,099	36.82%
12	Espírito Santo	Brazil	1.59	15,300	14,857	-443	-2.90%
13	Minas Gerais	Brazil	1.49	88,550	86,621	-1,929	-2.18%
14	Ceará	Brazil	1.38	49,500	46,487	-3,013	-6.09%
15	Aginsky Buriatsky autonomous region	Russia	1.36	29	160	131	451.72%
16	Tocantins	Brazil	1.28	2,200	4,570	2,370	107.73%
17	Paraíba	Brazil	1.24	8,550	11,816	3,266	38.20%
18	Pernambuco	Brazil	1.19	45,500	38,491	-7,009	-15.40%
19	Amazonas	Brazil	1.10	4,313	6,845	2,532	58.71%
20	Bahia	Brazil	1.10	50,850	50,398	-452	-0.89%
Source: The Monitor Group, Global Cluster Mapping Initiative							

TABLE 5 (COMPLETE DATA FOR FIGURE 48)

Biopharmaceuticals in the Advanced Economies						
Rank	Advanced Economy Region	Country	LQ (2006)	Employment 2001	Employment (2006)	Employment Growth (20012006)
1	Switzerland	Switzerland	8.69	39,283	46,351	17.99%
2	Ireland	Ireland	6.61	12,535	13,525	7.90%
3	Centre	France	5.74	12,564	23,834	89.70%
4	Denmark	Denmark	5.37	18,390	21,699	17.99%
5	Tokushima	Japan	5.14	5,195	5,609	7.98%
6	Toyama	Japan	4.39	7,533	8,410	11.64%
7	Region Wallonne	Belgium	4.10	8,922	9,546	6.99%
8	Picardie	France	3.90	7,449	10,003	34.29%
9	Uppsala	Sweden	3.88	2,250	1,932	-14.13%
10	Austria	Austria	3.61	14,591	16,028	9.85%
11	Iceland	Iceland	3.07	488	690	41.39%
12	Haute Normandie	France	3.06	11,861	8,685	-26.78%
13	Hessen	Germany	3.01	24,429	24,483	0.22%
14	Stockholm	Sweden	2.76	10,639	10,695	0.53%
15	Auvergne	France	2.67	3,517	5,827	65.68%
16	Basse Normandie	France	2.64	2,051	5,322	159.48%
17	Berlin	Germany	2.63	9,913	10,407	4.98%
18	Baden Württemberg	Germany	2.53	30,401	36,875	21.30%
19	Schleswig Holstein	Germany	2.48	6,518	7,488	14.88%
20	Rheinland Pfalz	Germany	2.31	8,728	10,410	19.27%
97	Massachusetts	United States	0.69	7,404	8,248	11.41%
Source: The Monitor Group, Global Cluster Mapping Initiative						

TABLE 6 (COMPLETE DATA FOR FIGURE 49)

Biopharmaceuticals in the BRIC countries						
Rank	BRIC Region	Country	LQ (2006)	Employment (2004)	Employment (2006)	Employment Growth (2004-2006)
1	Goa	India	27.82	7,415	8,880	19.76%
2	Himachal Pradesh	India	14.10	2,627	3,285	25.05%
3	Daman & Diu	India	11.21	4,321	6,092	40.99%
4	Hainan	China	7.76	6,198	6,725	8.50%
5	Gujarat	India	7.27	41,061	36,550	-10.99%
6	Tibet	China	7.24	1,241	1,059	-14.67%
7	Maharashtra	India	6.22	53,996	58,717	8.74%
8	Jilin	China	5.87	43,284	46,820	8.17%
9	Jiangxi	China	5.78	41,946	55,566	32.47%
10	Guangxi	China	5.58	33,366	41,547	24.52%
11	Tianjin	China	4.77	37,918	47,053	24.09%
12	Heilongjiang	China	4.65	42,126	50,412	19.67%
13	Beijing	China	4.52	39,656	45,192	13.96%
14	Hubei	China	4.43	50,930	71,009	39.42%
15	Dadra & Nagar Haveli	India	4.22	2,396	2,949	23.08%
16	Pondicherry	India	4.20	1,338	1,469	9.79%
17	Guizhou	China	4.07	21,562	22,536	4.52%
18	Uttaranchal	India	3.88	1,062	1,273	19.87%
19	Shaanxi	China	3.80	34,873	34,981	0.31%
20	Sichuan	China	3.60	57,778	66,671	15.39%
Source: The Monitor Group, Global Cluster Mapping Initiative						

TABLE 7 (COMPLETE DATA FOR FIGURE 50)

Medical devices in the Advanced Economies						
Rank	Advanced Economy Region	Country	LQ (2006)	Employment (2001)	Employment (2006)	Employment Growth (2001-2006)
1	Ireland	Ireland	15.00	14,763	19,199	30.05%
2	Fukui	Japan	9.65	8,442	8,375	0.80%
3	Switzerland	Switzerland	6.57	17,668	21,924	24.09%
4	Utah	United States	4.15	8,884	10,410	17.18%
5	Baden Württemberg	Germany	3.67	32,003	33,464	4.57%
6	Minnesota	United States	3.65	21,815	22,591	3.56%
7	Delaware	United States	3.63	1,080	3,740	246.15%
8	Denmark	Denmark	3.58	8,735	9,048	3.58%
9	Saarland	Germany	3.25	2,641	2,685	1.67%
10	Schleswig Holstein	Germany	3.20	6,541	6,050	-7.51%
11	Massachusetts	United States	2.99	20,511	22,463	9.51%
12	Hamburg	Germany	2.96	4,571	5,396	18.05%
13	Indiana	United States	2.73	16,091	18,066	12.27%
14	Iceland	Iceland	2.65	264	373	41.29%
15	Thüringen	Germany	2.51	3,234	4,355	34.66%
16	New Hampshire	United States	2.47	2,737	3,562	30.12%
17	Nebraska	United States	2.45	4,515	4,970	10.08%
18	Wisconsin	United States	2.33	10,065	14,540	44.46%
19	Rhode Island	United States	2.29	1,220	2,611	114.02%
20	Austria	Austria	2.25	6,159	6,235	1.24%
Source: The Monitor Group, Global Cluster Mapping Initiative						

TABLE 8 (COMPLETE DATA FOR FIGURE 51)

Medical devices in the BRIC countries						
Rank	BRIC Region	Country	LQ (2006)	Employment (2004)	Employment (2006)	Employment Growth (2004-2006)
1	Chandigarh(UT)	India	50.05	465	709	52.47%
2	Haryana	India	13.86	3,861	4,528	17.28%
3	Karnataka	India	8.32	3,300	4,419	33.91%
4	Pondicherry	India	7.26	360	326	-9.44%
5	Delhi	India	6.94	741	951	28.34%
6	Beijing	China	6.91	9,306	8,857	-4.82%
7	Himachal Pradesh	India	5.55	118	166	40.68%
8	Shanghai	China	4.64	19,703	12,921	-34.42%
9	Uttar Pradesh	India	4.20	2,026	2,336	15.30%
10	Sverdlov region	Russia	4.20	1,684	7,545	348.04%
11	Goa	India	4.05	174	166	-4.60%
12	Jiangxi	China	3.92	8,159	4,837	-40.72%
13	Maharashtra	India	3.81	3,543	4,614	30.22%
14	Kerala	India	3.75	760	1,029	35.39%
15	Ryazan region	Russia	3.43	582	1,462	151.20%
16	Daman & Diu	India	3.37	178	235	32.02%
17	Nizhny-Novgorod region	Russia	3.15	4,792	4,609	-3.82%
18	Gujarat	India	3.00	1,446	1,932	33.61%
19	Republic Mordovia	Russia	2.78	2,610	870	-66.67%
20	Madhya Pradesh	India	2.69	504	489	-2.98%
Source: The Monitor Group, Global Cluster Mapping Initiative						

TABLE 9 (COMPLETE DATA FOR FIGURE 52)

Analytical instruments in the Advanced Economies						
Rank	Advanced Economy Region	Country	LQ (2006)	Employment (2001)	Employment (2006)	Employment Growth (2001-2006)
1	Switzerland	Switzerland	9.74	72,376	69,013	-4.65%
2	Västermanland	Sweden	7.06	5,790	4,133	-28.62%
3	Limousin	France	5.53	5,093	9,016	77.03%
4	Akita	Japan	5.14	10,170	11,253	10.65%
5	Baden Württemberg	Germany	4.87	114,020	94,225	-17.36%
6	Nagano	Japan	4.17	29,793	18,987	-36.27%
7	Alentejo	Portugal	4.06	1,316	2,127	61.65%
8	Austria	Austria	3.80	20,493	22,427	9.44%
9	Bremen	Germany	3.58	5,227	5,026	-3.85%
10	Yamanashi	Japan	3.57	5,883	6,322	7.46%
11	Veneto	Italy	3.38	30,084	35,050	16.51%
12	Fukui	Japan	3.31	6,345	6,100	-3.86%
13	Hessen	Germany	3.30	39,905	35,679	-10.59%
14	Thüringen	Germany	3.15	12,444	11,591	-6.85%
15	HauteNormandie	France	3.10	8,042	11,688	45.34%
16	Fukushima	Japan	3.09	12,006	12,876	7.25%
17	Bayern	Germany	3.06	70,433	68,325	-2.99%
18	Yamagata	Japan	2.99	6,901	7,324	6.13%
19	Chungcheongbukdo	Korea	2.99	4,325	7,273	68.16%
20	Shimane	Japan	2.81	5,261	4,091	-22.24%
52	Massachusetts	United States	1.64	40,038	26,177	-34.62%
Source: The Monitor Group, Global Cluster Mapping Initiative						

APPENDIX C DATA SOURCES FOR INDICATORS AND SELECTION OF LTS

Data Availability
For the 2007 *Index*, data indicators were assembled using proprietary and other existing secondary sources. In most cases, data from these sources required the reconfiguration, reorganization, and recalculation of existing datasets. Since these data groupings were derived from a wide range of sources, there are variations in the time frames used and in the specific variables that define the indicators. This appendix provides notes and additional information on data sources for each indicator.

I. Selection of Leading Technology States (LTS) for Benchmarking Massachusetts Performance
A primary goal of the Index is to measure Massachusetts performance in the context of various indicators and appropriate benchmarks. The main focus of the Index is the Massachusetts Innovation Economy and Leading Technology States (LTS) with similar economic strengths were selected for the purposes of comparison. In addition to Massachusetts, the LTS includes: California, Connecticut, Illinois, Minnesota, New Jersey, New York, North Carolina, and Pennsylvania, and Virginia.

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

	CA	CT	IL	MA	MN	NC	NJ	NY	PA	VA
Advanced Materials	0.63	0.85	1.30	0.90	0.84	1.50	1.06	0.67	1.33	0.85
Biopharmaceuticals, Medical Devices, & Hardware	1.41	1.46	1.08	1.78	1.39	1.18	2.20	1.05	1.35	0.65
Business Services	1.04	0.85	0.97	1.02	0.84	0.69	1.05	1.24	0.99	1.17
Computer & Communications Hardware	1.97	1.04	0.87	1.96	1.47	1.42	0.66	0.88	1.01	0.48
Defense Manufacturing & Instrumentation	1.34	3.07	0.85	1.30	1.00	0.71	0.55	0.54	0.71	0.28
Diversified Industrial Manufacturing	0.91	1.81	1.64	1.31	1.34	0.75	0.75	0.83	1.24	0.60
Financial Services	0.93	1.60	1.22	1.49	1.17	0.86	1.26	1.55	1.08	0.69
Healthcare Delivery	0.85	1.09	1.01	1.29	1.06	0.90	1.11	1.13	1.26	0.82
Postsecondary Education	0.85	1.49	1.04	2.56	0.90	0.95	0.80	2.19	1.92	0.96
Scientific, Technical, & Management Services	1.35	1.02	1.33	1.55	0.76	0.96	1.24	0.97	1.08	1.69
Software & Communications Services	1.14	1.12	0.94	1.43	1.01	0.82	1.33	1.02	0.88	1.97
Total cluster concentrations >1.10	5	6	4	9	4	3	5	4	5	3

II. Notes on Data Sources for Individual Indicators

ECONOMIC IMPACT

1. Industry Cluster Employment and Wages
Moody's Economy.com tracks industry employment at the state level using a methodology based upon individual corporations filings with State Employment Securities Agencies (SESA) and the US Bureau of Labor Statistics (BLS). Data do not cover self-employment, employment of military personnel, or government employment. Definitions for each industry cluster are included in Appendix B.
http://www.economy.com
Data on cluster wages are from the US Bureau of Labor Statistics' (BLS) Quarterly Census of Employment and Wages (CEW). This survey assembles employment and wage data derived from workers covered by state unemployment insurance laws and federal workers covered by

the Unemployment Compensation for Federal Employees program. Wage data denote total compensation paid during the calendar quarter, regardless of when the services were performed. Wage data include pay for vacation and other paid leave, bonuses, stock options, tips, the cash value of meals and lodging, and contributions to deferred compensation plans.
http://www.bls.gov/cew/

2. Corporate Sales, Publicly Traded Companies
Corporate sales figures are provided by Standard & Poor's COMPUSTAT database. These data are derived from publicly traded corporations' annual 10k report filings with the US Securities & Exchange Commission (SEC). All sales data are aggregated to the location of the corporate headquarters.
http://www.compustat.com/www/

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

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

The 10 occupational categories included in this indicator are:

- Arts & Media: Arts, design, entertainment, sports, and media occupations
- Construction & Maintenance: Construction and extraction occupations; Installation, maintenance, and repair occupations
- Education: Education, training, and library occupations
- Healthcare: Healthcare practitioner and technical occupations; Healthcare support occupations
- Human Services: Community and social services occupations
- Life, Physical, & Social Sciences: Life, physical, and social science occupations
- Professional & Technical: Management occupations; Business and financial operations occupations; Computer and mathematical occupations; Architecture and engineering occupations; Legal occupations
- Production: Production occupations
- Sales & Office: Sales and related occupations; Office and administrative support occupations
- Other Services: Protective service occupations; Food preparation and serving related occupations; Building and grounds cleaning and maintenance occupations; Personal care and service occupations; Transportation and material moving occupations; Farming, fishing, and forestry occupations

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

4. Median Household Income
Data on median household income are from the US Census Bureau, March Current Population Survey. As recommended by the Census Bureau, a 3-year average is used to compare the relative standing of states. Income is presented in 2005 dollars.
http://www.census.gov

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

THE INNOVATION PROCESS
Business Development

6. New Business Incorporations and Business Incubators
New business incorporations data are from the Office of the Secretary of the Commonwealth of Massachusetts.
http://www.state.ma.us/sec

Data on business incubators are from the National Business Incubation Association (NBIA).
http://www.nbia.org/

7. Initial Public Offerings (IPOs) and Mergers & Acquisitions (M&As)
The total number and distribution by industry sector of filed initial public offerings (IPOs) by state and for the US are provided by Renaissance Capital's IPOHome.com, Greenwich, Connecticut. Industry classifications for IPOs are based upon the Index's definition of the ten key industry clusters.
http://www.ipohome.com

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

8. Technology Fast 500 Firms, and Inc. 500 Firms
Data for location of Technology Fast 500 companies located in Massachusetts and the LTS are provided by Deloitte and Touche, LLP. To be eligible for the Fast 500, a company must meet the following criteria: 1. Must own proprietary intellectual property or proprietary technology that contributes to a significant portion of the company's operating revenues or devotes a significant proportion of revenues to research and development of technology. Using other companies' technology in a unique way does not qualify; 2. Base-year operating revenues must be at least $50,000 USD or $75,000 CD and current-year operating revenues must be at least $5 million USD and CD. Companies are required to submit tax returns or audited financial statements with their submitted nomination to complete their eligibility; 3. Be in business a minimum of five years; 4. Be headquartered within North America. Subsidiaries or divisions are not eligible (unless they have some public ownership and are separately traded).
http://www.public.deloitte.com/fast500

Data on location of Inc. 500 companies located in Massachusetts and the LTS are from *Inc. Magazine*. The 2006 Inc. 500 list measures revenue growth from 2002 through 2005. To qualify, companies had to be U.S.-based, privately held independent – not

subsidiaries or divisions of other companies – as of December 31, 2005, and have at least $600,000 in net sales in the base year.
http://www.inc.com/inc500/

Technology Development

9. Small Business Innovation Research (SBIR) Awards
Data on SBIR awards are provided by the US Small Business Administration (SBA) and US Department of Commerce (DOC). Data are for the number and dollar value of awards distributed in each fiscal year. Phase I awards are for companies to research the technical merit and feasibility of their idea; Phase II awards build on these findings and further develop the proposed idea.
http://www.sba.gov

The distribution of SBIR and Small Business Technology Transfer (STTR) awards for Massachusetts by federal funding agency is provided by the SBA's, Tech-Net database. The STTR Program fact sheet describes the program as similar to the SBIR program in that both programs seek to increase the participation of small businesses in federal R&D and to increase private sector commercialization of technology developed through federal R&D. For both Phase I and Phase II STTR projects, at least 40% of the work must be performed by the small business, and at least 30% of the work must be performed by a non-profit research institution. Such institutions include federally-funded research and development centers (for example, US Department of Energy (DOE) national laboratories), universities, non-profit hospitals, and other non-profits.
http://tech-net.sba.gov/

10. FDA Approval of Medical Devices and Biotech Drugs
Data regarding medical device approvals in the US are provided by the US Food and Drug Administration (FDA) via the Freedom of Information Act (FOIA). Medical device companies are required to secure premarket approvals (PMAs) before intricate medical devices are allowed market entry. A 510(k) is an approval sought by a company for a device that is already on the market and is looking for approval on components that do not affect the type of device, such as new packaging or new name. 510(k)'s have a higher approval rate than PMAs and thus, are in larger numbers compared to PMAs.

Research

11. Corporate Research & Development Expenditures, Publicly Traded Companies
Corporate research & development (R&D) expenditure data are from Standard & Poor's COMPUSTAT database. These data are derived from publicly traded corporations' annual 10k report filings with the SEC. Corporate R&D expenditure totals include only those companies that reported any R&D expenditures. All data are aggregated to the location of the corporate headquarters.
http://www.compustat.com/www/

12. Patent Applications, Patent Awards, and Invention Disclosures
Patents per capita data for the LTS are provided by the US Patent and Trademark Office (USPTO).
http://www.uspto.gov

Patent distribution by industry sectors are based on analyses developed by Jaffe et al: The NBER U.S. Patent Citations Data File: Lessons, Insights, and Methodological Tools. These data comprise detailed information on almost 3 million US patents granted between January 1963 and December 1999, all citations made to these patents between 1975 and 1999 (over 16 million), and a reasonably broad match of patents to COMPUSTAT (the dataset of all firms traded in the US stock market). These datasets are described in detail in Hall, B. H., A. B. Jaffe, and M. Tratjenberg (2001). "The NBER Patent Citation Data File: Lessons, Insights and Methodological Tools." NBER Working Paper 8498. Further documentation on uses of the patent citation data is available in the book "Patents, Citations and Innovations: A Window on the Knowledge Economy," by Adam Jaffe and Manuel Trajtenberg, MIT Press, Cambridge (2002).
http://mitpress.mit.edu/main/home/default.asp?sid=944AB2DA-BD6F-4B39-8A43-6E97507A570E

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

13. Technology Licenses and Royalties
Data on licensing agreements involving Massachusetts institutions are from the Association of University Technology Managers (AUTM). These datasets are derived from the same institutions providing patent and invention disclosure information.
http://www.autm.net

INNOVATION CAPACITY
Resources

14. Investment Capital
Data for total venture capital investments, venture capital investments by industry activity, and distribution of venture capital by stage of financing are provided by PricewaterhouseCoopers LLP, Venture Economics, and the National Venture Capital Association Money Tree Survey. Industry category designations are determined by PricewaterhouseCoopers LLP, Venture Economics, and the National Venture Capital Association.
http://www.pwcmoneytree.com

Definitions for the industry classifications and stages of development used in the MoneyTree Survey can be found at the PricewaterhouseCoopers LLP website.
http://www.pwcmoneytree.com/moneytree/nav.jsp?page=definitions

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

Data on federal health R&D spending at academic and nonprofit research institutions are from the NSF. These data are for all R&D expenditures by the US Department of Health and Human Services (HHS); more than 95% of these expenditures are funded by the National Institutes of Health (NIH).

http://www.nsf.gov

16. Intended College Major of High School Seniors and High School Dropout Rates
Data for intended majors of students taking the Scholastic Aptitude Test (SAT) Reasoning Test in Massachusetts and the LTS are provided by The College Board, Profile of College-Bound Seniors. The Profile of College-Bound Seniors presents data collected from high school graduates who participated in the SAT Program. Students are counted once no matter how often they tested, and only their latest scores and most recent Student Descriptive Questionnaire (SDQ) responses are summarized. The college-bound senior population is relatively stable from year to year; moreover, since studies have documented the accuracy of self-reported information, SDQ information for these students can be considered a highly accurate description of the group.
http://www.collegeboard.com

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

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

Data on appropriations of state and local tax funds for operational expenses of public higher education are provided by the Grapevine Center for the Study of Education Policy, Illinois State University. The Grapevine Center reports on total state effort for higher education, including tax appropriations for universities, colleges, community colleges, and state higher education agencies. Examples of operating expenses include salaries and wages and maintenance of offices.
http://coe.ilstu.edu/grapevine

Raw data on total expenditures for public secondary and higher education are provided by the National Information Center for Higher Education Policymaking and Analysis. Total enrollment data are provided by the National Center for Education Statistics (NCES).
http://www.higheredinfo.org
http://nces.ed.gov/

18. Educational Attainment and Engineering Degrees Granted
Data on percent of adult population with a bachelor's degree or higher for Massachusetts, the LTS, and the US, are from the US Census Bureau, Current Population Survey.
http://www.census.gov/population/www/socdemo/educ-attn.html

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

19. Population Growth Rate and Migration
Data on population growth rate by state and the US are derived from the US Census Bureau. http://www.census.gov/popest/datasets.html

Total foreign and domestic migration data are provided by the US Census Bureau's Population Estimates Program. This dataset is an annual release that reflects estimates of the total population as of July 1st for the respective calendar year.
http://www.census.gov/popest/datasets.html

20. Median Price of Single-Family Home, Home Ownership Rates, and Housing Starts
The Federal Housing Finance Board (FHFB) provides data for median sales price of single-family homes that have been sold. Data are collected from the Finance Board's Monthly Survey of Rates and Terms on Conventional Single-Family Non-farm Mortgage Loans. Single-family homes are defined in two ways: They could be unit structures detached from any other house, such as one-family homes and mobile homes or trailers to which one or more permanent rooms have been added; and, they could be unit structures attached to another structure, but with one or more walls extending from the ground to roof separating it from the adjoining structure, such as double houses or townhouses.
http://www.fhfb.gov/

Data on homeownership rates are provided by the US Census Bureau.
http://www.census.gov

Data on total number of housing starts by state are provided by the US Census Bureau, Manufacturing, Mining, and Construction Statistics. Population data are for July 2005 and are also provided by the US Census Bureau.
http://www.census.gov/const/www/permitsindex.html

APPENDIX D

INDUSTRY CLUSTER DEFINITIONS

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

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

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

Modification to Cluster Definitions

For the purposes of accuracy, several cluster definitions were modified for the 2007 edition. The former "Healthcare Technology" cluster was reorganized into two new clusters: "Biopharmaceuticals, Medical Devices, & Hardware" and "Healthcare Delivery." The former "Textiles & Apparel" cluster was removed and replaced with an experimental "Advanced Materials" cluster. While "Advanced Materials" does not meet the most strict baseline criteria for analysis, it is included to in an attempt to quantify and assess innovative and high-growing business activities from the former "Textiles & Apparel" cluster.

With the exclusion of Advanced Materials in the 2007 edition, clusters are assembled from those interrelated NAICS code industries that have shown to be individually significant according to the above measures. The eleven key industry clusters as defined by the Index reflect the changes in employment concentration in the Massachusetts Innovation Economy over time.

Advanced Materials

3133 Textile and Fabric Finishing and Fabric Coating Mills
3222 Converted Paper Product Manufacturing
3251 Basic Chemical Manufacturing
3252 Resin, Synthetic Rubber, and Artificial and Synthetic Fibers and Filaments Manufacturing
3255 Paint, Coating, and Adhesive Manufacturing
3259 Other Chemical Product and Preparation Manufacturing
3261 Plastics Product Manufacturing
3262 Rubber Product Manufacturing
3312 Steel Product Manufacturing from Purchased steel
3313 Alumina and Aluminum Production and Processing
3314 Nonferrous Metal (except Aluminum) Production and Processing

Biopharmaceuticals, Medical Devices, & Hardware

3254 Pharmaceutical and Medicine Manufacturing
3391 Medical Equipment and Supplies Manufacturing
6215 Medical and Diagnostic Laboratories
4234[29] Professional and Commercial Equipment and Supplies Merchant Wholesalers
5417[30] Scientific Research and Development Services
3345[31] Navigational, Measuring, Medical, and Control Instruments Manufacturing

Business Services

5411 Legal Services
5413 Architectural, Engineering, and Related Services
5418 Advertising & Related Services
5614 Business Support Services

Computer & Communications Hardware

3341 Computer and Peripheral Equipment Manufacturing
3342 Communications Equipment Manufacturing
3343 Audio and Video Equipment Manufacturing
3344 Semiconductor and Other Electronic Component Manufacturing
3346 Manufacturing and Reproducing Magnetic and Optical Media
3351 Electric Lighting Equipment Manufacturing
3359 Other Electrical Equipment and Component Manufacturing

Defense Manufacturing & Instrumentation

3329 Other Fabricated Metal Product Manufacturing
3336 Engine, Turbine, and Power Transmission Equipment Manufacturing
3345 Navigational, Measuring, Electro-medical, and Control Instruments Manufacturing
3364 Aerospace Product and Parts Manufacturing

Diversified Industrial Manufacturing

3279 Other Nonmetallic Mineral Product Manufacturing
3321 Forging and Stamping
3322 Cutlery and Handtool Manufacturing
3326 Spring and Wire Product Manufacturing
3328 Coating, Engraving, Heat Treating, and Allied Activities
3332 Industrial Machinery Manufacturing
3333 Commercial and Service Industry Machinery Manufacturing
3335 Metalworking Machinery Manufacturing
3339 Other General Purpose Machinery Manufacturing
3351 Electric Lighting Equipment Manufacturing
3353 Electrical Equipment Manufacturing
3399 Other Miscellaneous Manufacturing

Financial Services

5211 Monetary Authorities – Central Bank
5221 Depository Credit Intermediation
5231 Securities and Commodity Contracts Intermediation and Brokerage

5239 Other Financial Investment Activities
5241 Insurance Carriers
5242 Agencies, Brokerages, and Other Insurance Related Activities
5251 Insurance and Employee Benefit Funds
5259 Other Investment Pools and Funds

Healthcare Delivery
621[32] Ambulatory health care services
622 Hospitals

Postsecondary Education
6112 Junior Colleges
6113 Colleges, Universities, and Professional Schools
6114 Business Schools and Computer and Management Training
6115 Technical and Trade Schools
6116 Other Schools and Instruction
6117 Educational Support Services

Scientific, Technical, & Management Services
5416 Management, Scientific, and Technical Consulting Services
5417 Scientific Research and Development Services
5419 Other Professional, Scientific, and Technical Services

Software & Communications Services
5111 Newspaper, Periodical, Book, and Directory Publishers
5112 Software Publishers
5171 Wired Telecommunications Carriers
5172 Wireless Telecommunications Carriers (except Satellite)
5173 Telecommunications Resellers
5174 Satellite Telecommunications
5175 Cable and Other Program Distribution
5179 Other Telecommunications
5181 Internet Service Providers and Web Search Portals
5182 Data Processing, Hosting, and Related Services
5415 Computer Systems Design and Related Services
8112 Electronic and Precision Equipment Repair and Maintenance

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US Bureau of Labor Statistics
US Census Bureau
US Citizenship & Immigration Services
US Department of Commerce
US Department of Homeland Security
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US Small Business Administration
US Trade Representative, Office of
Venture Economics
World Intellectual Property Organization
World Trade Organization

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