10 YEARS

of the **Index**

of the Massachusetts Innovation Economy

MASSACHUSETTS TECHNOLOGY COLLABORATIVE
John Adams Innovation Institute

Research & Analysis Advisory Board for the Index of the Massachusetts Innovation Economy

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The Massachusetts Technology Collaborative

The Massachusetts Technology Collaborative is an independent, non-partisan development agency chartered by the Commonwealth to promote new economic opportunity and foster a more favorable environment for the formation, retention, and expansion of technology-related enterprises in Massachusetts.

MTC serves as a catalyst in growing the knowledge- and technology-based industries that comprise the state's Innovation Economy and in promoting the development and use of renewable energy technologies. It is also working with major healthcare organizations to implement e-health solutions that save lives and reduce costs.

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

MTC energizes emerging markets by filling gaps in the marketplace, connecting key stakeholders, expanding broadband services, conducting critical economic analyses, and providing access to intellectual and financial capital.

The John Adams Innovation Institute

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

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

- Improve Massachusetts' competitive edge in the Innovation Economy region by region, sector by sector
- Foster new job creation and job retention in knowledge- and technology-based companies
- Strengthen industry clusters, identifying needed actions and resources through collaboration with stakeholders and policymakers
- Support rigorous collaborative research and development (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
- Secure the economic benefits of downstream production and employment as new research and technologies are commercialized in the marketplace
- Embrace fact-based understanding and analysis to shape the growth strategies for the Massachusetts Innovation Economy

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

- Cross-sector and cross-cluster collaboration
- Strategic investments
- Research and analysis
- Convening policymakers and stakeholders
- Cutting-edge initiatives

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.

Executive Summary

THE INDEX: TEN YEARS OF ANALYSIS

This year's edition of the *Index of the Massachusetts Innovation Economy* marks the tenth anniversary of its publication. Over the past decade, the *Index* has been unique in tracking the indicators of innovation and measuring the performance of Massachusetts against other Leading Technology States (LTS). At the *Index's* inception, the leadership of the Massachusetts Technology Collaborative (MTC) conceived of the report as a means of informing the public policy dialogue around economic development and underscoring the growing importance of the Innovation Economy in the Commonwealth.

Prior to publication of the *Index*, elected officials, opinion leaders, and the media described the Massachusetts economy in terms of traditional industries and manufacturing jobs in standalone fashion. There was little reference to science and technology, the institutions of research and medicine, and the connection between research, development, technology, commercialization, and new industry growth. The *Index* brought consideration of the elements of the "system of innovation" into the public discussion of the Massachusetts economy.

The tenth anniversary of the *Index* affords an opportunity for a retrospective review of the performance of the "Indicators of Innovation" with the benefit of a decade of accumulated data and analysis. It provides a means of examining longer term trends and identifying areas in which improvements are necessary in order to assure robust future growth.

To achieve these objectives, the *2006 Index* introduces new lenses to assess the ten year body of data, a *Problem Statement* and a number of complementary *Competitiveness Issues*. The *Problem Statement* considers that, even though there are recent signs of a modest jobs recovery in some key clusters, the growth in employment in the majority of these clusters is alarmingly slow when compared to the other LTS. This overarching problem is framed by a series of *Competitiveness Issues* that are detailed cumulative evaluations of factors that have been cited regularly by policy makers and industry leaders as critical components of the Innovation Economy. Commentary from respected experts and industry executives in these fields is included to provide insight on the data and trends presented by these Issues. The analysis concludes with some suggested responses and interventions to address identified weaknesses and concerns. These new elements for the *2006 Index* augment the traditional indicators of innovation, cluster analyses, and comparative LTS data.

The performance of Massachusetts in these highlighted *Issues* provides evidence of strength in the Innovation Economy in its historical areas of competitive advantage, but also significant weakness in fundamental prerequisites for robust future growth. For example:

- The Massachusetts economy remains adept in attracting research funds, in patenting activity, in venture capital funding, and in new business incorporations. However, its performance in job creation in most of the key clusters, and especially in comparison with the other LTS, is lackluster. Recent economic growth is concentrated in clusters, such as life sciences, that require extended development periods for discovery, approval, and commercialization of products. This may be a contributing factor to delays in demonstrable and comparable job growth, compounded by the steady loss of manufacturing jobs and the on-going transition of the Massachusetts economy away from manufacturing to more service-oriented enterprises.
- The Commonwealth continues to lead the LTS in per capita performance in many categories of research and development (R&D), in the efficient initial commercialization of research, and in generating new company growth. Yet, what had once been a commanding lead among the LTS is now narrowing as competition from other LTS and internationally is more aggressively and strategically focused.
- Venture capital investments in Massachusetts companies remain strong, but there has been a marked shift away from seed and start-up stages of development to more conservative, later stage investments. In addition, Massachusetts' share of total US venture capital investments has dropped from an historic high of 14% in 2003 to only 11% in 2005.
- Massachusetts has always prided itself on and promoted its highly skilled workforce. Yet, the availability of workers generally, and especially younger workers who can respond to the growth of innovation industries with the skills necessary to meet the demands of knowledge-driven companies, is declining. This is a result of the perverse combination of flat or negative population growth, continued high labor participation rates, slow growth in the labor force, and troubling trends in the interest levels of secondary school students in mathematics and science. Compounding the problem is the growing pattern of

The Commonwealth continues to lead the LTS in per capita performance in many categories of research and development, in the efficient initial commercialization of research, and in generating new company growth.

graduates from Massachusetts colleges and universities leaving the state for better job opportunities and a lower cost of living elsewhere in the United States.

- Massachusetts' businesses are expanding their presence in global markets and exports are steadily increasing. The most significant growth areas are limited to pharmaceuticals, medical instruments, and optics. Exports of computer devices and electrical machinery lag the other LTS.

Certainly, there have been recent, encouraging signs that employment losses in key industry clusters have been stemmed and that the economy may be poised for a period of modest growth. When the data is considered in the aggregate, however, Massachusetts faces a perplexing conundrum. The competitive advantages and growth potential afforded by its highly effective performance in research and development, early-stage commercialization, venture capital financing, and new company growth, as well as its capacity to capture the value-added of downstream manufacturing, could be limited by the reduced scale and skill sets of its workforce.

THE INNOVATION ECONOMY IN 2006: A CLUSTER SNAPSHOT

The strengths and weaknesses summarized above in the areas of employment, R&D, investment resources, workforce availability and skills, and global market presence, are underscored more specifically in a review of the performance of the industry clusters benchmarked by the *Index* over the last ten years. The ten key industry clusters tracked in the *Index* are the engines that drive the Massachusetts Innovation Economy. They contribute significantly to the fiscal well-being of the Commonwealth and its citizens and offer the brightest promise of future growth and prosperity. Therefore, the performance of these clusters and the impact of the identified *Competitiveness Issues* on their economic success are critically important in evaluating the vitality of the Massachusetts Innovation Economy. The *Index* highlights the following cluster-specific trends in 2006:

- **Computer & Communications Hardware.** The Computer & Communications Hardware cluster is a sector of the Massachusetts industrial base which was hit the hardest by the dot-com collapse, losing more than 30% of its employment since 2001. For the first time in five years, it shows signs of recovery, with a leveling off of the sharp decline in employment witnessed in years past. Employment opportunities in this cluster provide some of the highest relative salaries. However, the cluster faces a challenging business environment, including commoditization, low investment in R&D, stagnation in exports, and slow growth of sales among publicly traded companies. This slow growth in sales relative to other clusters in the Commonwealth and to the performance of the cluster in other LTS raises concerns about its capacity to return to the levels of business activity and employment experienced prior to 2001.
- **Defense Manufacturing & Instrumentation.** Employment in the Defense Manufacturing & Instrumentation cluster continues to shrink while employment growth in the cluster in all other LTS is increasing. Sales of Massachusetts publicly traded companies in this cluster are healthy and these firms continue to invest in R&D at a rate comparable to other LTS. The cluster appears competitive and benefits from a substantial investment of federal research funds in related technologies, and the availability of a workforce that matches its skills needs. While extensive subcontracting and productivity improvements may explain stagnant employment, it is troubling that the cluster is unable to convert its competitive strengths into healthy employment growth in Massachusetts.
- **Healthcare Technology.** Sales of publicly traded companies are growing rapidly in this cluster, growing at an average annual rate of 22% between 1996 and 2005. These companies are also investing heavily in R&D and the cluster exhibits the most rapid increase in Massachusetts exported commodities. The pipeline for new products is kept full with the highest per capita research investment in the nation in local institutions by the National Institutes of Health (NIH), a high percentage of patents awarded to research organizations, and a large number of US Food & Drug Administration (FDA) drug and device approvals. This cluster has been a cornerstone of the state's economic potential, but there are some challenges that demand immediate attention.

Competition from other LTS and other countries is aggressively challenging the Commonwealth's leadership position and making substantial inroads. In addition, the industries that comprise Healthcare Technology, despite their enviable success in sales and revenue, have not yet demonstrated the ability to substantially expand their employment base.

- **Scientific, Technical, & Management Services.** This cluster is experiencing the fastest employment growth in Massachusetts. With strong employment gains, high wages, and important intellectual contributions to the research enterprise, it is a service cluster that underpins many of the other industry clusters. It prospers in Massachusetts because of the availability of highly trained professional technology specialists and the inherent cluster base that exists in the state. The *2006 Index* underscores the growing importance of this cluster to the Massachusetts Innovation Economy as a whole.
- **Software & Communications Services.** With more than 121,000 employees, this cluster is one of the largest in the state. However, it has suffered a significant decline since 2001, shedding some 36,000 jobs. For the first time since 2001, the *2006 Index* reports employment growth and a modest recovery in public corporations' sales. Patent applications and awards in the field of computer hardware and software continue to be strong, and the level of venture capital investment in Software & Communications Services is healthy, leading all other sectors in the Commonwealth. However, since the growth of this cluster relies on the availability of a labor force with the science and math skills demanded by its industries, some of the workforce concerns raised in the *Index* must be considered in predicting future vitality, potential, and contribution of the cluster to the Massachusetts economy.
- **Postsecondary Education.** From 2004 to 2005, cluster employment in Postsecondary Education remained virtually flat and has grown at an average annual growth rate (AAGR) of less than 1% between 2001 and 2005. During the same period, California, Connecticut, Illinois, New York State, and Virginia, all posted average growth rates of 3 to 5 times that of Massachusetts. The Postsecondary Education system of universities and other institutions provide the pipeline for future skilled workers and is at the heart of the Commonwealth's system of innovation and competitive advantage. Employment in Postsecondary Education is also an indicator of the demand created by student enrollment and growth in the academic research enterprise. This sluggish rate of employment growth in our preeminent knowledge cluster is of significant concern.

The *2006 Index* documents that we are starting to recover from the sharp employment declines experienced over the last five years. The most recent monthly employment reports confirm that the recovery is continuing—and accelerating. While this is encouraging, it is still early and the employment gains have been uneven, especially when compared with the performance of the other LTS.

As the *Index* bears witness, Massachusetts is heavily reliant on the knowledge-based Innovation Economy. Like other LTS, the state has not and will not compete on a sustained basis in domestic and international markets for industry and talent on the basis of cost. We must fuel growth with the new products, technologies, and start-ups emerging from the research of our universities, nonprofit research institutions, and industrial laboratories. The genesis of this growth is three-fold: 1) the ability to attract a disproportionate share of investments from federal and industrial R&D; 2) the willingness to invest in bringing these new ideas and inventions to market, and; 3) the ability to attract and keep the best and the brightest students, entrepreneurs, and technical talent from around the world. These preconditions of innovation are the underpinning of the Massachusetts economy and there is ample cause for concern given the current realities of the state's Innovation Economy. First, federal research expenditures are flattening, especially at the NIH and other agencies that have been the largest source of R&D funding to the Commonwealth's universities and academic health centers. In addition, other states are aggressively competing for this reduced pool of federal R&D funds and investing significant amounts of their own revenues to do so. The Commonwealth also creates fewer high-tech start-ups than some of its faster growing competitors. Further, those start-ups that are formed are finding it much more difficult to find venture capitalists and other financiers willing to invest in these early, riskier stages. VC funding, not only in Massachusetts but nationally, appears to be shifting to more conservative later stage investments. Vigorous cluster employment growth requires capturing the downstream value of the expansion of these new companies and the state has not yet created the necessary economic conditions to do so. Lastly, continued population losses and the exodus of younger skilled workers will seriously undermine positive aspects of the Massachusetts Innovation Economy and make capitalizing on its inherent strengths that much more difficult going forward.

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The State of the Innovation Economy in 2006

The Massachusetts Innovation Economy is burdened by stagnant employment growth in key industry clusters, persistent emigration, and a progressively limited workforce.

Massachusetts has rebounded more slowly than competing LTS in the aftermath of the 2001 economic downturn. The after effects of the post dot-com downturn have finally fully cleared and there is some promising evidence of an ongoing recovery. Yet this progress may prove to be fleeting unless the Commonwealth can respond to the challenge by maintaining adequate human resources with the skills to sustain and augment this growth.

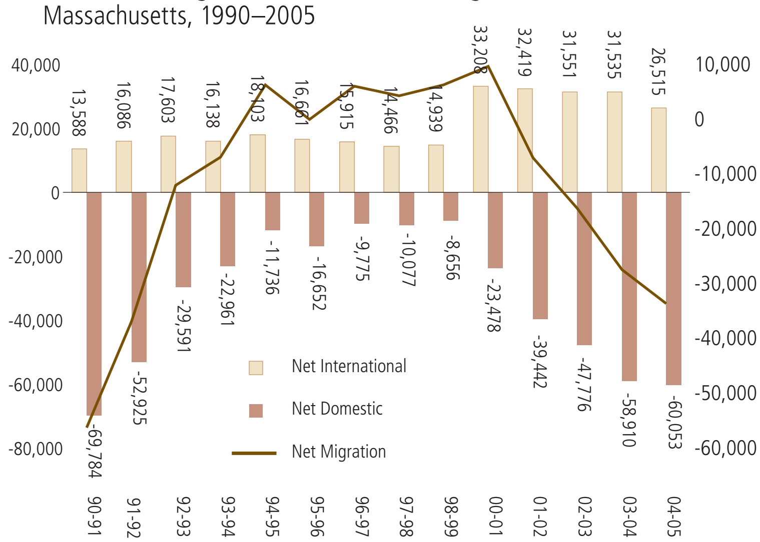
The Massachusetts research and innovation infrastructure of world-class institutions and universities is steadfast, the venture capital community thrives, and emerging global markets hold great promise. But the fundamental element that has traditionally sustained the Massachusetts economy in times of uncertainty—a highly capable and available workforce—is jeopardized by pervasive population loss and a genuine concern about the loss of key skill levels as critically important demographic groups continue to migrate out-of-state. As a result of this thinning workforce, Massachusetts may find itself sub-optimally equipped to capitalize on the next economic wave, whether fueled by advances in nanotechnology, the life sciences, the Web 2.0 and e-commerce, renewable energy, or other emerging industries or clusters.

The health of the ten industry clusters identified in the *2006 Index* is a mirror of the vitality of the Innovation Economy overall. The general state of these clusters is tested in large part by examining data for employment growth and demographic changes over time. Measurable decline in or shifts in the balance of industry clusters likely presage the weakening of a sector or a collection of sectors, identify threats to the Massachusetts Innovation Economy, and suggest explanations for underperformance. Similarly, expansion, particularly in those clusters focused on knowledge creation and early-stage development, can presage new opportunities for growth.

The underpinnings of the Massachusetts Innovation Economy are increasingly under stress given the following factors:

- **Historic and accelerated population loss continues to undercut the available labor pool.** Since 2001, Massachusetts has consistently suffered from negative net migration, losing a total of more than 60,000 residents from 2004-2005 alone, resulting in a net migration of nearly -34,000 when factoring in the addition of newly arrived residents. In the coveted 22-34 age cohort, where workers are seeking to establish both personal and career roots in a region, Massachusetts experienced a 2% decline between 2003 and 2005, the fourth largest loss among the LTS, after New Jersey, Connecticut, and Pennsylvania. Massachusetts also maintains the 3rd highest median age among the LTS, reflecting the aging of the population[1]. In the end, Massachusetts is losing a significant segment of its population, people who could fill Innovation Economy jobs now and that could respond to times of potential expansion (see Figure 2.1 and Figure 2.2).
- **Key cluster employment growth seriously lags the other LTS over a five-year period.** Of all of the LTS, when measured by either percentage change or average annual growth rate (AAGR), Massachusetts experienced the greatest decline in employment from 2001–2005 in the following four key clusters: Diversified Industrial Support, Financial Services, Healthcare Technology, and Software & Communications Services. In just the last year, however, the Software & Communications Services cluster has posted positive growth, hinting it is poised for continued growth (see Figure 2.3).

Figure 2.1:
International migration and net domestic migration, Massachusetts, 1990–2005



Source: US Census Bureau

1. US Census Bureau, American Community Survey, 2003 & 2005.

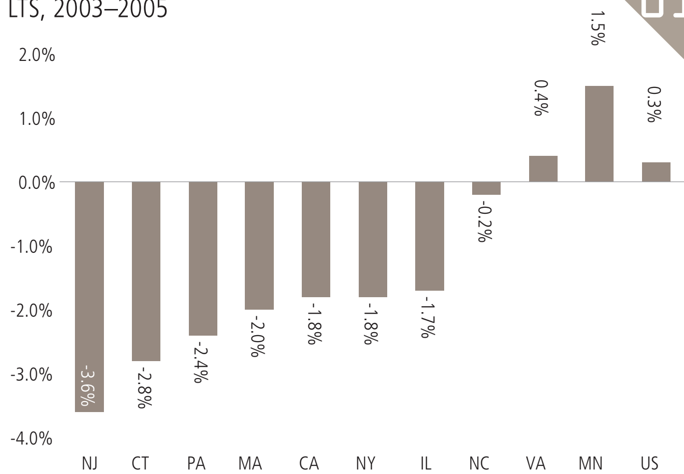
- **Continued loss of the share of defense cluster employment to other LTS.** Massachusetts experienced nearly a 2% decline in employment in its Defense Manufacturing & Instrumentation cluster from 2004 to 2005, while most of the other LTS show moderate to strong growth, especially North Carolina and Virginia. What is more, the Diversified Industrial Support and Defense Manufacturing & Instrumentation clusters combined are shedding jobs at a rate greater than any other LTS. For example, the Commonwealth lost almost 18% of jobs in the defense sector and is losing jobs at an average rate of 5% per year. Meanwhile, the cluster is increasingly fueled by the US Department of Defense (DoD), which has increased total spending 35% since 2001 in response to emerging global threats and security risks (see Figure 2.3).

Despite these negative trends, there are other positive signs for the Innovation Economy:

- **Near-term recovery in select clusters.** On an annual basis (2004-2005), employment growth in Massachusetts appears to be recovering with moderate growth rates in three select clusters: Scientific, Technical, & Management Services; Business Services; and Software & Communications Services. In the Software & Communications Services cluster, one of the Commonwealth's largest clusters with more than 121,000 employees, employment has grown at a rate greater than every other LTS, with the exception of North Carolina. When compared to the other LTS, Massachusetts has demonstrated stable employment (less than 1% change) in four key clusters. Of particular note, even though the Computer & Communications Hardware cluster lost a modest 0.4% employment, it outperformed all other LTS, excluding Virginia (see Figure 2.4).

- **Higher wages for key industry cluster jobs that consistently outpace the average annual wage for the state as a whole.** Given that the average annual wage for Massachusetts for 2005 is $45,970, average cluster wages are substantially higher in all but one cluster. Given these higher key cluster wages, it is clear that households in innovation segments of the economy are economically better off. Higher wages in general also reflect higher educational attainment and result in increased earning power for this segment. Further, wages in these industry clusters in the Commonwealth outpaced inflation, growing at an average annual rate of 4.6% between 2004 and 2005, well above the US inflation rate of 3.4% (see Figure 2.5).

Figure 2.2:
Population change of 22-34 year-olds , LTS, 2003–2005



Source: US Census Bureau

Figure 2.3: Massachusetts employment growth rate trails all LTS in four key industry clusters

LTS	% change 2001–2005	AAGR 2001–2005	LTS	% change 2001–2005	AAGR 2001–2005
Diversified Industrial Support			Healthcare Technology		
VA	-7.5%	-1.9%	MN	9.5%	2.3%
MN	-12.0%	-3.1%	NC	8.7%	2.1%
CT	-15.0%	-4.0%	CA	1.5%	0.4%
PA	-15.7%	-4.1%	VA	-0.1%	0.0%
IL	-17.0%	-4.5%	NY	-1.5%	-0.4%
NJ	-18.2%	-4.9%	NJ	-3.2%	-0.8%
NC	-18.2%	-4.9%	PA	-4.7%	-1.2%
CA	-18.8%	-5.0%	IL	-5.5%	-1.4%
NY	-22.3%	-6.1%	CT	-6.3%	-1.6%
MA	-24.7%	-6.8%	MA	-10.4%	-2.7%
Financial Services			Software & Communications Services		
NC	8.5%	2.1%	VA	-9.6%	-2.4%
CA	5.9%	1.4%	NC	-10.4%	-2.7%
MN	3.3%	0.8%	PA	-13.6%	-3.6%
VA	2.6%	0.6%	MN	-15.0%	-3.9%
NJ	0.3%	0.1%	IL	-16.7%	-4.4%
PA	-2.4%	-0.6%	CT	-17.5%	-4.6%
IL	-3.3%	-0.8%	CA	-18.7%	-4.9%
CT	-3.6%	-0.9%	NJ	-20.1%	-5.4%
NY	-5.2%	-1.3%	NY	-20.2%	-5.4%
MA	-7.8%	-2.0%	MA	-23.2%	-6.2%

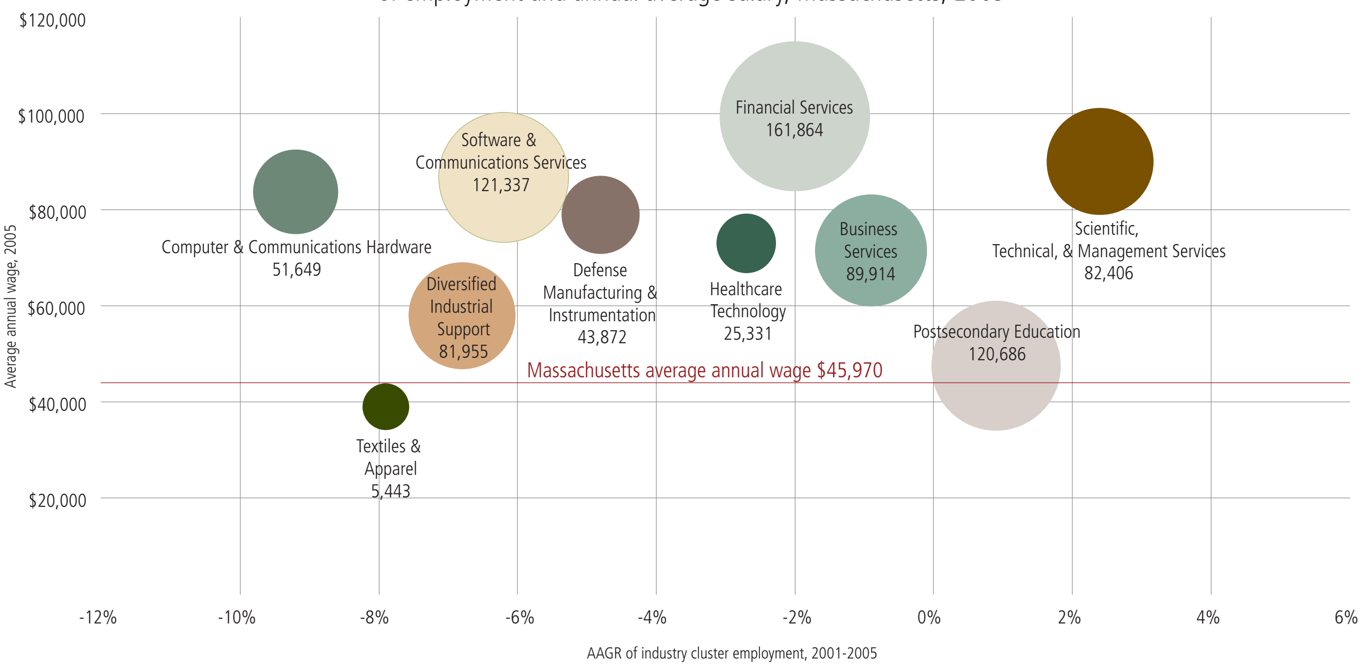
Source: Moody's Economy.com

Figure 2.4: Cluster employment percent change, LTS, 2004-2005

	MA	CA	CT	IL	MN	NJ	NY	NC	PA	VA
Computer & Comm. Hdw.	-0.4%	-1.6%	-3.3%	-2.3%	-1.2%	-1.4%	-5.2%	-0.8%	-1.3%	4.5%
Defense Mfg. & Instrument.	-1.8%	-0.3%	0.3%	0.8%	1.9%	0.0%	3.3%	6.2%	1.0%	4.1%
Diversified Ind. Support	-4.7%	-1.0%	-1.5%	-1.0%	0.2%	-1.6%	-2.9%	-1.0%	-1.2%	1.6%
Financial Services	-0.3%	1.8%	0.0%	0.3%	1.4%	1.1%	2.0%	2.2%	-0.2%	0.5%
Healthcare Technology	-0.7%	1.7%	-0.3%	-2.2%	4.3%	-2.9%	-0.7%	2.1%	-0.5%	1.5%
Sci., Tech., & Mgmt. Srvcs.	5.4%	7.0%	0.2%	4.1%	1.7%	4.2%	2.2%	6.4%	5.4%	14.1%
Business Services	1.5%	3.1%	0.0%	2.1%	-0.9%	-0.3%	1.7%	2.9%	0.7%	3.9%
Post-secondary Education	0.0%	4.8%	2.9%	5.1%	2.7%	-0.1%	1.1%	1.4%	3.3%	3.8%
Software & Comm. Srvcs.	1.9%	0.4%	-1.1%	-0.3%	-0.9%	0.2%	-0.3%	2.5%	-0.3%	-0.9%
Textiles & Apparel	-4.9%	-6.6%	-7.7%	-3.7%	-3.1%	-10.4%	-9.8%	-10.8%	-11.2%	-9.6%

Source: Moody's Economy.com

Figure 2.5:
Portfolio of ten key industry clusters in Massachusetts by average annual growth rate (AAGR) of employment and annual average salary, Massachusetts, 2005



Note: Numeral below name of occupational category is 2005 total employment
Source: Occupational Employment Statistics, US Bureau of Labor Statistics

The State of the Innovation Economy in 2006 Conclusions

- **Massachusetts is lagging in the restoration of employment in key industry clusters that yield relatively high wages.** Compared to the other LTS, Massachusetts has demonstrated only flat to modest growth in rebuilding the base of industry cluster employment. Failing to re-establish a solid, jobs-based economic foundation to the Innovation Economy makes energizing firm starts and supporting expansions more difficult. What is more, these trends indicate that Massachusetts is not expanding the pool of available employment opportunities in relatively high wage categories typically created by industry cluster firms, contributing to the exodus of younger workers and graduates. Over time, this situation could hurt prosperity and the standard of living in the Commonwealth, particularly given relatively high—and escalating—costs of living.

- **Persistent out-migration and the resulting net population losses undermine the quality and size of the available workforce.** Massachusetts has endured a net loss of more than 84,000 residents since 2001 and has lost a notable share of its younger population. This represents a drain on the overall potential of the Innovation Economy. Discouraging economic conditions are fostering out-migration and could signal to firms that Massachusetts is not in a position to provide a workforce that can satisfy either current and/or future labor demands.

- **Massachusetts is at risk of being ill-equipped to ride building economic waves and realize their benefits.** This confluence of anemic cluster growth, population loss, and a workforce stretched by declining numbers in key age cohorts endangers the Massachusetts Innovation Economy and prosperity in the state more broadly. Compounding the issue, clusters in which Massachusetts excels, such as Scientific, Technical, & Management Services, are both support systems and breeding grounds for new firms and technologies. Yet, a nurturing of product and firm outputs of these growing clusters might be stymied by an inadequate workforce capacity. While Massachusetts can still offer an impressive research and development (R&D) infrastructure and ample sources of venture capital, if current migration trends persist, the Commonwealth could find itself lacking the human capital to sustain the broader economy recovery that is portended in other indicators.

Rating Massachusetts' Keys to Competitiveness

The end game of the state's economic development strategy is to raise economic competitiveness and to position Massachusetts as a critical and highly supportive business venue for existing and emerging cluster industries. An honest assessment of both the Commonwealth's assets and its liabilities is a necessary precondition to an effective diagnosis of any existing problems and to fostering the strengths and mitigating the weaknesses seen in the Innovation Economy.

To provide context and transform the data from stark numbers and statistics into the foundation for an actionable plan to address challenges and exploit opportunities, this year's *Index* will present the data and appropriate inferences drawn through a series of oft-mentioned and prevailing *Competitiveness Issues*. These issues provide a microscope through which to probe the dynamics of the Innovation Economy and can help identify opportunities to correct systemic faults. These four key *Competitiveness Issues* are:

Competitiveness Issue #1:

Research and development investments and conversion to new technologies, products, and businesses

Competitiveness Issue #2:

The availability of capital and the quality of investment opportunities in Massachusetts relative to other LTS

Competitiveness Issue #3:

The availability of a workforce with the scalability and skills necessary to feed expansion

Competitiveness Issue #4:

Global market competition and the demands and opportunities of export growth

Competitiveness Issue #1:

Research and development investments and conversion to new technologies, products, and businesses

ISSUE AT HAND

The "system of innovation" is a perpetual cycle borne out of the critical inputs of intellectual and financial capital, translated into new technologies and products that lead to new firm formation and job creation, generating revenues that may be re-invested into the system. Research and development (R&D) investments, patent generation, and technology commercialization are among the critical foundations of the Innovation Economy. These essential elements, in a well-tuned Innovation Economy, will yield and protect new ideas, attract capital and other funding, and result in positive sales and revenue, and net economic growth.

Since the system of innovation consists of multiple components, it can also have multiple points of weakness or failure. For example, if investments (research funding, personnel infrastructure) in or by academic and other research institutions are inadequate, both the quantity and quality of the outputs will suffer. If institutions are not effectively linked to industry and to the investment community, then the knowledge/intellectual property generated will not be efficiently transferred to the marketplace. LTS endeavor to keep this engine of growth at peak performance, maximizing investments and yielding significant economic growth and benefits.

Issue Insight

Boston supplied essential support to the nation's war effort during WWII and the Cold War, and afterwards Washington turned to its two most scientifically developed regions (the San Francisco Bay area and Greater Boston) to kick-start the country's economic and technological leadership. Federal funding and venture capital at local research universities and teaching hospitals helped replace the stagnant manufacturing economy with scientific development, particularly in the field of electronics.

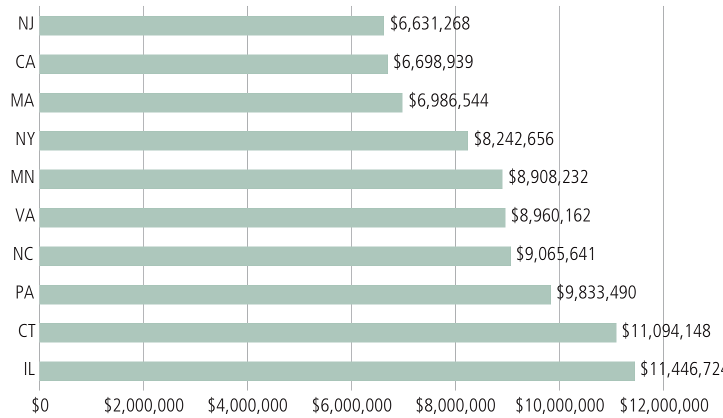
Source: Boston History & Innovation Collaborative

DATA ANALYSIS

All of the LTS have well-developed academic and industrial research infrastructures that make use of public and private research funds to initiate and foster new ideas. The end-goal is to transition these academic and/or scientific pursuits into new commercial products and services, new companies, and new jobs.

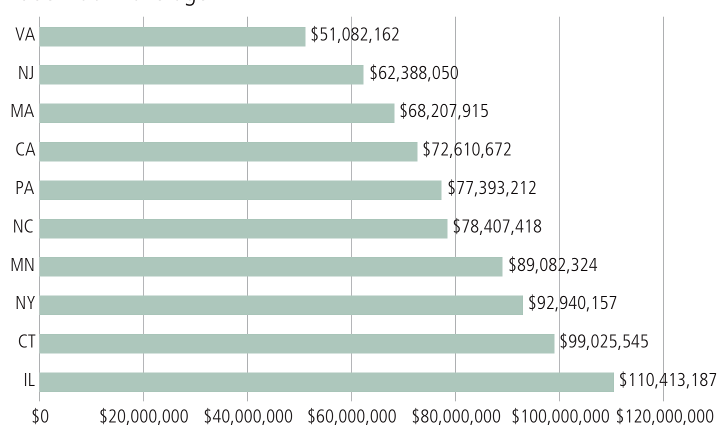
- **In general, the innovation process in Massachusetts is relatively efficient, and in many cases, best in class.** Billions of dollars are invested each year at universities and other research institutions for R&D aimed squarely at invention and innovation. In the broadest terms of patent and start-up outputs per dollar of investment, Massachusetts performs well (see Figures 3.1 and 3.2). Massachusetts also ranks at or near the top of the LTS in terms of the intermediate metrics for outputs of academic R&D, including:
  - ❍ Articles published per $M of academic R&D.
  - ❍ Articles published per thousand science & engineering (S&E) doctorates employed by academic institutions.
  - ❍ Patents per capita of S&E doctorates employed by academic institutions.
  - ❍ Patents per $M of academic R&D investment.
  - ❍ Licenses granted per $M of academic R&D investment.
- **In total patent generation, however, Massachusetts lags faster growing LTS.** Massachusetts has lost its once commanding lead in academic patent generation. In 1993, Massachusetts ranked first among the LTS and second in the nation in patents per thousand S&E doctorates employed in academic institutions. By 1999, it had dropped to second among the LTS and fourth in the nation, with a rate almost 25% less than that of California. On a broader basis, Massachusetts ranked fifth among the LTS in terms of total patents generated per thousand employees in S&E occupations, well above the US average, but significantly behind California. Overall, Massachusetts, as in most of the LTS, maintains a consistent share of total patents awarded. A notable exception to this trend is California, which has seen its share of patents awarded grow from 16-23% over the past decade. This suggests that businesses and academic institutions in California are placing a higher priority on the identification and protection of intellectual property

Figure 3.1:
Expenditure per patent issued to state institutions, 1995–2004 average



Source: Association of Technology Managers

Figure 3.2:
Expenditure per start-up Initiated from state institutions, 1995-2004–average

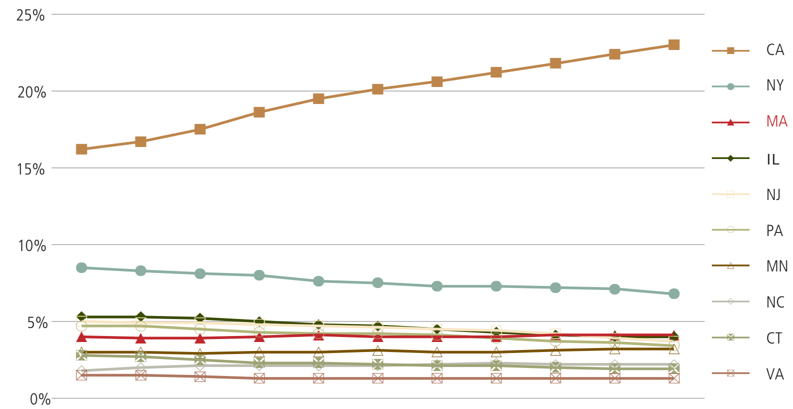


Source: Association of Technology Managers than their peers elsewhere among the LTS. As a result, Massachusetts has surrendered its five year leadership among the LTS as the state with the most patents per capita (see Figure 3.3 and Figure 3.4).

- **Despite the fact that Massachusetts is still one of the highest generators of patents per capita and in patents generated by academic institutions per $ academic R&D investment, the Commonwealth lags significantly in patents per total $ R&D investment.** Between 1995 and 2005, Massachusetts generated an average 0.27 patents per million dollars of total R&D investment, compared to a US average of 0.37, and an LTS average of 0.38. However, when compared with economic output (GSP), patent generation per million dollars of GSP in Massachusetts (0.014) appears to be strong compared to that of the other LTS (0.011) and the US as a whole (0.010). This suggests that there may be significant parts of the R&D investment in Massachusetts that are not currently generating intellectual property that is either commercially viable or that the owners view as worthy of patent protection. The academic patent data confirms that the issue is probably not in the academic research institutions. The relatively high ratio of patent generation to GSP suggests that the problem is probably not in the industrial sector either. This suggests that there may be R&D investments in some of our federal labs and nonprofits that are not resulting in patented technology. This stranded R&D investment could represent an untapped opportunity for economic development.

- **Massachusetts continues to be one of the most R&D intensive economies in the US, but appears to lag in converting investments into economic growth.** In absolute dollars, Massachusetts ranked third in the nation in total R&D investments, behind only California and Michigan. Massachusetts ranked second in terms

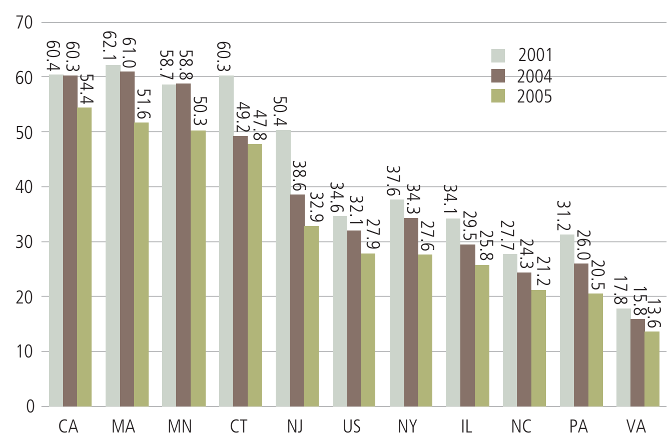
Figure 3.3:
Percentage of total US patents granted, LTS, 1995–2005



	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
CA	16.2%	16.7%	17.5%	18.6%	19.5%	20.1%	20.6%	21.2%	21.8%	22.4%	23.0%
NY	8.5%	8.3%	8.1%	8.0%	7.6%	7.5%	7.3%	7.3%	7.2%	7.1%	6.8%
MA	4.0%	3.9%	3.9%	4.0%	4.1%	4.0%	4.0%	4.0%	4.1%	4.1%	4.1%
IL	5.3%	5.3%	5.2%	5.0%	4.8%	4.7%	4.5%	4.3%	4.1%	4.0%	4.0%
NJ	5.0%	4.9%	4.9%	4.8%	4.7%	4.6%	4.5%	4.4%	4.2%	3.9%	3.7%
PA	4.7%	4.7%	4.5%	4.3%	4.2%	4.2%	4.1%	3.9%	3.7%	3.6%	3.4%
MN	3.0%	3.0%	2.9%	3.0%	3.0%	3.1%	3.0%	3.0%	3.1%	3.2%	3.2%
NC	1.8%	2.0%	2.1%	2.1%	2.1%	2.1%	2.2%	2.3%	2.2%	2.2%	2.2%
CT	2.8%	2.7%	2.5%	2.3%	2.3%	2.2%	2.1%	2.1%	2.0%	1.9%	1.9%
VA	1.5%	1.5%	1.4%	1.3%	1.3%	1.3%	1.3%	1.3%	1.3%	1.3%	1.3%

Source: US Patent & Trademark Office (USPTO)

Figure 3.4:
Patents per capita, Massachusetts, the other LTS and US, 2001, 2004, 2005



Source: US Patent & Trademark Office (USPTO)

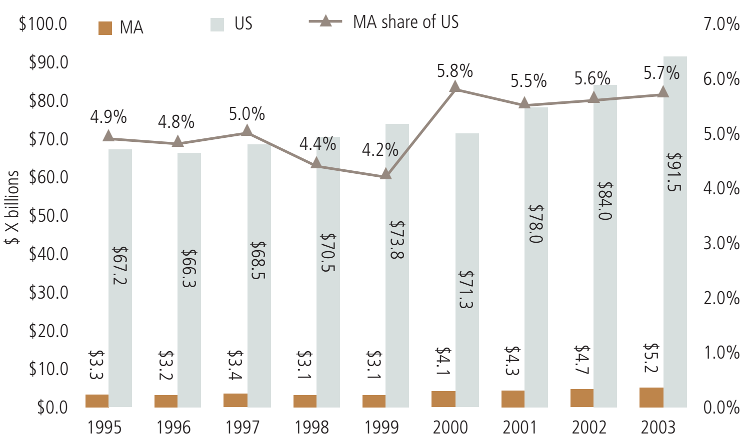
Figure 3.5: R&D and gross state product, LTS, 2002

State	R&D as Share of Gross State Product (Percent) 2002	$ GSP/ $ R&D
CA	3.76	27
CT	4.09	24
IL	2.1	48
MA	4.97	20
MN	2.62	38
NC	1.71	58
NJ	3.42	29
NY	1.69	59
PA	2.28	44
VA	2.05	49

Note: Total R&D includes R&D performed by federal agencies, industry, universities, and other nonprofit organizations. Total R&D and gross state product are reported in current dollars.

Source: National Science Foundation (NSF)

Figure 3.6:
Federal R&D expenditure and percent of total US federal R&D expenditures for Massachusetts, 1995–2003



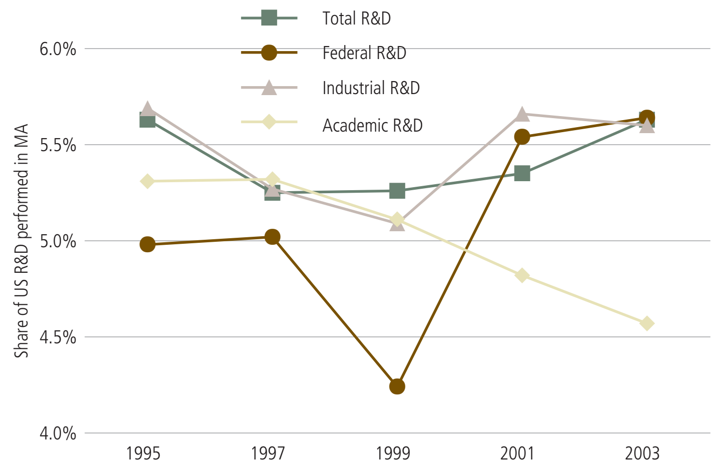
Source: National Science Foundation (NSF) and US Census Bureau

of R&D intensity, defined as the ratio of dollars invested in R&D to dollars of output as measured by gross state product (GSP). These metrics are consistent with what has been historically viewed as a core competitive advantage of the Commonwealth. However, the real issue for Massachusetts is the overall effectiveness by which these investments are converted into economic growth. In 2002, the ratio of GSP to R&D invested in the Massachusetts economy was approximately 20:1, the lowest rate among the LTS and approximately 20% less than the comparable rates in California and Connecticut (see Figure 3.5). This suggests that Massachusetts may be less efficient than its LTS peers in converting the investments in the innovation process into downstream economic growth. As noted above, this could be the result of stranded R&D investments that do not currently produce downstream economic benefit or that yield their primary economic impact outside of Massachusetts.

- **Although Massachusetts excels in attracting R&D investments, the growth rates and overall mix of investments may limit economic growth.** The R&D funding mix is much different in Massachusetts than in most of the other LTS. In 2003, 43% of the investment for research in Massachusetts came from the federal government and the state attracted nearly 6% of total federal R&D expenditure (see Figure 3.6). With the notable exception of Virginia, the level of federal funding for R&D was at or less than the national average of 35% in every other LTS. The role that federal research investments play in Massachusetts becomes even more apparent when the funding sources for research conducted by industry are examined. Twenty percent of industrial research in Massachusetts is funded by the federal government. The comparable figure for the other LTS is between 2% and 15%. This has important implications for technology commercialization. Given the high proportion of federal R&D funding, Massachusetts continues to have a very high stake in federal R&D budget decisions—particularly at a time when growth in federal support for R&D is lagging.

- **Massachusetts is successful in attracting research investments to the state, but declining market share in research performed by universities and colleges threatens their competitive advantage.** Massachusetts has generally done a good job of maintaining its disproportionate share of research investments across all classifications of R&D performers, with one notable exception. Despite the world-class reputation of Massachusetts' universities and colleges, they tend to lag their LTS counterparts in growing R&D enterprises. Fifty years ago, universities and colleges in Massachusetts performed more than 15% of the R&D conducted by academic institutions. By 1995, their share had dropped to 5.3%. Over the past decade it continued to steadily decline to 4.6% (see Figure 3.7). From 1998 to 2003, the rate of growth in academic R&D expenditure trailed all other leading technology states at 35.1% (see Figure 3.8). In 1995, Massachusetts universities and colleges received approximately 44% of the investment received by their counterparts in California, which is remarkable considering the relative population of the two states. By 2003, universities and colleges in Massachusetts received 34% of the investment of their counterparts in California. All of this confirms that Massachusetts is continuing to lose what has traditionally been viewed as one of its strongest competitive advantages to one of it strongest competitors.

Figure 3.7: R&D market share, Massachusetts, 1995, 1997, 1999, 2001, 2003



Source: National Science Foundation (NSF)

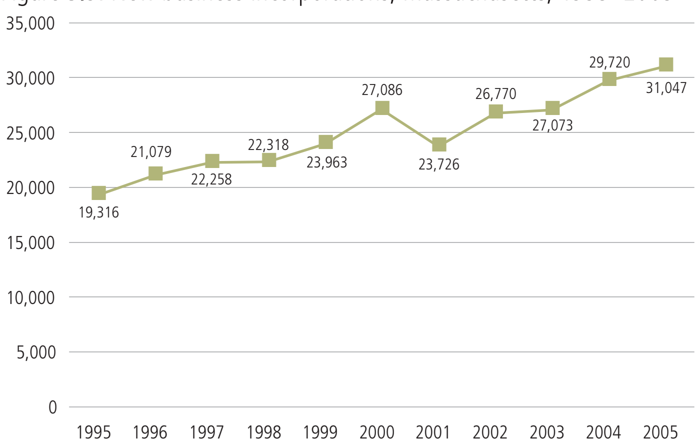
Figure 3.8: Academic R&D growth, 1998–2003

State	1998	1999	2000	2001	2002	2003	**Growth rate**
Massachusetts	1,348,220	1,401,851	1,486,174	1,578,924	1,697,102	1,821,817	**35.13%**
Connecticut	406,618	419,289	468,435	498,745	538,070	594,541	**46.22%**
New Jersey	484,942	521,304	567,666	628,040	690,642	747,481	**54.14%**
New York	1,925,264	2,069,952	2,291,749	2,476,008	2,763,447	3,089,988	**60.50%**
Pennsylvania	1,348,265	1,390,563	1,552,417	1,692,930	1,912,760	2,013,453	**49.34%**
Illinois	1,030,819	1,101,453	1,170,743	1,280,955	1,440,716	1,613,691	**56.54%**
North Carolina	899,219	1,012,576	1,039,812	1,137,248	1,276,823	1,394,545	**55.08%**
Virginia	496,781	504,937	553,612	610,717	693,606	776,026	**56.21%**
California	3,389,742	3,662,636	4,065,130	4,428,024	4,891,562	5,362,683	**58.20%**
Minnesota	367,779	377,393	418,029	469,086	503,973	517,346	**40.67%**

Source: National Science Foundation (NSF) and US Census Bureau

- **Formation of new business enterprises in Massachusetts remains strong, but it is not creating new high-tech businesses at the rate of some of its faster growing peers.** New business formation is an essential ingredient in any economy based on innovation. With the exception of the effects of the global economic downturn of 2001, Massachusetts has consistently posted impressive growth in new business incorporations since 1996, with more than 31,000 new business starts in 2005 alone. Massachusetts has recorded an average annual growth rate of almost 4% from 1996-2005 and 6% for the five year period 2001-2005 (see Figure 3.9). However, the real competitive issue in the Innovation Economy is the rate of formation of new high-tech businesses. The most recent data available (2000) shows that Massachusetts created 12.8 new high-tech businesses per 100 high-tech establishments, compared to 14.6 in California and 14.1 in Virginia. Subsequent data on net new business formation (births minus deaths) suggest that Massachusetts has continued to lag competitor states in forming new high-tech businesses. Based on year 2000 data, Massachusetts would need to create approximately 250 new start-ups per year to match the rate of high-tech business formation in California. The rate of formation of start-ups from academic institutions in Massachusetts has declined over the past decade and is concentrated in only three or four institutions. MIT continued to lead the nation in spinouts with 20 in 2004, but Brandeis, Northeastern, and Tufts each posted impressive rates for their research volume. Harvard, the University of Massachusetts, and most of the teaching hospitals represent relatively untapped potential for new business formation.

Figure 3.9: New business incorporations, Massachusetts, 1995–2005



Source: Commonwealth of Massachusetts

AN EXPERT TAKE

Dr. Rory P. O'Shea and Dr. Thomas J. Allen
MIT Sloan School of Management
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The commercial exploitation of new knowledge created in universities has become of central importance to universities and to the governments that fund university research. In recent years university heads and policymakers are increasingly looking to among other things, a continuous supply of new products and services that improve the national competitiveness. Although university research in the US has spun out numerous high-impact companies, for the most part this phenomenon has occurred largely among a small number of highly entrepreneurial universities. As a result, a great number of promising discoveries here consistently fail to be developed and brought to market for practical use. For many institutions the path to enhanced start-up creation is not an easy or smooth one. Successful spin-off efforts have shown to be difficult to mount, if only because of the continuing inability to make sense of the longitudinal character and the complex forces which give rise to spin-off creation.

In order to explain the inter-institutional variation rates of university start-up activity, we draw from a number of national databank and survey input variables, and built an eight-year longitudinal dataset of 141 US universities. According to our findings, high performing entrepreneurial universities:

- Conduct excellent research in a number of 'practical fields,' combined with a willingness to pursue interdisciplinary research. The result is a strong driver in the creation of the knowledge that start-up companies have exploited.
- Traditionally work with industry, which in turn facilitates the production of commercially oriented innovations.
- Have a number of dedicated and experienced organizational structures supporting spin-off creation, including technology transfer offices, with technically trained, industrially experienced licensing officers, and entrepreneurial development programs that are dedicated to promoting emerging technological opportunities and training potential academic entrepreneurs.
- Have a successful tradition and history at commercializing radical technologies (via start-ups) that has created a 'success breeds success' start-up culture among academics and staff with their respective institutions.
- Nurture informal internal and external networks between government, industry, and academia. These networks have increased and leveraged research funding at universities and thus has allowed for the sharing of knowledge. This has in turn helped to stimulate high-tech entrepreneurship.
- Demonstrate a strong commitment to the exploitation of research. This commitment is supported by top down leadership and clear policies that are consistently applied to support and encourage start-up formation by academics.

From a policy perspective our results argue: 1) the need for the development of a commercially supportive culture to emerge within universities to enable academic entrepreneurship to flourish; 2) the need for active partnership and financial support with industry and government funding agencies; 3) the recruitment and development of science and engineering academic star scientists; and 4) the development of a commercial infrastructure to enable the valorization of academic research to occur.

AN INDUSTRY TAKE

Thomas Clay, Chief Executive Officer
Z Corporation, Burlington, MA
www.zcorp.com

From our vantage point, as a company spawned from the research and development infrastructure in Massachusetts, the system works pretty well. Massachusetts clearly has the innovation mindset, the universities where many ideas are developed, and the talent to build the ideas into companies. I do think, however, that a lot of ideas are invented and incubated here and then get sucked up and drawn away to other places. We have seen many successful start-up companies hit the mid-stage, and then be acquired and leave Massachusetts. While we are continuing to grow and add jobs here, we also experience the challenges of operating in such a high cost market.

MASSACHUSETTS' KEYS TO COMPETING

- **Expand efforts to attract R&D investments, particularly at academic institutions, emphasizing opportunities where potential exists for capturing downstream economic benefit.** Massachusetts must acknowledge that one of its core competitive advantages is the ability of its companies and research institutions to attract investment or to self-invest in R&D. This ability is driven in large part by intellectual curiosity, a vision of how and where to drive R&D, intelligence with respect to funding/investment opportunities. Also required is a willingness to develop effective collaborations on multiple levels to address the complexities of today's science and technology and the challenges of bringing technology to market. The Commonwealth also must recognize the key role federal R&D funding plays in the capacity to innovate and create the products necessary to penetrate new markets and to, in turn, attract complementary funding from industry and other sources. Federal funding is a primary driver of knowledge creation that supports the state's Innovation Economy, and the state must continue to be an active proponent and aggressive pursuer of such funding. In addition, the Commonwealth also must act with the understanding that the full leverage for economic growth is created when knowledge is transferred into the marketplace and then captured in the form of new products, services, businesses, and ultimately jobs. To the extent that R&D funding is focused on basic and applied research, it provides essential support to universities, colleges, and other research institutions and, in many cases, to start-up companies. At the same time, it necessitates the creation of effective linkages and pathways for commercialization from those institutions so that the Commonwealth is in a better position to capture the downstream economic benefit that will ultimately grow the Massachusetts Innovation Economy.

- **Identify opportunities/barriers and leverage best practices across all elements of the innovation process.** The system of innovation in Massachusetts has become more dynamic and more complex. While Harvard, Massachusetts General Hospital, and MIT rightly receive international renown for their research and innovation capacity, the research enterprise in Massachusetts today consists of a far broader array of public and private universities, colleges, academic health centers, and other research institutes. The industrial landscape has become even more complex, with multiple tiers of technology developers, system integrators, and channels to market in emerging industries such as nanotechnology, biotechnology, and robotics. This creates both a need and an opportunity to capitalize on the Commonwealth's diversity of intellectual and industrial innovation in order to enhance its global competitiveness for R&D investment, its effectiveness in translating that investment into intellectual property, and its success in creating strong partnerships to accelerate commercialization and capture downstream value-added.

- **Improve the environment for new start-ups and entrepreneurs.** The reputation of Massachusetts institutions as seed beds for innovation, turning out a multitude of research-driven ideas and inventions, is well deserved and unassailable. Yet, the immutable nature of technological innovation is that it tends to become obsolete—replaced by new products or in many cases by entirely new industries that challenge the status quo. Success in the Innovation Economy implies a willingness to accept risk at multiple levels, from product development, to investment, to technology adoption and not only to manage, but to thrive, on this churn. Massachusetts has the fundamental conditions and an entrepreneurial culture that should rightly yield a healthy and steady stream of knowledge-driven start-ups. The data confirm this; but also suggest that Massachusetts generates the kinds of start-ups that must rely more heavily on patient seed and early stage investments in order to fuel robust growth of the Innovation Economy.

Competitiveness Issue #2:

The availability of capital and the quality of investment opportunities in Massachusetts relative to other LTS

ISSUE AT HAND

Central to an Innovation Economy is the availability of financial resources and the resulting networks of technical and management expertise that are stimulated by venture capital (VC) firms. As elsewhere, VC firms in Massachusetts are a critical driver in the evolution of businesses from the start-up phase through to established firm caliber and preface eventual larger contributions to overall economic growth and vitality. Massachusetts has always maintained a vibrant VC community that is integral in providing this lifeblood of funding to growing Innovation Economy firms.

DATA ANALYSIS

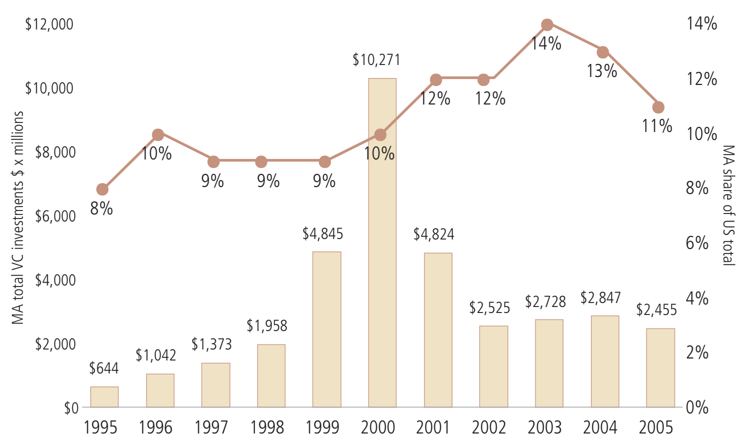
- **A significant share of total US VC is invested in Massachusetts, rivaled only by California.** Massachusetts venture investments amount to nearly 11% of the US total, second only to California at 47%, and more than double the investment level of the next nearest LTS, New York State, which represents 4.8% of the US total. The Commonwealth has managed to increase its share of total VC investment since 1996. Yet, the Commonwealth's share in 2005 continues a three-year decline from its high of 14% in 2003 (see Figure 3.10).

Issue Insight

General Georges Doirot of Harvard Business School initiated the first modern venture capital firm with American Research and Development in 1946, funding what was for decades a stalwart electronics company, Digital Equipment Corporation.

Source: Boston History & Innovation Collaborative

Figure 3.10: Total venture capital investment in Massachusetts and as a share of total venture capital investment in the US, 1996–2005



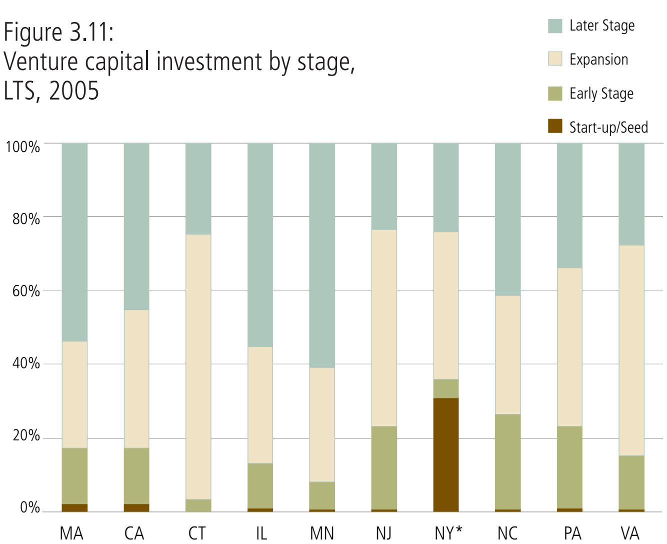
Source: PricewaterhouseCoopers/Thomson Venture Economics/National Venture Capital Association MoneyTree™ Survey

- **Massachusetts VC firms are trending to more conservative investments.** In 2005 alone, Massachusetts shows a greater percentage of "later-stage" investments than seven of its competing LTS, trailing only Minnesota and Illinois (see Figure 3.11). Since 2000, VC investments in Massachusetts overall have trended toward more conservative, and generally safer, later-stage investments (see Figure 3.12). And, somewhat counter-intuitively, VC activity in early stage ventures has not declined, but remained steady since the year 2000. Massachusetts invests just 2% of its VC in start-up/seed and early stages, a figure comparable to that of California. In 1995, however, both states had double-digit percentages on VC investment at the start-up/seed stage, with Massachusetts investing approximately 17% of total state investment (see Figure 3.13).

- **Massachusetts trails all LTS in VC investments in expansion stage companies.** As defined by PricewaterhouseCoopers, an "expansion stage" company is typically three or more years old and has a product or service in production and commercially available. Firms of this type typically have revenue growth but may or may not be profitable. Regrettably, Massachusetts lags all of its competing LTS in financing ventures at this rallying stage, where a firm may be poised for growth and/or profitability and primed for development to a more established footing (see Figure 3.14).

- **Massachusetts dominates in attracting funding from the federal Small Business Innovation Research Program (SBIR).** From 1996-2005, Massachusetts companies have been awarded a disproportionately large

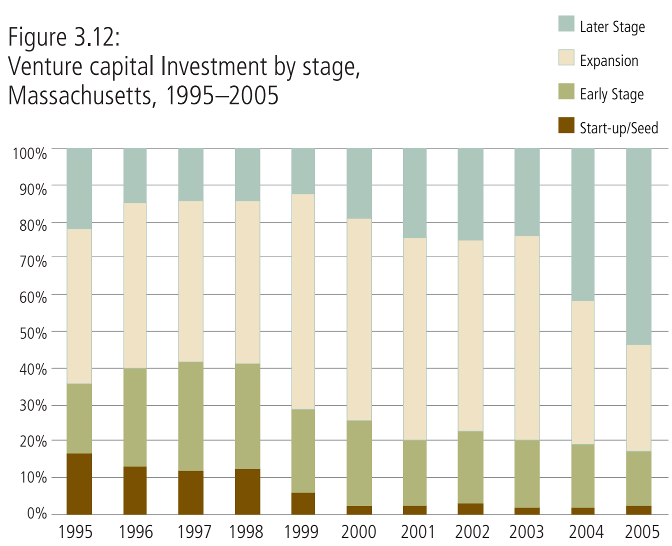
Figure 3.11:
Venture capital investment by stage, LTS, 2005



*New York State had one uncharacteristically large deal that went to one company, Integro, which received $311.8 million in Q2 2005.

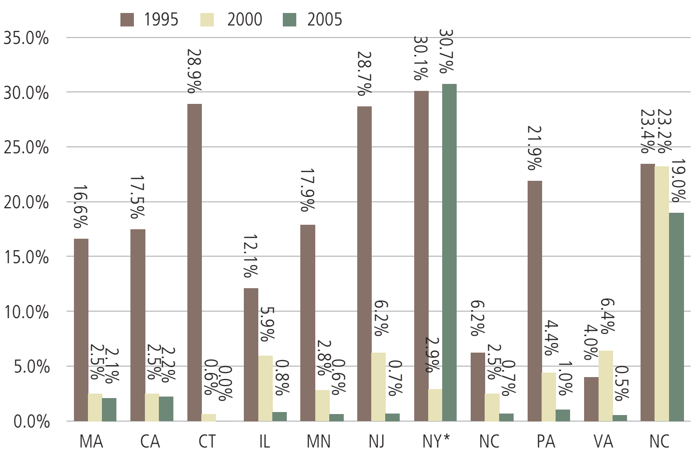
Source: PricewaterhouseCoopers/Thomson Venture Economics/National Venture Capital Association MoneyTree™ Survey

Figure 3.12:
Venture capital Investment by stage, Massachusetts, 1995–2005



Source: PricewaterhouseCoopers/Thomson Venture Economics/National Venture Capital Association MoneyTree™ Survey number of Phase I and Phase II SBIR grants, both in terms of total number of awards and in dollar value per capita. While the number of awards to Massachusetts between 2004 and 2005 has declined slightly, this mirrors a comparable decline among most of the LTS. Most impressively, however, SBIR awards in Massachusetts are nearly $4 million per 100,000 residents, nearly three times higher than any other LTS (see Figures 3.15 and 3.16).

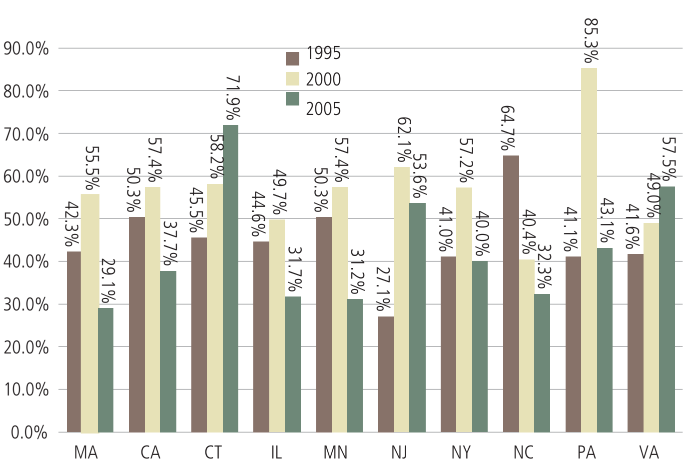
Figure 3.13: Start-up/seed stage venture capital as a percentage of total state venture capital investment, LTS, 1995, 2000, 2005



*New York State had one uncharacteristically large deal that went to one company, Integro, which received $311.8 million in Q2 2005.

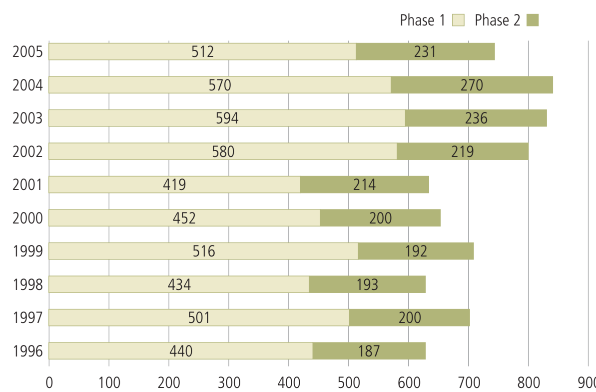
Source: PricewaterhouseCoopers/Thomson Venture Economics/National Venture Capital Association MoneyTree™ Survey

Figure 3.14: Expansion stage venture capital as a percentage of total state venture capital investment, LTS, 1995, 2000, 2005



Source: PricewaterhouseCoopers/Thomson Venture Economics/National Venture Capital Association MoneyTree™ Survey

Figure 3.15: SBIR awards by phase, Massachusetts, 1996–2005



Source: US Small Business Administration

Figure 3.16: Dollar value of SBIR awards, per 100,000 people, LTS, 2005

State	Phase 1	Phase 2	Total
MA	$921,685	$2,856,684	$3,778,369
VA	$296,095	$973,895	$1,269,990
CA	$252,028	$818,452	$1,070,480
CT	$181,500	$603,567	$785,067
PA	$151,014	$451,244	$602,258
MN	$124,892	$438,560	$563,452
NJ	$133,160	$398,361	$531,522
NY	$109,207	$347,421	$456,628
NC	$83,384	$340,347	$423,732
IL	$62,156	$129,408	$191,564

Source: US Small Business Administration

AN EXPERT TAKE

Rick Burnes, Co-founder & Partner
Charles River Ventures, Waltham, MA
www.crv.com

The greatest single strength of the Massachusetts economy is the wealth of talent resident in our multiple universities and innovative companies. In the past this strength has generated enormous intellectual and economic progress.

But the growth industries and venture capital business, both of which thrived in the '80s and '90s, are currently in a state of transition. Information technology has matured and shifted to more consumer-oriented products and markets—areas where Massachusetts has not been as strong. Massachusetts engineers are very good at technical innovation and providing an industrial payback, but generally are not as well-skilled in figuring out the latest consumer website or the next generation consumer electronic device.

The brightest spot is the ever growing and evolving life sciences field. Massachusetts is the clear leader in this field and it is critically important that we maintain that position. From a VC perspective, medical devices and biotechnology have always been difficult areas in which to build companies and earn a return, but there is tremendous potential and we have some of the leading life sciences focused venture firms in the state.

It is not clear where the current transition in venture investing will lead. Most of the VC firms have ample capital and experienced management and are experimenting in a number of different areas to find the next major growth businesses. Nanotechnology, the "green revolution" and alternative energy are among the areas being carefully looked at and others are emerging.

Fundamental innovation is going to be the key driver of the area that emerges and the type of innovation it will take is likely to come out of one of our universities. Finding it will require fresh thinking on old problems and will, if history is our guide, be done by a young person, likely under 30."

AN INDUSTRY TAKE

Milan Shah, Vice President of Engineering
IMlogic, a Symantec company
Waltham, MA
www.imlogic.com

The primary anchor that keeps IMlogic in Massachusetts, even though we strongly considered moving at one time, is proximity to the venture capitalist community. And it's not just in a monetary sense, we're here for their significant industry experience as well.

MASSACHUSETTS' KEYS TO COMPETING:

- **Understanding and addressing the decline in Massachusetts' share of total VC investment.** VC has consistently been the "mother's milk" of the Innovation Economy, offering a vital source of funding for speculative and unproven endeavors unlikely to attract more traditional funding. Although Massachusetts attracts a disproportionate share of total US VC investments, 2005 reinforced a decline in this share. While its effect on the Innovation Economy may be underappreciated, this decline is a significant cause for concern warranting renewed attention.

- **Improved access to seed capital.** Of all varieties of VC investment, riskier, seed capital VC funding has fallen out of favor as an investment opportunity throughout the LTS. Yet it remains a critical driver of sustainable growth in an Innovation Economy. Because of a declining number of headquarters or similarly-sized business and/or manufacturing enterprises in the Commonwealth, economic and employment benefits must derive from a steady stream of start-up firms. As a result, the contraction in seed and start-up VC investments disproportionately affects the health of the Massachusetts Innovation Economy more adversely than competing LTS. In other words, Massachusetts subsists on a steady diet of emerging tech firms rather than on a handful of larger business enterprises. If the funding of these emerging industries is compromised, Massachusetts bears an inordinate brunt as smaller firms find it more difficult to survive and grow. In turn, downstream development and the capture of that concomitant economic expansion suffer. This dynamic demands far more focus on seed capital markets and the firms that require this stage of investment to engender the next generation of companies.

- **Targeted economic development and retention efforts to companies at the expansion stage.** Massachusetts VC firms are losing ground to the other LTS in funding companies at the expansion stage, where companies are usually poised to enter a period of growth and maturation. In an era where most firms are faced with only an initial public offering (IPO) or a merger and acquisition (M&A) as paths to liquidity, nurturing firms at this juncture of development should yield significant long-term dividends. This strategy could forestall an acquisition by an out-of-state firm or an exodus from Massachusetts for other financial reasons.

Competitiveness Issue #3:

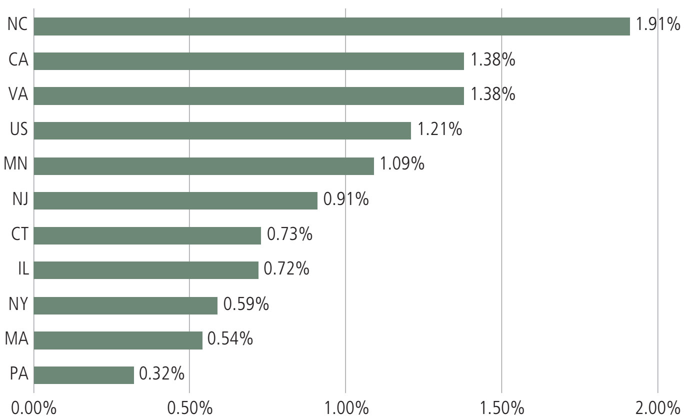
The availability of a workforce with the scalability and skills necessary to feed expansion

Issue Insight

In 1743, Boston led all other colonial towns in shipbuilding, finished goods, meatpacking, shipping, and a series of other trades. Over this era, the town lost its economic stranglehold on these industries due to war, high taxes, out-migration, pauperism, and the compounding of all of these problems. Boston was a center of inter-colonial and trans-Atlantic trade in 1730, but as New York, Philadelphia, and other towns grew, Boston lost its colonial hegemony. The eve of the revolution found Boston in a declining position, struggling economically, as it thrived as the beating heart of the revolution.

Source: Boston History & Innovation Collaborative

Figure 3.17:
Average annual population growth rate, LTS and US, 1995–2005



Source: US Census Bureau

ISSUE AT HAND

In low volume, high-value economies, maintaining the appropriate balance of skills and talents is essential. As a consequence, a healthy Innovation Economy relies most heavily on both an appropriately sized workforce and also one with the proper, often diverse, skill sets that meet the needs of innovative employers. Critical components include a population growth rate that assures labor force growth, the retention of graduates and younger workers, and an effective secondary school system that fosters a student population rich in scientific and technical disciplines. In addition, requisite conditions include a best-of-breed university and higher-education system that attracts, prepares, and retains world-class thinkers and innovators to the Commonwealth.

Especially in the more developed, relatively high-cost, and service-oriented economies of the LTS, the value and necessity of a workforce that is both suitable and adaptable to the needs of industry is clear.

DATA ANALYSIS:

- **Flat population growth and the out-migration of younger workers constrict labor force growth in the Commonwealth.** For the last five years, population growth has been stagnant in Massachusetts, and would be negative but for international immigration. This contrasts with population data from many of the other LTS. Since the labor force participation rate in Massachusetts is high at 67.6% and exceeds that national average by almost 2%[2], the potential expansion of the pool of available workers overall is limited, particularly in times of economic growth (see Figure 3.17).

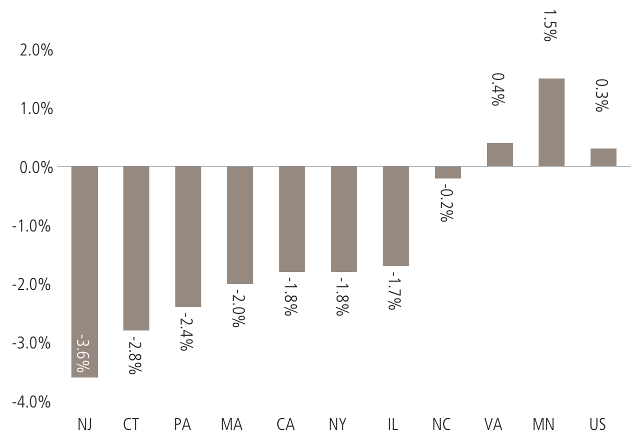
2. "Future Growth of the Massachusetts Labor Force," November 2005, Commonwealth Corporation & the Center for Labor Market Studies, Northeastern University.

- **Younger workers between the ages of 22 and 34 continue to leave the Commonwealth in growing numbers.** Massachusetts lost 2% of the 22-34 year old age cohort from 2003 to 2005, amounting to a loss of more than 22,000 residents in this age group. This amounts to the fourth highest percent loss among the LTS. When the most recent college graduates are factored out, Massachusetts lost more than 3% of the 25-34 year old group. Experts speculate that slow growth in job creation within higher wage clusters and the cost of housing for first-time buyers are contributing factors to this loss of workers as they are seeking to establish roots in the region. This is exacerbated by the fact that recent graduates from the Commonwealth's institutions of higher education generally possess the education and skills necessary to excel in the knowledge economy. While other LTS, notably California, have consistently high housing costs and low percentages of homes in the first-time buyer category, they appear to better mitigate the impact of housing costs by performing better than Massachusetts in creating jobs in innovation industries (see Figure 3.18).

- **The lack of affordable housing undermines Massachusetts standard of living and undercuts the state's competitiveness.** Massachusetts has the lowest share of affordable stock among all LTS, offering only 5.3% of its total housing stock at $100,000 or less as the asking price. Massachusetts offering of moderately-priced homes is also relatively limited, as in the median house price range of $100,000 to $300,000, only California, New York State, and Pennsylvania offer fewer homes at this price point. At the high-end, more than half (54.4%) of Massachusetts available housing stock exceeds $300,000 (see Figure 3.19).

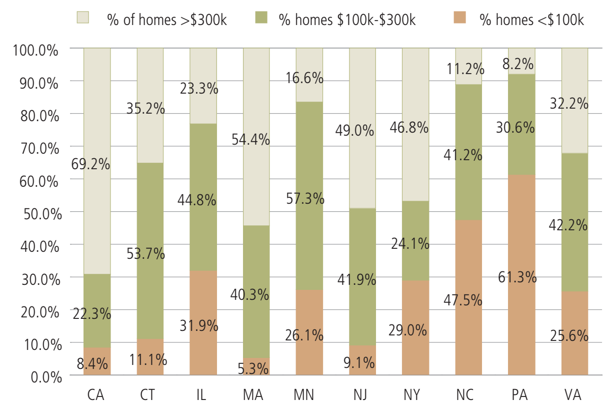
- **For those who remain, Massachusetts still dominates the LTS in terms of workforce educational attainment levels.** For 2005, Massachusetts residents remain exceptionally well-educated, with roughly 37% of those 25 and older holding a bachelor's degree—a baseline credential for potential Innovation Economy employees (see Figure 3.20).

Figure 3.18:
Population change of 22-34 year-olds ,LTS, 2003–2005



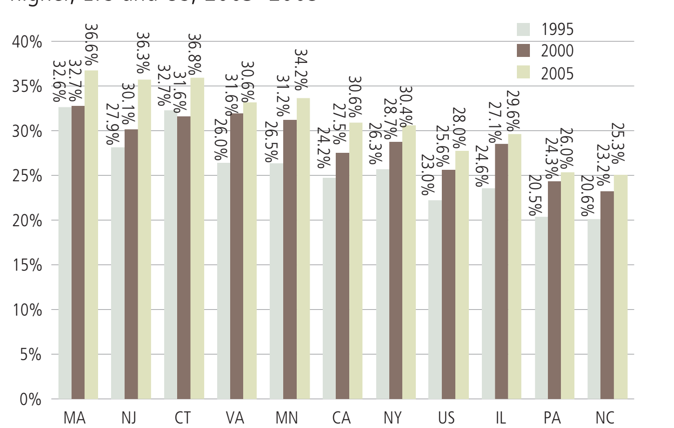
Source: US Census Bureau

Figure 3.19:
Distribution of home price range among, LTS, 2005



Source: US Census Bureau

Figure 3.20:
Percent of persons 25 years old and over with a bachelor's degree or higher, LTS and US, 2003–2005



Source: US Census Bureau

- **Yet, Massachusetts ranks near the bottom of all LTS in turning out high-school students interested in scientific and technological majors.** An early indicator of the potential for a native workforce to excel in an Innovation Economy is the intended college majors reported by high-school seniors. While interest in technology-related disciplines remained fairly constant or increased in some cases, Massachusetts performance relative to its LTS counterparts is poor. Specifically, interest in Computer, Engineering, and Information Science has dropped modestly between 2000 and 2005; and, while the percentage of students interested in health and allied sciences as a major has increased between 2000 and 2005, it too pales when compared to both the US and LTS average (see Figure 3.21).

Figure 3.21

Percent of high school seniors planning to major in Computer, Engineering, or Information Science in the LTS					Percent of high school seniors planning to major in Health and Allied Services in the LTS			
	2000	2004	2005			2000	2004	2005
VA	16%	—	14%		NC	21%	23%	23%
IL	16%	14%	13%		US	16%	17%	17%
CA	16%	14%	12%		PA	15%	17%	17%
MN	15%	14%	14%		CA	15%	16%	16%
NC	14%	14%	13%		IL	15%	15%	15%
US	14%	14%	12%		VA	14%	—	16%
PA	13%	12%	10%		MN	14%	13%	13%
NY	13%	12%	10%		NY	13%	14%	15%
NJ	13%	12%	10%		NJ	12%	15%	14%
MA	12%	12%	11%		MA	12%	13%	14%
CT	10%	11%	9%		CT	11%	14%	14%

Source: The College Board

AN EXPERT TAKE

Cathy E. Minehan
President and Chief Executive Officer
Federal Reserve Bank of Boston
www.bos.frb.org/

Although economic conditions in Massachusetts have improved over the past three years, performance since the 2001 recession—at least as measured by job growth—has been disappointing. The state's weak economic performance contrasts sharply with the prosperity of the late 1990s, when income growth soared and unemployment rates fell to 3 percent.

To a considerable degree, Massachusetts is a victim of its earlier success. Massachusetts was on the forefront of the stock market boom, the telecommunications boom, the build-up to Y2K, and the dot-com bubble. In each case, growth based on strong fundamentals gave way to excessive exuberance and a major correction ensued. Moreover, while strength fed on strength during the upturn, weakness compounded weakness in the subsequent decline.

Massachusetts' disappointing economic performance has given rise to considerable anxiety about the state's long term competitive position. This is understandable; and a careful and realistic assessment of the Commonwealth's assets and liabilities, as provided by the Index of the Massachusetts Innovation Economy, is critically important to enhancing our position. At the same time, however, we must take care not to overstate the problems. Massachusetts has a history of responding to challenges with bursts of innovation. Often, the resurgence has not been recognized until it was almost fully blossomed.

The key to Massachusetts' past re-inventions has been skilled and resourceful people. And such workers remain the key to Massachusetts' success. Indeed, the improvement we have seen in the state economy in the past year has been spearheaded by such Massachusetts specialties as high technology manufacturing, financial activity, and professional and business services, all of which are characterized by their dependence upon such workers. Looking ahead, the central challenge for Massachusetts is to continue to attract, retain, and "grow its own" skilled workforce. This requires that Massachusetts remain a desirable place in which to work and to live. To this end, we should focus on practical steps that have the potential to effect meaningful change. We should be open-minded and prepared to emulate what has worked well in other states. And while we must be realistic, we should recognize that perceptions of the desirability of Massachusetts as a place to work and live depend importantly upon creating a positive vision of the future.

AN INDUSTRY TAKE

Paul Egerman, CEO & Chairman
eScription Inc, Needham, MA
www.escription.com

I can only be successful if I can attract thoughtful and skilled employees. The Commonwealth needs to expand on the talent pool by investing more in the University of Massachusetts and also in the state colleges. We also need greater emphasis on both science and engineering in K-12 curricula. In particular, there is too little attention given to engineering skills. It is extremely important to be able to hire younger people, near the start of their careers and in their first, second, or third jobs. Their greatest challenge in working for us involves obtaining affordable and reasonable housing.

MASSACHUSETTS' KEYS TO COMPETING:

- **Increase entry-level housing stock.** To stem the flow of younger workers out of Massachusetts and retain more graduates of our colleges and universities, an increase in the housing stock within an affordable price range for these population segments is necessary. State government, with the assistance and support of many business and technology associations, has taken steps to overcome the historical resistance of communities to the development of more affordable housing. These efforts must be accelerated not only because of the societal benefits of home ownership, but also because of the identified economic necessity.

- **Re-double efforts to foster an interest and competency in science and technology related subjects at the high-school level.** The overall performance of K-8 students in technology-related standardized tests is commendable. Yet, there is a stark disconnect between these levels of general competency in science and math and the dismal levels of interest in these disciplines as indicated by high school seniors. Many organizations and businesses in the Commonwealth have developed programs to foster greater student interest in the diverse applications of science and mathematics in everyday life and in business. The Science, Technology, Engineering, and Math (STEM) Pipeline Fund has been created at the Board of Higher Education to support regional networks focused on elevating STEM interest in K-12. Retired engineers have taught along side science and math teachers in K-8 in order to provide real world experience, and teachers have been provided with internships at major technology companies to learn first-hand how their teaching results in the growth of innovative companies. Area colleges have made their facilities available to high schools that lack the resources for their own science labs, as evidenced by Boston University's "City Lab," a mobile science laboratory that travels from school to school as a resource for teachers and students. In addition, role models, such as Craig Mello, the recent Nobel Laureate from the University of Massachusetts Medical School, are critical in demonstrating to students and teachers alike that achievement in science can lead to great recognition and reward. Support for these types of efforts must be increased and "best practices" must be replicated across the Commonwealth. In addition, government and industry must collaborate to make this a priority and lead the campaign to engender greater interest among secondary school students in science and mathematics.

- **Retain and attract workers in key demographics.** Increasing the supply of affordable housing can help to mitigate the impact of overall costs in Massachusetts for younger workers and graduates. It is also clear that the other issues identified in this year's *Index* such as the factors contributing to slow employment growth in relatively high-wage industry clusters must also be remedied. After all, the availability of a well-paying, high-quality job is the most effective palliative to relatively high costs of living and is an essential means for both stemming the flow of 22-34 year old workers and graduates out of the Commonwealth as well as attracting younger workers to the state.

Competitiveness Issue #4:

Global market competition and the demands and opportunities of export growth

ISSUE AT HAND

As the digital world has blurred conventional trade boundaries and eased the global flow of goods, communications, and ideas, Innovation Economies must not only compete among LTS at the state and national level but also in the global marketplace. New and attractive markets have emerged across the globe, and Massachusetts industry sectors must penetrate these markets and compete at an international level. Additionally, this worldwide market integration, introduces more than new markets, but new competitors as well. Just as North Carolina's Research Triangle must be cognizant of competition from California for R&D dollars and in the IT hardware industry, it must be equally aware of a rapidly growing industry cluster in China. Similarly, as Massachusetts seeks to enhance its position as the preeminent location for the life sciences and related industries, it must also consider the cluster competition from both India and New York State. In short, the comparative environment that once encompassed only states and regions within the US must now consider emerging and developed international economies—as both markets and competitors.

Issue Insight

In the 17th and 18th centuries, global demand came from the Atlantic World, particularly the West Indies, the Atlantic coastal trade with other colonies, and with Europe. In the 1790s, this expanded to China and East Asia. In the mid-19th century, this expanded into the growing US national market. And in the 20th century, it grew to a truly global perspective, from United Fruit's trade with Central America to Fidelity's "back offices" in India.

Source: Boston History & Innovation Collaborative

DATA ANALYSIS:

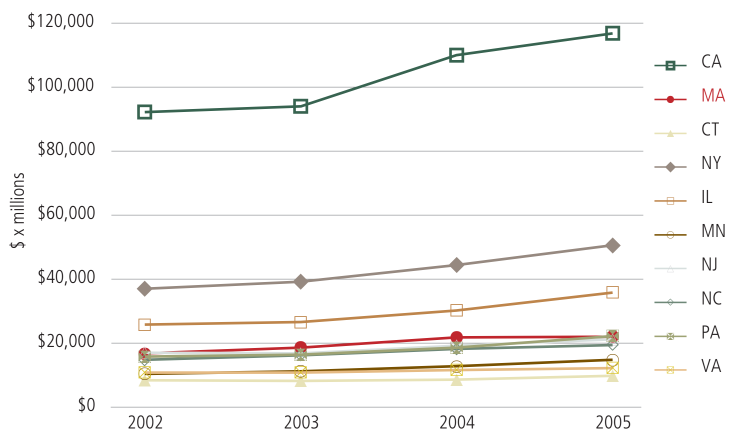
- **International exports are vital to the Commonwealth's economy and are growing.** Generally, regions are working hard to increase their share of gross state product (GSP) that is a result of sales in international markets. Massachusetts exports have grown from 6.3% to 7.4% of the state's gross product between 2001 and 2005 (see Figure 3.22).

Figure 3.22: Exports as a percentage of GSP in the LTS

	2001	2002	2003	2004	2005
CA	8.33%	7.10%	7.01%	7.80%	7.94%
MA	6.32%	6.08%	6.61%	7.47%	7.35%
IL	6.55%	5.51%	5.53%	6.18%	7.18%
MN	5.65%	5.44%	5.69%	6.12%	7.00%
NC	6.04%	5.21%	5.61%	6.10%	6.31%
NY	5.31%	4.67%	4.88%	5.29%	5.82%
CT	5.34%	5.24%	5.09%	5.13%	5.60%
NJ	5.34%	4.75%	4.59%	5.08%	5.47%
PA	4.41%	3.91%	3.97%	4.39%	5.18%
VA	4.31%	3.98%	3.86%	3.91%	3.89%

Source: Export.gov and US Bureau of Economic Analysis

Figure 3.23:
Total exports, LTS, 2002–2005



Source: US Department of Commerce, Foreign Trade Division

- **Total exports have grown consistently across the LTS.** Massachusetts, similar to competitor LTS, has realized consistent growth in total exports (see Figure 3.23). LTS export performance measured by average annual growth rate ranges from 4.2% to 12.3%. From 2002-2005, Massachusetts exports achieved a healthy annual growth rate of 9.9%, but trails New York State, Illinois, Minnesota, and Pennsylvania (see Figure 3.24).

- **Narrow and limited export growth in Massachusetts innovation clusters.** Massachusetts export volume predominates in the pharmaceuticals and medical instruments clusters (see Figures 3.25 to 3.28).

Figure 3.24: Growth rates in exports, LTS, 2002–2005

State	AAGR 2002-2005
MA	9.9%
CA	8.4%
CT	5.4%
NY	11.0%
IL	12.0%
MN	12.3%
NJ	7.6%
NC	9.8%
PA	12.4%
VA	4.2%

Source: US Department of Commerce, Foreign Trade Division

Export volume and growth rates in select clusters, LTS, 2002–2005

Figure 3.25

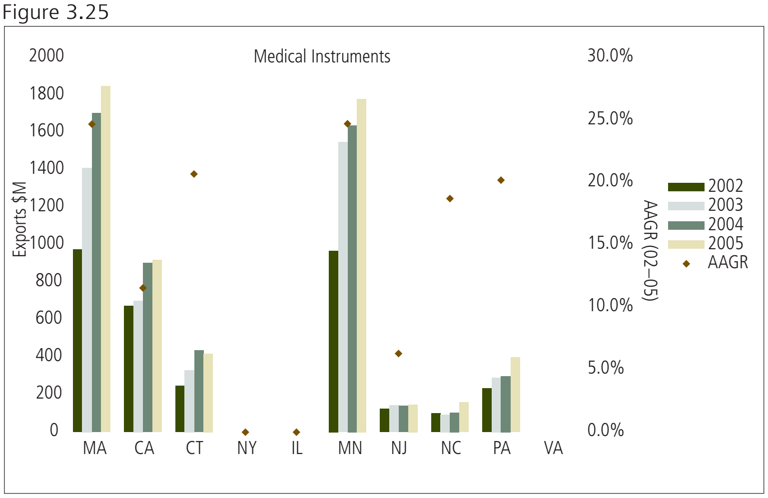


Figure 3.26

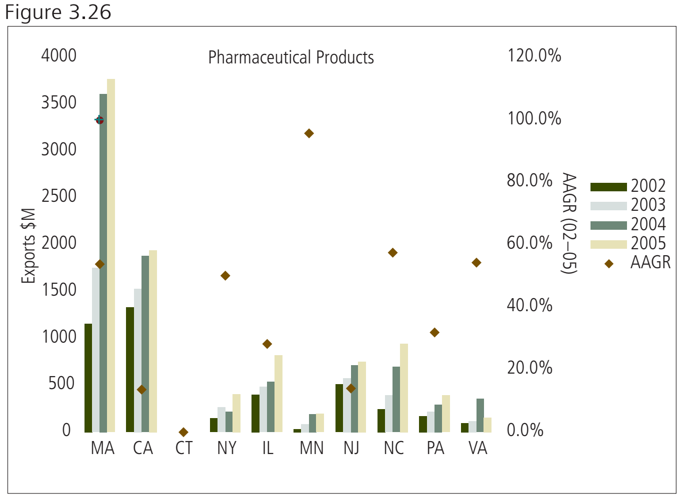


Figure 3.27

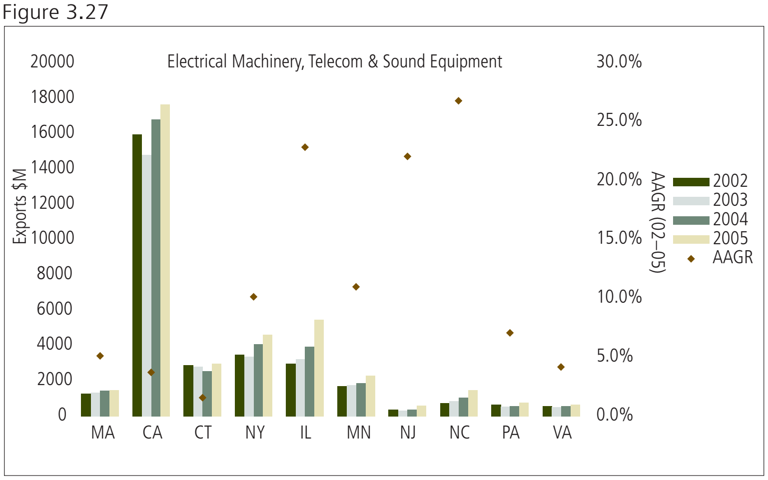
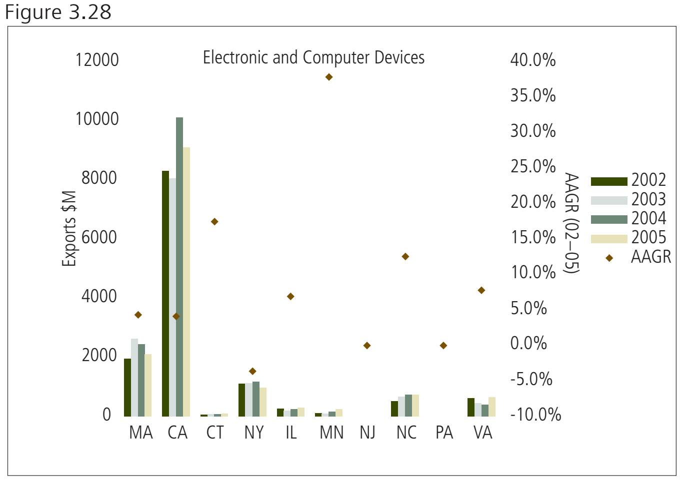


Figure 3.28



Source for these four figures: US Department of Commerce, Foreign Trade Division

- **Massachusetts exports growth rates in computer devices and electrical machinery lag other LTS.** While the average annual growth rate (AAGR) in pharmaceutical products is a vigorous 54%, and in medical devices is 25%, these growth rates are similar to those of the other LTS in the same clusters. However, with an AAGR of only 4% in electronic and computer devices and 5% in electrical machinery, telecommunications & sound equipment, Massachusetts lags the other LTS.
- **Massachusetts exports are limited to a relatively small set of commodities.** The top 10 commodities exported were 36.6% of total state exports in 2005. This high share in a small number of products indicates a lack of diversity and susceptibility to market fluctuations and competition. All other LTS, with the exception of Connecticut, have a more diverse base of exports (see Figure 3.29).
- **The Netherlands, Canada, and the Federal Republic of Germany are the leading purchasers of Massachusetts exports.** Export destination countries are geographically distributed across continents and are providing expanding markets and growing exports to state industry (see Figure 3.30). However, in comparing the top 25 countries of the other LTS with Massachusetts, there are a number of other regions in which Massachusetts industries are noticeably absent (see Figure 3.31):

» **Middle East:** Other than Israel (0.6%) Massachusetts exports to no other Middle Eastern country in the top 25 countries. In contrast, New York State and New Jersey have strong exports to the Middle Eastern nations of United Arab Emirates and Saudi Arabia.

» **South and Central America:** The only South and Central American countries to which Massachusetts exports are Mexico and Brazil. In contrast, North Carolina, for example, also has substantial exports to Honduras, Costa Rica, and El Salvador.

» **China:** Many of the LTS are exporting a larger portion of their total to China, such as California at 6.7%, and Virginia at 5.9%. But Massachusetts is exporting a modest 4% of its total to this giant economy—one that has grown at an average annual rate of 9.6 percent over the past 28 years and is now the fourth largest in the world with a gross domestic product of US $2.23 trillion.

» **India:** Massachusetts exports to this dynamic economy are lagging other LTS. Massachusetts exports to India are only 0.9% of the total. Yet the Indian economy is growing at a blistering rate of 32% per year and offers a sizable opportunity for market expansion of Massachusetts firms.

Figure 3.29: Share of export total of top 10 commodities, LTS, 2005

State	(% of state total)
CT	44.8%
MA	36.6%
NY	33.1%
MN	30.4%
CA	24.4%
IL	21.3%
NJ	21.3%
NC	18.1%
PA	12.8%
VA	30.8%

Source: US Department of Commerce, Foreign Trade Division

Figure 3.30: Massachusetts top ten export partners

Rank	Country	2005 Value	2005 % Share	% Change, 2004–2005	AAGR 02-05
1	Netherlands	3,002	13.6	19.3	43.1%
2	Canada	2,926	13.3	0.9	2.7%
3	Federal Republic of Germany	2,151	9.8	-14.5	25.4%
4	Japan	1,898	8.6	4.6	5.9%
5	United Kingdom	1,628	7.4	8.3	1.3%
6	China	883	4	0.9	34.3%
7	France	805	3.7	-6.3	-0.1%
8	Taiwan	797	3.6	-16.2	22.3%
9	South Korea	794	3.6	23	19.1%
10	Mexico	780	3.5	3.3	11.9%

Source: US Department of Commerce, Foreign Trade Division

AN INDUSTRY TAKE

Margaret Clancy
Chief Financial Officer & Chief Operating Officer
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I believe the major obstacle for small technology firms wanting to first enter the global marketplace is a mountainous terrain of regulations that can only be safely negotiated by investing a great amount of time and resources. To better compete globally small businesses need access to accurate and timely information about export regulations, hiring foreign national workers, and doing business abroad. Honestly, for many small firms the cost of getting correct information in these matters is prohibitively expensive and the penalties for any missteps can be hefty and frightening.

MASSACHUSETTS' KEYS TO COMPETING:

- **Pursue targeted strategies in underperforming clusters.** Export growth across the LTS demonstrates strong international market demand for electronic and computer devices, electrical machinery, telecom, and sound equipment. Massachusetts flat exports growth in these sectors might indicate a competitive disadvantage and a need to pursue new niche strategies. Such strategies might benefit from the global success of the biopharmaceutical and medical devices sectors.
- **Build-on cluster success to replicate growth in untapped markets.** Similarly, broadening the reach into international markets of our products might assist local industry that is struggling with tough competition from domestic and global rivals. Leveraging the success of the medical devices and the biopharmaceutical clusters in these new markets might provide an entry point for other Massachusetts companies in underserved markets.
- **Give a leg up to small firms to compete internationally.** Focused marketing and export assistance to local industry can unlock global markets for small, lower volume, but higher-value, technically advanced products. Massachusetts should work to establish a beachhead for these niche players in very promising markets in the Asia-Pacific region, South America, and the Middle East.

Figure 3.31: Top export partners, LTS

Rank	MA	CA	CT	NY	IL	MN	NJ	NC	PA	VA
1	Netherlands	Mexico	Canada	Canada	Canada	Canada	Canada	Canada	Canada	Canada
2	Canada	Japan	France	Israel	Mexico	Ireland	United Kingdom	Japan	Mexico	Federal Republic of Germany
3	Federal Republic of Germany	Canada	Federal Republic of Germany	United Kingdom	Japan	Japan	Federal Republic of Germany	Mexico	United Kingdom	Japan
4	Japan	China	United Kingdom	Japan	United Kingdom	China	Japan	United Kingdom	Japan	United Kingdom
5	United Kingdom	South Korea	Mexico	Mexico	Federal Republic of Germany	United Kingdom	Mexico	China	China	China
6	China	Taiwan	Japan	Federal Republic of Germany	Australia	Netherlands	France	Federal Republic of Germany	Federal Republic of Germany	Belgium
7	France	United Kingdom	Netherlands	Switzerland	Belgium	Federal Republic of Germany	Italy	Honduras	Belgium	Nether-lands
8	Taiwan	Hong Kong	China	Hong Kong	Netherlands	Mexico	South Korea	France	Netherlands	Mexico
9	South Korea	Federal Republic of Germany	Belgium	China	China	South Korea	China	Italy	Brazil	Singapore
10	Mexico	Singapore	Singapore	Belgium	Brazil	Hong Kong	Netherlands	South Korea	South Korea	France

Source: US Department of Commerce, Foreign Trade Division

The Framework for Innovation

The *2006 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 the *Innovation Framework*. The *Framework*, detailed in Figure 4.1, 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 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.

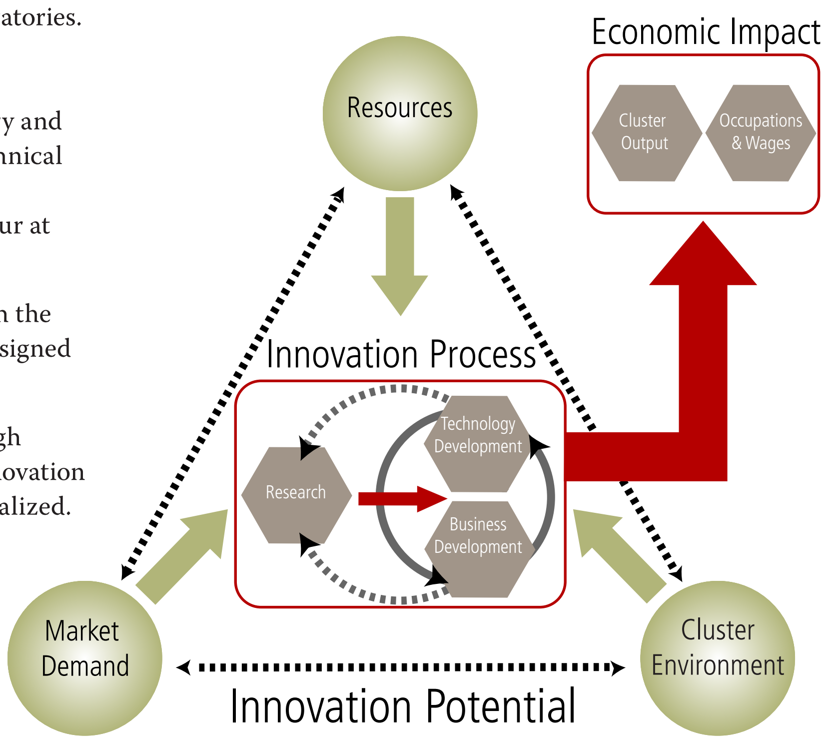
To more fully assess both the societal impacts and other outcomes of the Innovation Economy, the *Index* examines the overall *Economic Impact* of the *Innovation Process*. The *Economic Impact* is considered at both the *Cluster Level* and at the *State Level*. In both, the impact of the *Innovation Process* is measured by reviewing changes in employment and wages, and in 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 4.1



Indicator Selection

Indicators are quantitative measures that illustrate how well a particular 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 *2006 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.

Ten Key Industry Clusters

The *2006 Index* monitors the impact of innovation through ten industry clusters that are critical to the state's economy and that are linked uniquely to the *Innovation Process*. These industry clusters are:

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

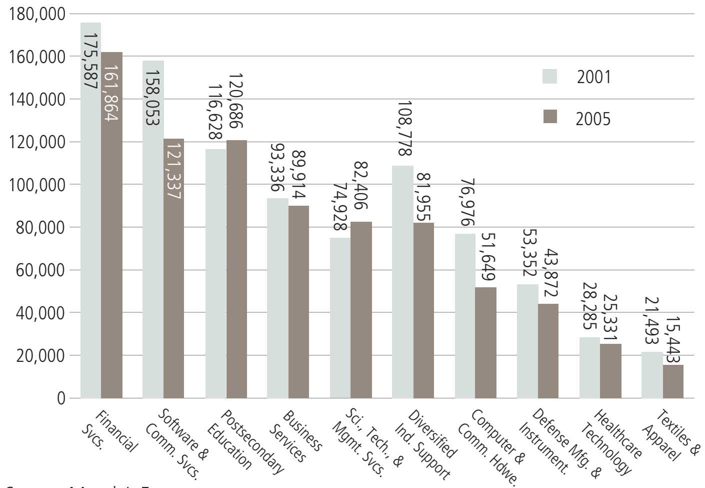
The portfolio of key industry clusters differs from prior editions of the *Index* as a result of dividing the previously designated "Innovation Services" cluster into two new and distinct clusters: "Business Services" and "Scientific, Technical, & Management Services." This redefinition reduces ambiguity and will offer more accurate insights into the performance of these critical areas of economic activity. Appendix B provides a detailed definition for each of these clusters.

Together, these ten clusters account for approximately 25% 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.[3] For purposes of the *Index* analysis, however, indirect employment effects are not considered.

3. See studies on employment multipliers published by the Economic Policy Institute and others.

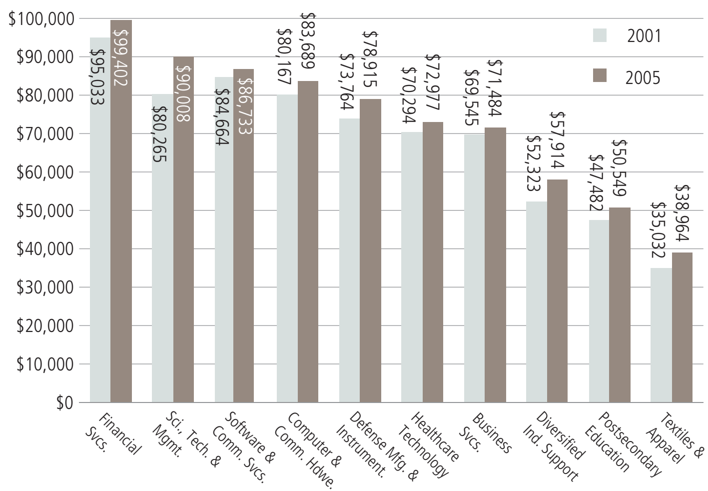
Industry Cluster Employment and Wages

Total employment by key industry cluster, Massachusetts, 2001 and 2005



Source: Moody's Economy.com

Average annual wage by cluster, in 2005 dollars, Massachusetts, 2001 and 2005



Source: US Bureau of Labor Statistics and Moody's Economy.com

Why Is It Significant?

Each of the ten key industry clusters consists of geographic concentrations of interdependent industries and each has an employment concentration above the national average. Together they form an ecosystem of commerce, comprising approximately 25% 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 more than 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?

In recent years, the majority of key industry clusters in Massachusetts have experienced employment losses at a greater rate than the other LTS. The 2005 data, however, provide early indications of a recovery in a number of clusters. Software & Communications Services, which employs 121,337 people, has grown by 1.9% in the last year (compared to losses of 3.4% in 2004, and 9.7% in 2003). Similarly, the Scientific, Technical, & Management Services and Business Services clusters demonstrate high rates of job growth. However, the manufacturing-intensive sectors of Defense Manufacturing & Instrumentation, Diversified Industrial Support, and Textiles & Apparel continue their persistent rates of decline in employment at 1.8%, 4.7%, and 4.9% respectively between 2004 and 2005.

Overall, real wages in the industry clusters increased relative to 2001 and outpaced inflation in all sectors. The recovery in employment in certain clusters and the continued strength of wages in all ten clusters contribute to the strength of median household income in the Commonwealth and offer the potential for a more pervasive recovery.

Indicator #1 Key Takeaways:

- Job losses in a number of clusters continue in Massachusetts, but at a rate that is significantly slower than witnessed in previous years.
- The rate of job loss in manufacturing clusters in Massachusetts continues to be higher than other LTS.
- Greatest employment growth in Massachusetts in 2005 is seen in R&D and service-intensive clusters such as Scientific, Technical, & Management Services.
- Employment in the Postsecondary Education cluster in Massachusetts has slowed and is flat from 2004-2005.

Figure 2.3: Cluster employment percent change, LTS, 2004–2005

	MA	CA	CT	IL	MN	NJ	NY	NC	PA	VA
Computer & Comm. Hdw.	-0.4%	-1.6%	-3.3%	-2.3%	-1.2%	-1.4%	-5.2%	-0.8%	-1.3%	4.5%
Defense Mfg. &Instr.	-1.8%	-0.3%	0.3%	0.8%	1.9%	0.0%	3.3%	6.2%	1.0%	4.1%
Diversified Ind. Support	-4.7%	-1.0%	-1.5%	-1.0%	0.2%	-1.6%	-2.9%	-1.0%	-1.2%	1.6%
Financial Services	-0.3%	1.8%	0.0%	0.3%	1.4%	1.1%	2.0%	2.2%	-0.2%	0.5%
Healthcare Technology	-0.7%	1.7%	-0.3%	-2.2%	4.3%	-2.9%	-0.7%	2.1%	-0.5%	1.5%
Sci., Tech., & Mgmt. Srvcs.	5.4%	7.0%	0.2%	4.1%	1.7%	4.2%	2.2%	6.4%	5.4%	14.1%
Business Services	1.5%	3.1%	0.0%	2.1%	-0.9%	-0.3%	1.7%	2.9%	0.7%	3.9%
Post Second. Education	0.0%	4.8%	2.9%	5.1%	2.7%	-0.1%	1.1%	1.4%	3.3%	3.8%
Software & Comm. Srvcs.	1.9%	0.4%	-1.1%	-0.3%	-0.9%	0.2%	-0.3%	2.5%	-0.3%	-0.9%
Textiles & Apparel	-4.9%	-6.6%	-7.7%	-3.7%	-3.1%	-10.4%	-9.8%	-10.8%	-11.2%	-9.6%

Corporate Sales, Publicly Traded Companies

Why Is It Significant?

The amount 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 employment changes and the potential of a cluster to create and/or maintain jobs.

How Does Massachusetts Perform?

Massachusetts has among the lowest total corporate sales of publicly traded companies of all of the LTS. Yet, much of the Commonwealth's comparative position among the LTS in this category may be attributed to the fact that corporate sales are allocated to the state where a corporation's headquarters is located. While many of the operations of major corporations are conducted in Massachusetts, corporate headquarters are not largely resident here. This lack of corporate headquarters located in-state is a potential weakness of the local Innovation Economy, especially in terms of mergers and acquisitions when upstart Massachusetts firms are acquired by larger parent companies. As such and in some instances, corporate sales data may under-report the actual amount of business activity underway in the Commonwealth.

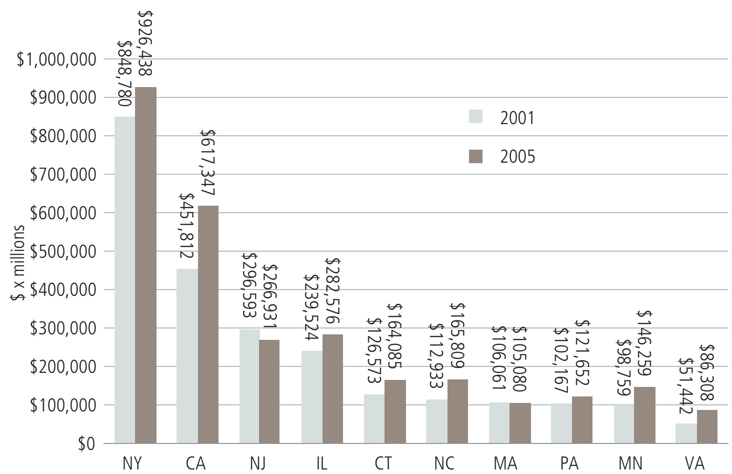
To best try and access the implications of corporate sales data, then, it is necessary to consider the sales trends within the specific industry clusters. For example, there is a sharp decline in corporate sales in the Diversified Industrial Support sector when compared to previous years. But this decline can be attributed largely to the acquisition of Boston-based Gillette Company by Cincinnati-based Procter & Gamble. As a result of this merger, these corporate sales are no longer attributed to a Massachusetts corporation, yet cluster employment in the state did not comparably decline. In addition, the significant increase in sales within the Healthcare Technology cluster suggests a strengthening of market demand for the cluster's products in Massachusetts and globally. Of special interest are changes in corporate sales in the Defense Manufacturing and Instrumentation between 2001 and 2005. This sharp growth in sales did not result in a comparable increase in employment in this cluster within Massachusetts.

For 1996–2005, the average annual growth rate (AAGR) of corporate sales in Massachusetts is 7%. The LTS with the most impressive growth rate in corporate sales is North Carolina at a strong 16%, followed by its southeastern neighbor Virginia at 12%. The poorest performing LTS in terms of corporate sales growth is Connecticut, showing just a 4% AAGR.

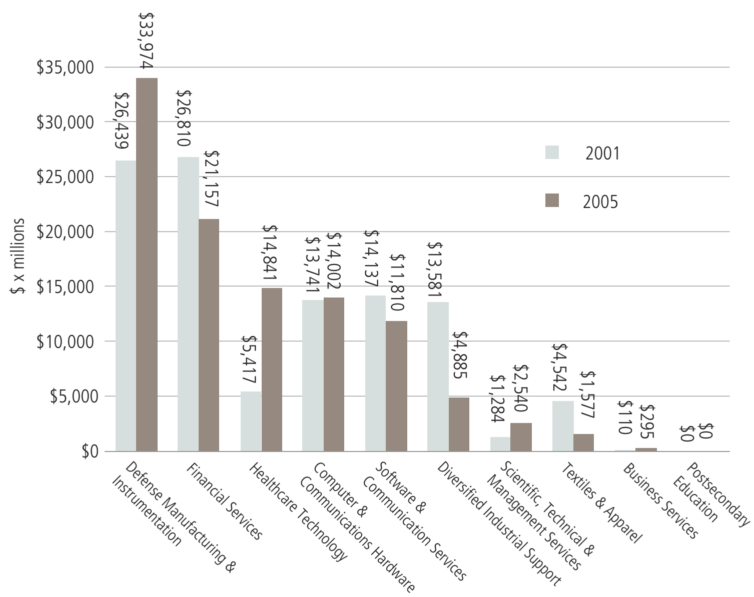
Indicator #2 Key Takeaways:

- Excluding Massachusetts and New Jersey, all other LTS show an increase in overall sales by public corporations between 2001 and 2005.
- Growth in corporate sales in Massachusetts far outpaces growth in employment.
- Sharp declines in sales occurred in Financial Services, Diversified Industrial Support and Textiles & Apparel clusters between 2001 and 2005 in Massachusetts.
- Strong growth in sales occurred in Defense Manufacturing & Instrumentation and Healthcare Technology clusters in Massachusetts.

Corporate sales, publicly traded companies, LTS, 2001 and 2005



Corporate sales by cluster, publicly traded companies, Massachusetts, 2001 and 2005

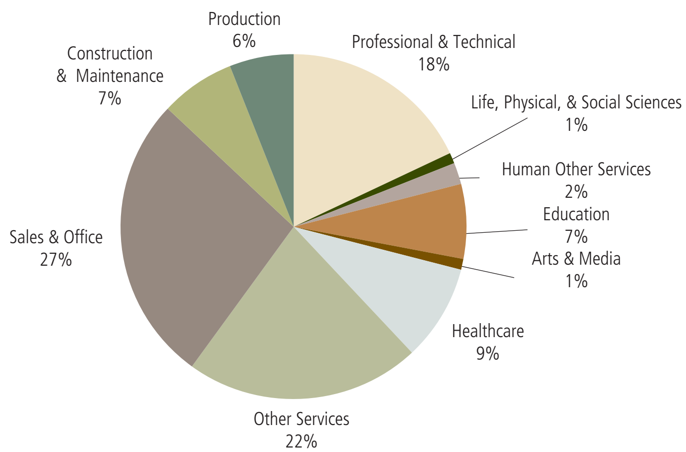


Note: Decline in corporate sales in Diversified Industrial Support cluster is attributed largely to acquisition of Gillette by Procter & Gamble

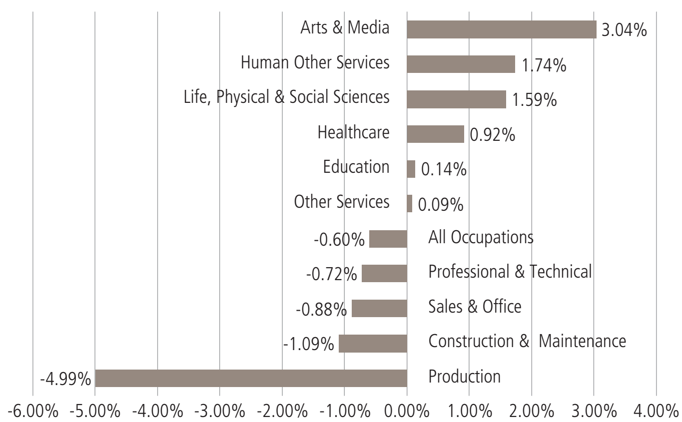
Source of all data for this indicator: Standard & Poor's COMPUSTAT

Occupations and Wages

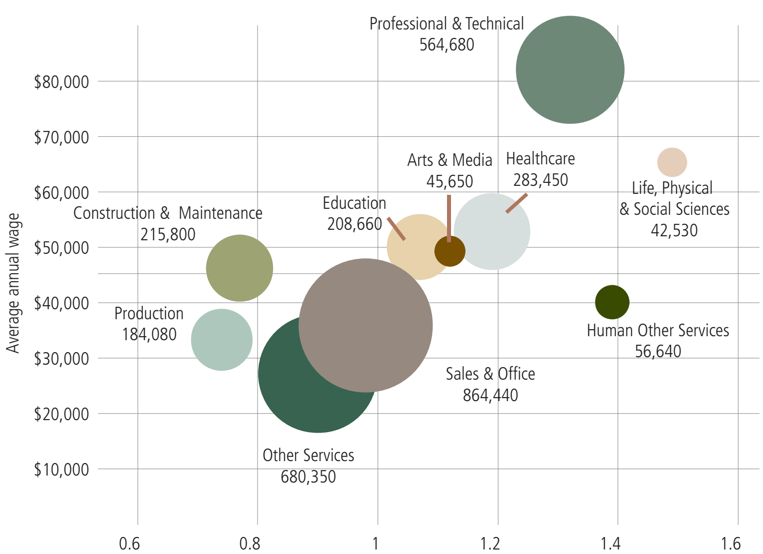
Distribution of occupations, Massachusetts, 2005



Average annual growth rate by occupational category, Massachusetts, 2001–2005



Portfolio of occupations by employment concentration and average annual wage, Massachusetts, 2005



Note: Numeral below name of occupational category is 2005 total employment
Source of all data for this indicator: US Bureau of Labor Statistics

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?

Among the LTS, Massachusetts has the greatest shares of its total state employment in the Professional & Technical (18%) and Life, Physical & Social Sciences (1.4%) occupational categories. Massachusetts also ranks as an LTS co-leader in percent of total employment in the Healthcare and Human Services categories.

Indicator #3 Key Takeaways:

- Massachusetts' share of Professional & Technical employment, the occupational category offering the highest average wage, is greater than that of all other LTS and the national average.
- Among the LTS, Massachusetts and Pennsylvania lead the LTS in share of total state employment in the Healthcare category.
- The Life, Physical, & Social Sciences; Education; and Arts & Media sectors have above-average wages and show employment increases in Massachusetts.

LTS employment by sector as a percentage of total state employment

	MA	CA	CT	IL	MN	NJ	NY	NC	PA	VA
Prof. & Tech.	18.0%	15.3%	16.2%	14.3%	15.8%	14.9%	13.7%	11.9%	12.4%	16.7%
Life, Phys. & Soc. Sci.	1.4%	1.0%	1.0%	0.8%	1.0%	1.1%	1.0%	1.0%	0.9%	1.0%
Human Other Svcs.	1.8%	1.2%	1.8%	1.1%	1.8%	1.4%	1.8%	1.2%	1.8%	1.1%
Edu-cation	6.6%	6.2%	7.3%	6.6%	5.7%	6.4%	8.1%	6.5%	5.8%	6.0%
Arts & Media	1.5%	2.0%	1.2%	1.1%	1.3%	1.2%	2.1%	0.9%	1.0%	1.3%
Health-care	9.0%	6.2%	8.4%	7.4%	8.0%	7.7%	8.7%	8.1%	9.0%	6.4%
Other Svcs.	21.6%	23.7%	21.5%	24.3%	22.8%	24.1%	22.0%	23.6%	23.6%	23.2%
Sales & Office	27.5%	28.8%	28.7%	27.8%	26.9%	30.0%	30.0%	26.4%	28.3%	28.1%
Const. & Main.	6.9%	8.7%	6.7%	7.6%	8.0%	7.3%	7.4%	9.2%	8.6%	10.3%
Prod-uction	5.9%	6.7%	7.0%	9.0%	8.8%	5.7%	5.2%	11.1%	8.5%	6.1%

** shading denotes Massachusetts as LTS leader or co-leader

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 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 the state.

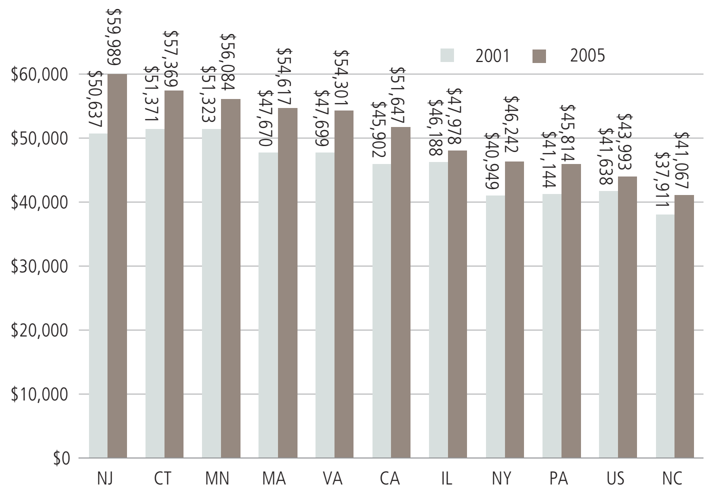
How Does Massachusetts Perform?

After a decline in the three-year average median household income in 2004, Massachusetts experienced a substantial increase of 7.2% for 2005. This increase is significantly above the US three-year average (1.5%) and above that of California (6.2%), Connecticut (5.3%), Minnesota (2.9%), and Virginia (4.7%). But it is lower than New Jersey (8.5%) and North Carolina (8.0%). Over the last four years, median household income in Massachusetts maintained an annual average rate of increase of 1.8% in real 2005 dollars. The Commonwealth's rate of annual increase is lower than the US rate (2.4%) and trails California (2.3%), North Carolina (2.6%), New Jersey (5.3%), and New York State (2.9%).

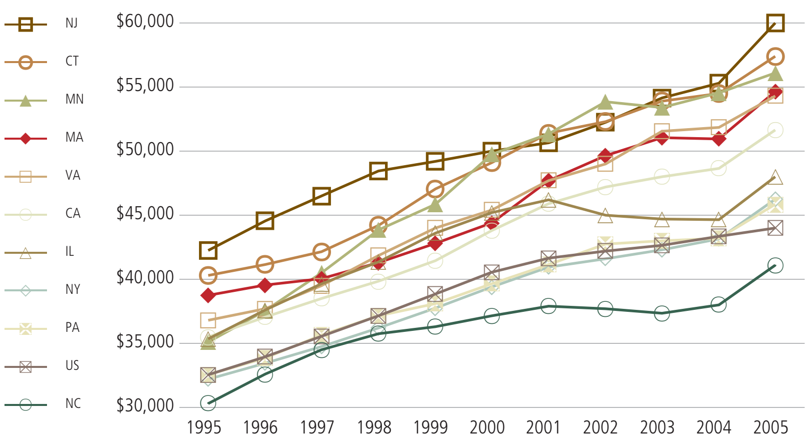
Indicator #4 Key Takeaways:

- Annual average growth rate (AAGR) of median household income in Massachusetts in the last four years is 1.8%, which is lower than the US AAGR (2.4%).
- Massachusetts corrected for the 2004 median household income decline and rebounded to $54,617.
- The 2005 median income in Massachusetts indicates recovery and shows an increase of 7.2% relative to 2004 and outpaces the US average of 1.5%.
- The 2005 median income in Massachusetts indicates recovery and shows an increase of 7.2% relative to 2004 and outpaces the US average of 1.5%.

Three-year average median household income, in 2005 dollars, LTS and US, 2001 and 2005



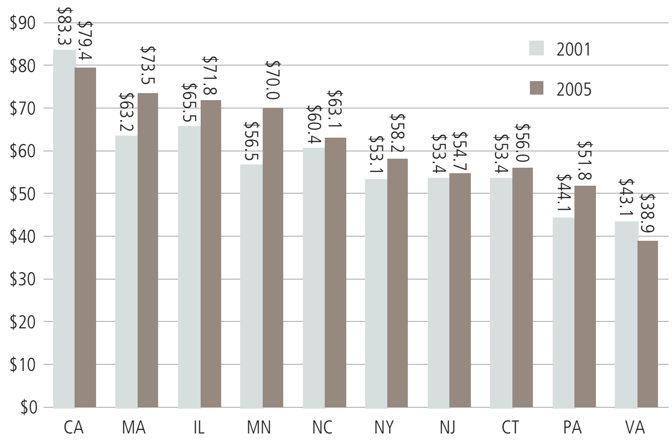
Three-year average median household income, in 2005 dollars, LTS and US, 1995–2005



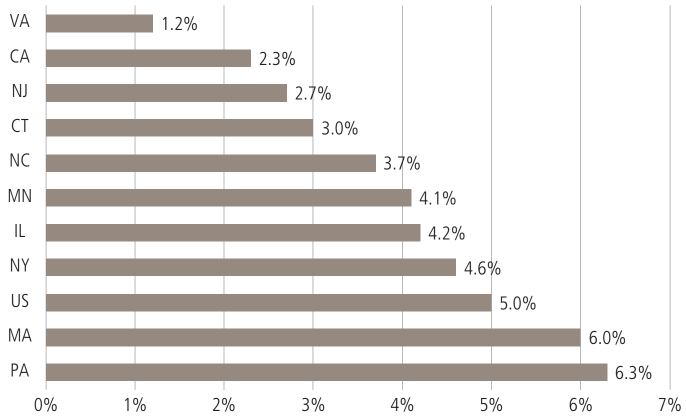
Source of all data for this indicator: US Census Bureau

Manufacturing Exports

Manufacturing exports per $1,000 GSP, LTS, 2001 and 2005



Average annual growth rates of manufacturing exports, LTS and US, 2001-2005



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 creates a countercyclical hedge against an economic downturn or recession in any particular international region.

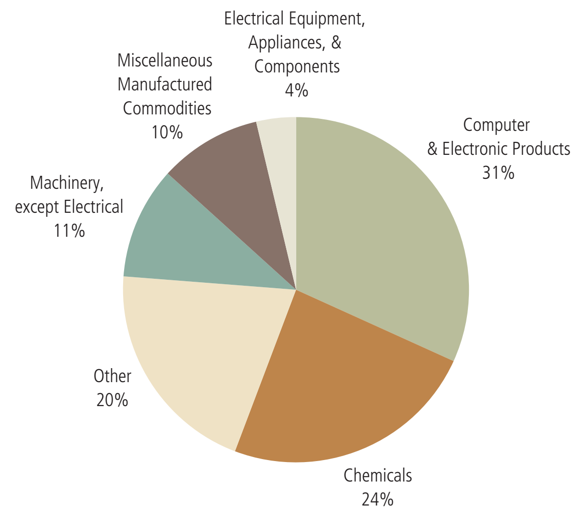
How Does Massachusetts Perform?

Massachusetts experienced a significant annual increase in manufacturing exports in 2003 and 2004 of 11.7% and 17.0% respectively. The 2005 growth in exports, however, is more moderate at 0.9%. As a result of the sharp declines in 2000 and 2001 and the turnaround beginning in 2002, the AAGR between 2001 and 2005 is a healthy 6%. Relative to gross state product (GSP), the state's manufacturing exports maintain a strong $73 per $1,000 GSP, second only to California, and ahead of all other LTS. As more than half of the manufacturing exports in Massachusetts are Computer & Electronic Products and Chemicals, which includes medical devices and pharmaceutical products, the importance of international markets to the state's Innovation Economy cannot be understated. These clusters are also the areas of economic activity that maintain strong year-to-year growth in exports, while Electrical Machinery, Plastics and other traditional manufacturing clusters show flat or declining performance.

Indicator #5 Key Takeaways:

- Average annual growth in manufacturing exports in Massachusetts from 2001 to 2005 is healthy at 6.0%, but stagnant from 2004 to 2005.
- In terms of GSP, Massachusetts exports are strong and leading most other LTS.
- Export growth in Massachusetts is limited to relatively few sectors.

Distribution of manufacturing exports, Massachusetts, 2005



Source of all data for this indicator: Source: US Department of Commerce (DOC), 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?

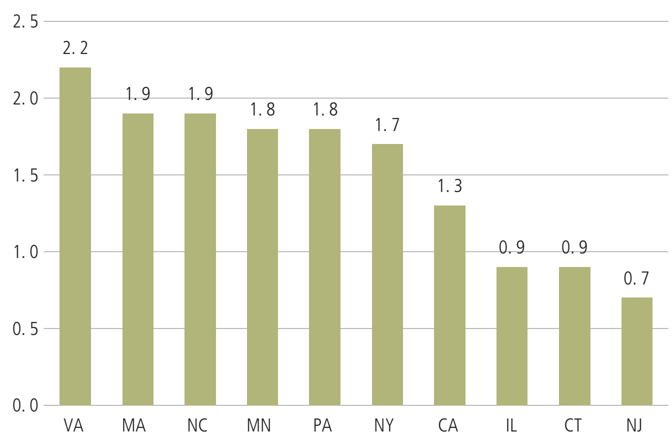
After the 2001 recession, new business incorporations have increased on a consistent basis. This steady growth stimulates both cluster-specific and ancillary employment growth and is critical to overall health of the workforce and expansion of the economy. Another very positive sign is that incorporations of for-profit businesses have increased almost 50% in the last five years. These enterprises are typically highly entrepreneurial, growth-oriented, and pay relatively high wages.

Massachusetts also boasts a healthy ratio of business incubators to business establishments, second only to Virginia among the LTS. These incubators provide fertile ground for innovative start-up companies to convert university and industry research into new products and services and on to mature, full-fledged, high-technology firms.

Indicator #6 Key Takeaways:

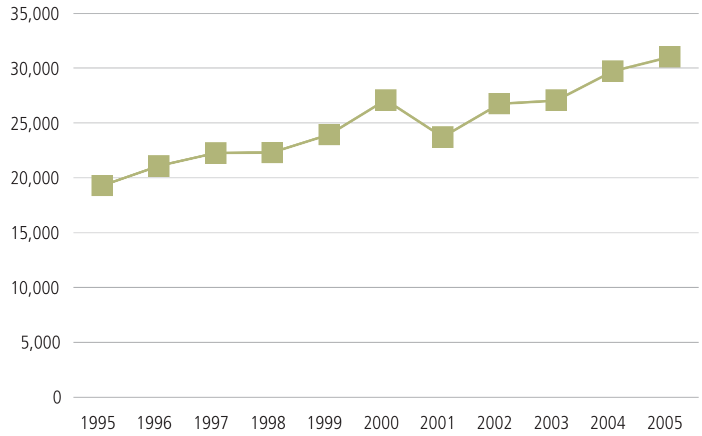
- Massachusetts demonstrates strong and growing for-profit business incorporations.
- Total new business incorporations in Massachusetts achieved a record level of more than 30,000 in 2006.
- Rate of growth in for-profit business incorporations in Massachusetts is greater in the period 2001 to 2005, than in 1995 to 2001.

Business incubators per 10,000 business establishments, LTS, 2005

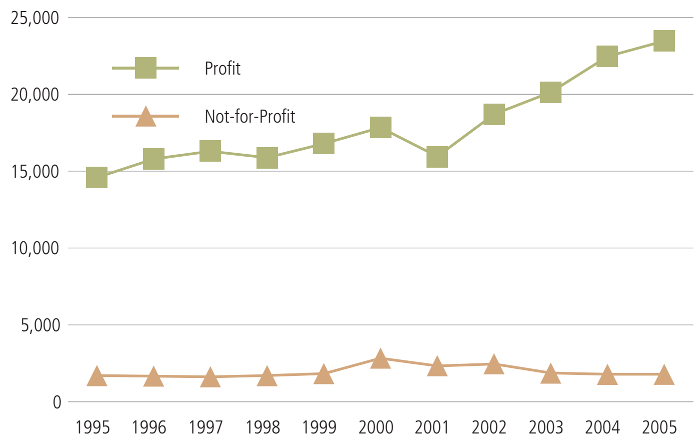


Source of all data for this indicator: Commonwealth of Massachusetts

New business incorporations, Massachusetts, 1995–2005

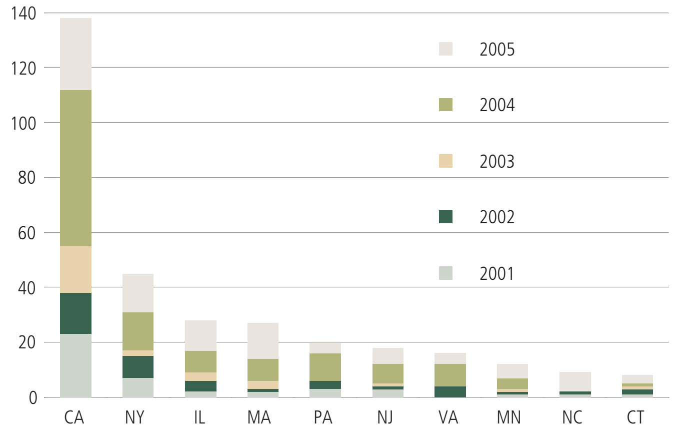


New business incorporations by category, Massachusetts, 1995–2005



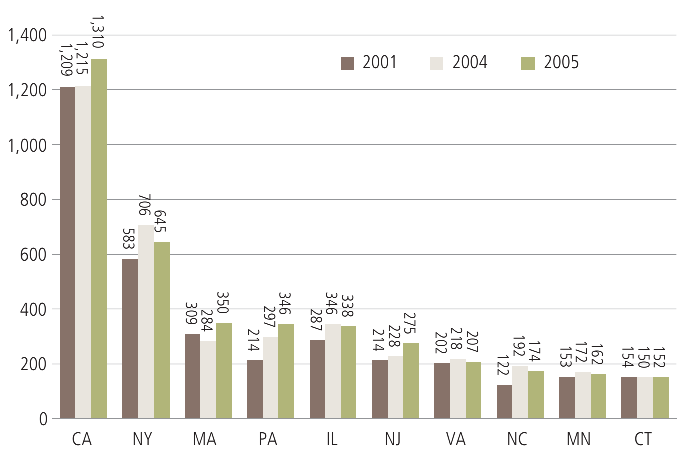
Initial Public Offerings (IPOs) and Mergers and Acquisitions (M&As)

Initial public offerings, LTS, 2001–2005



Source: Renaissance Capital's IPOhome.com

Mergers and acquisitions by location of acquired company, LTS, 2001, 2004, and 2005



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" 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 2005, Massachusetts ranks third among the LTS in the number of IPOs, with 13, a 60% increase over 2004 and ranks fourth in total IPOs conducted between 2001 and 2005. While the Commonwealth is recognized for the presence of an active venture capital community, the solid increase in the number of IPOs over the last five years suggests that healthy business development exists beyond early stage capital investment. In 2005, Massachusetts was one of only four LTS to experience an increase in M&As of 23%, with a total of 350 such deals. This illustrates that the Commonwealth grows numerous firms attractive for acquisition.

Indicator #7 Key Takeaways:

- There is a significant increase in new business activity in Massachusetts reflected in a large number of IPOs and M&As when compared to other LTS.
- The total number of M&As in Massachusetts increased by the largest percentage among all LTS.
- While most LTS demonstrate a decline in the number of IPOs from 2003 to present, Massachusetts shows a consistent increase.

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.[4] 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, not limited to technology sectors.

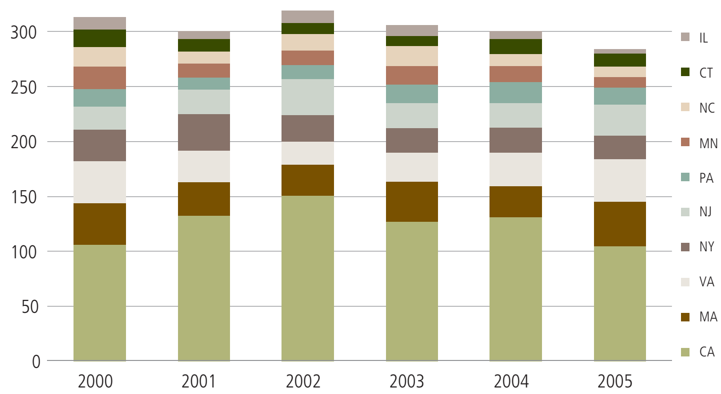
How Does Massachusetts Perform?

Massachusetts experienced a significant increase in Technology Fast 500 firms, from 28 to 40 such firms from 2004 to 2005. Massachusetts has shown a modest increase in Inc. 500 firms from 23 to 26 firms from 2004 to 2005. However, the numbers of these types of firms have fluctuated between 2000 and 2005, testifying to the volatility of these markets and industries. Overall, the total number of companies fitting these two profiles in Massachusetts has remained substantially the same. Across the LTS for 2003 to 2005, the number of Inc. 500 companies is on the rise while the number of Technology Fast 500 companies located in the LTS has decreased consistently. This trend suggests a broadening in the geographic distribution of technology intensive companies and increasing competition among the LTS.

Indicator #8 Key Takeaways:

- The number of Technology Fast 500 firms in Massachusetts increased dramatically between 2004 and 2005 rising to the highest number in the last five years.
- Of the Inc. 500 firms, Massachusetts is home to the highest number it has had since 2001.

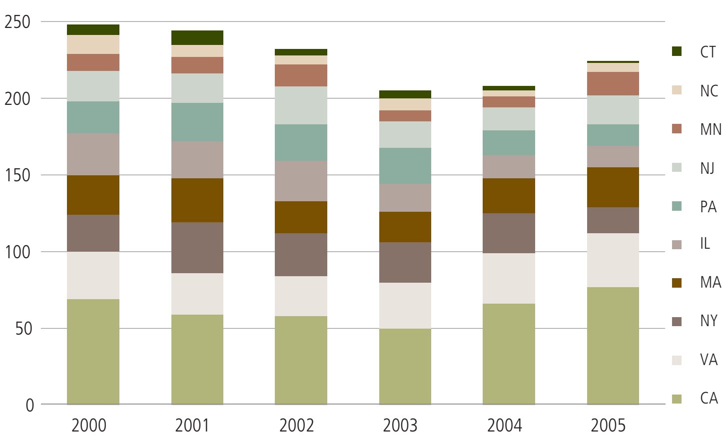
Technology Fast 500 firms, LTS, 2000–2005



	2000	2001	2002	2003	2004	2005	total
IL	11	7	11	10	7	4	50
CT	16	11	10	9	13	12	71
NC	18	11	15	18	11	9	82
MN	20	13	13	17	15	10	88
PA	16	11	13	17	19	15	91
NJ	21	22	33	23	22	29	150
NY	29	33	24	22	23	21	152
VA	38	29	21	27	31	39	185
MA	38	31	28	36	28	40	201
CA	106	132	151	127	131	105	752

Source: Deloitte and Touche, LLP

Inc. 500 companies, LTS, 2000–2005



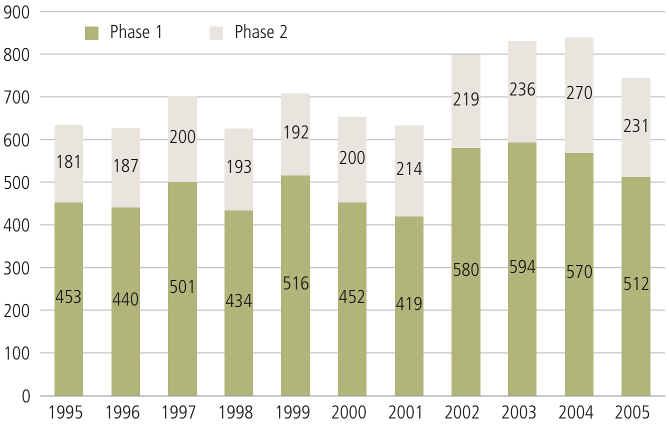
	2000	2001	2002	2003	2004	2005	total
CT	7	9	4	5	3	1	29
NC	12	8	6	8	4	6	44
MN	11	11	14	7	7	15	65
NJ	20	19	25	17	15	19	115
IL	27	24	26	18	15	14	124
PA	21	25	24	24	16	14	124
MA	26	29	21	20	23	26	145
NY	24	33	28	26	26	17	154
VA	31	27	26	30	33	35	182
CA	69	59	58	50	66	77	379

Source: *Inc. Magazine*

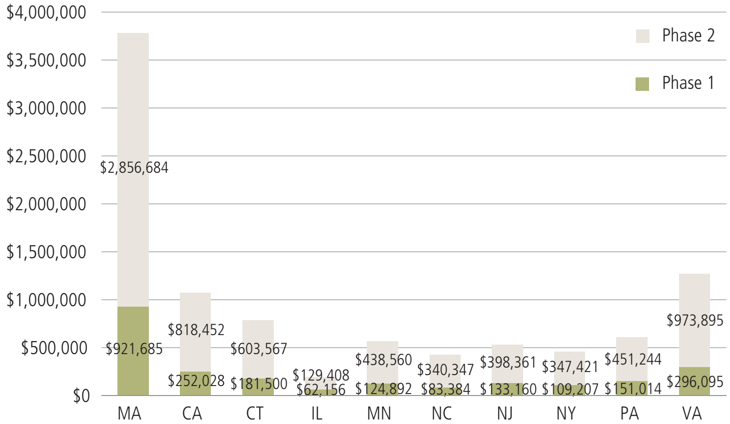
4. A "gazelle" firm is one that has grown at 20% per year or greater for at least a five year period.

Small Business Innovation Research (SBIR) Awards

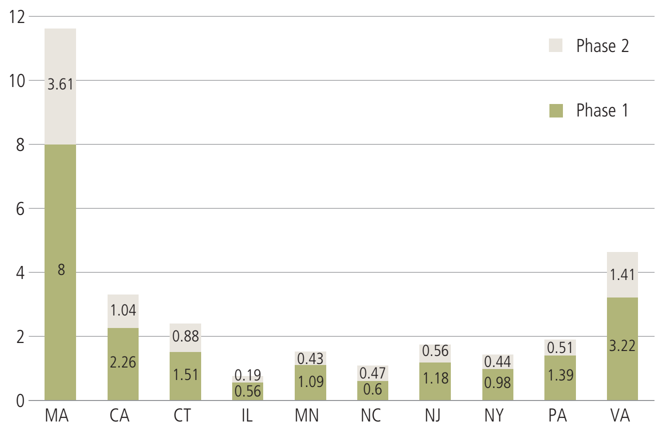
SBIR awards to companies by phase, Massachusetts, 1995–2005



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 federal 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, with Virginia in second place.
- For 2005, Massachusetts experiences a reversal of a ten year growth trend in Phase 2 awards.

Regulatory 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 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. 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.

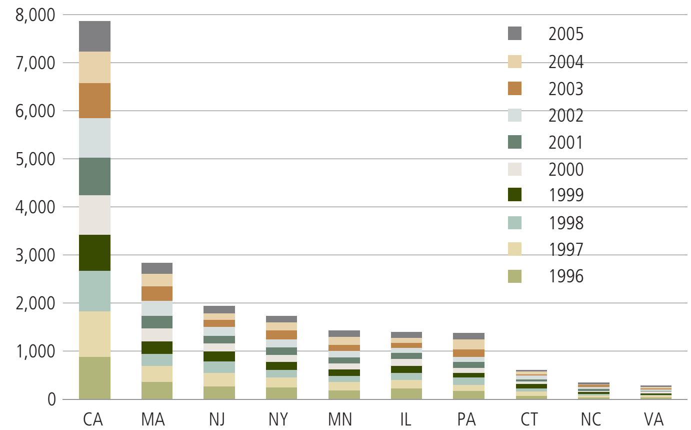
How Does Massachusetts Perform?

Massachusetts regularly ranks high among the LTS with regard to medical device approvals and biotechnology drug approvals. This performance reflects the state's strong performance historically in the Life Sciences and Healthcare Technology sectors. In 2005, however, Massachusetts experienced a significant decrease in both PMA and 510(k) approvals indicating that research institutions and medical corporations are not being as efficient in generating new products, securing necessary regulatory approvals, moving products to the market, and thereby growing their businesses. Total FDA PMAs declined in 2005 to only one approval. Yet, the three-year average changed only slightly, highlighting the impact of the lengthy approval process and not necessarily indicative of a trend. Releasable 510(k)s are at their lowest number in the last decade with only 227 such approvals. Given the intricacies of the FDA approval process, the extended product development cycle, and the volatile market demand for drugs and devices, the results for 2005 may simply be a function of timing and/or decisions by companies concerning the readiness of their products or schedules for submissions to the FDA.

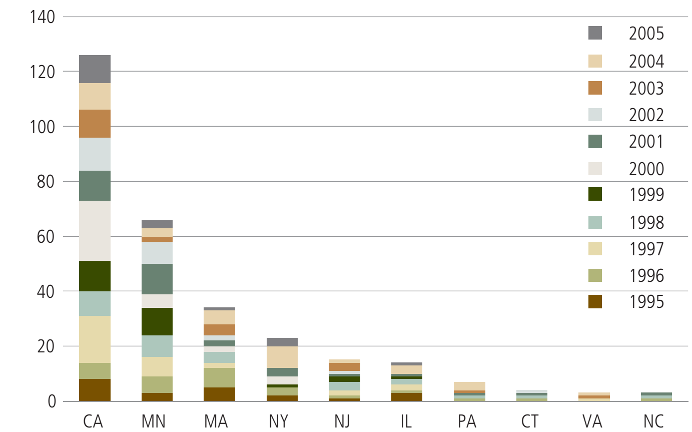
Indicator #10 Key Takeaways

- Compared to 2004, Massachusetts had far fewer biotechnology drug approvals in 2005.
- The number of releasable 510(k)s in Massachusetts continue the decline that began in 2002 and is 15% lower than 2004.
- Releasable 510(k) approvals for Massachusetts firms are at their lowest in ten years.

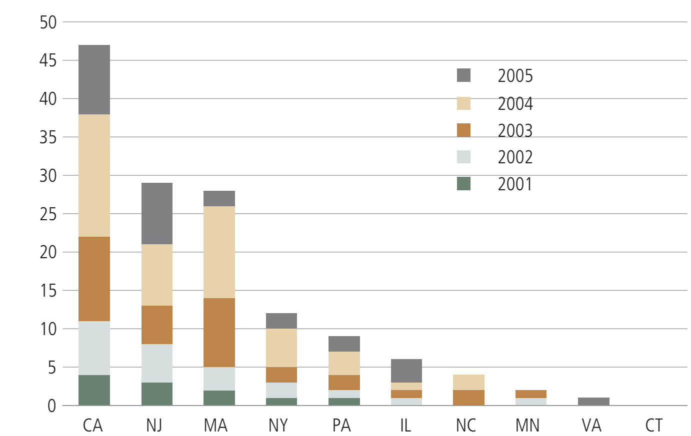
Releasable 510(k)s, LTS, 1996–2005



Premarket approvals, LTS, 1995–2005



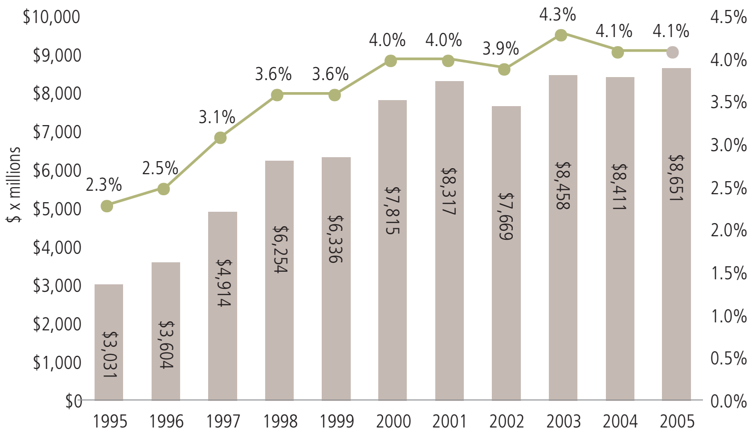
Biotechnology FDA drug approvals, LTS, 2001–2005



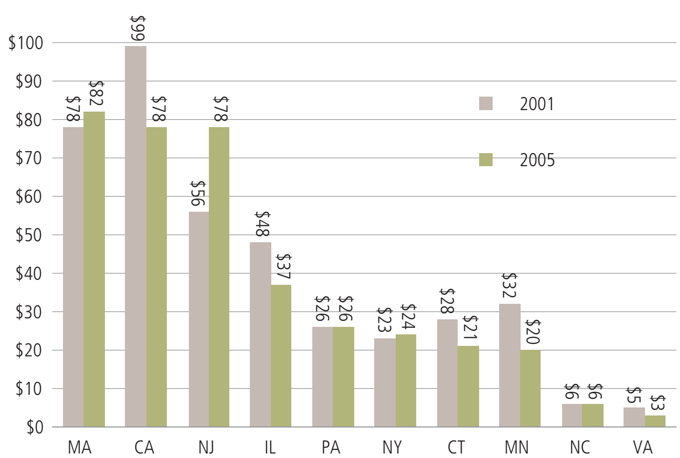
Source of all data for this indicator: Food and Drug Administration

Corporate Research and Development Expenditures, Publicly Traded Companies

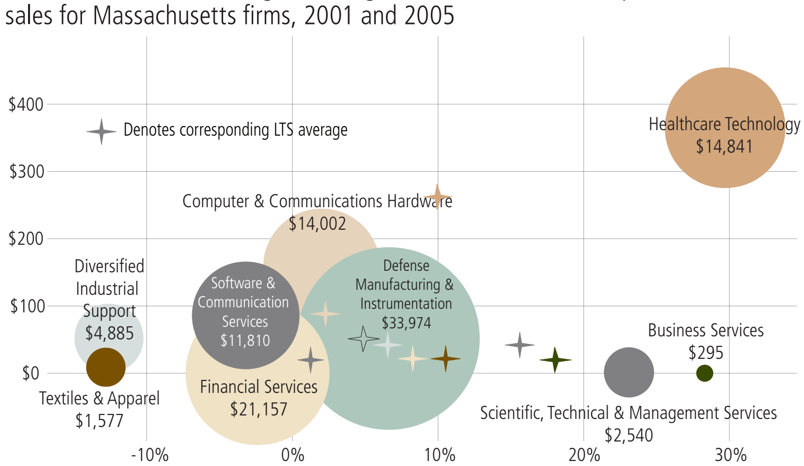
Corporate research and development (R&D) expenditure and as a share of US total, publicly traded companies with R&D expenditures, Massachusetts, 1995-2005



Corporate R&D expenditures, per $1,000 of corporate sales, publicly traded companies, LTS, 2001 and 2005



Average corporate research and development (R&D) expense, per $1,000 of sales, and average annual growth rate (AAGR) of corporate sales for Massachusetts firms, 2001 and 2005



Source of all data for this indicator: Standard and Poor's Compustat

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.

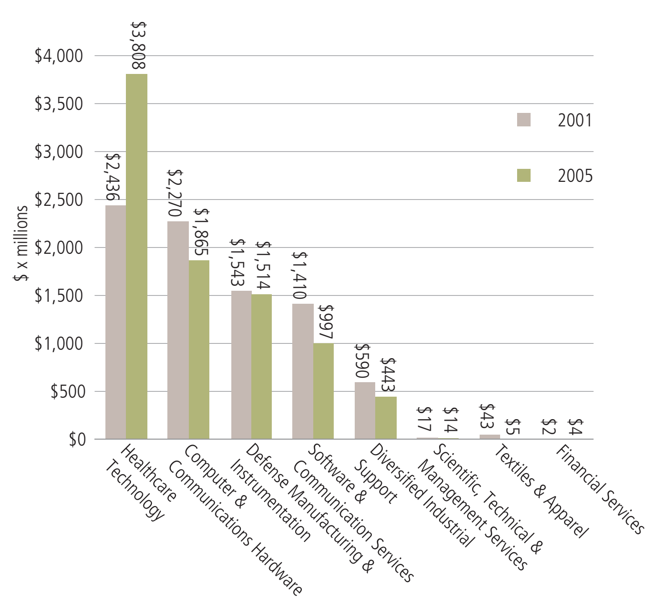
How Does Massachusetts Perform?

Massachusetts' share of US corporate R&D expenditures remains constant and strong at 4.1%. The annual growth rate in corporate R&D in Massachusetts, which averaged 20.9% per year in the late 90s, has slowed significantly since 2001, averaging just 1.0% between 2001 and 2005. This is less than the average LTS AAGR of 3.7%, but remains on par with the US AAGR of 1.0%. Massachusetts still leads the LTS with the highest corporate R&D expenditure with $82 per $1,000 in sales compared to New Jersey and California both at $78 per $1,000 in sales. The Healthcare Technology cluster experienced significant growth in R&D investment between 2001 and 2005, while all other clusters remain less than expenditures made in 2001.

Indicator #11 Key Takeaways:

- Corporate R&D investment by public companies in Massachusetts is level, experiencing minimal growth in the past four years.
- Massachusetts' share of corporate R&D expenditure by public companies remained flat between 2004 and 2005 at approximately 4%.
- Between 2001 and 2005, R&D expenditure in Massachusetts declined in all clusters except Healthcare Technology.

Corporate R&D expenditures by cluster, publicly traded companies, Massachusetts, 2001 and 2005



Note: Postsecondary Education and Business Services were essentially zero.

Patent Grants, Invention Disclosures, and Patent Applications

Why Is It Significant?

Patents reflect 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.

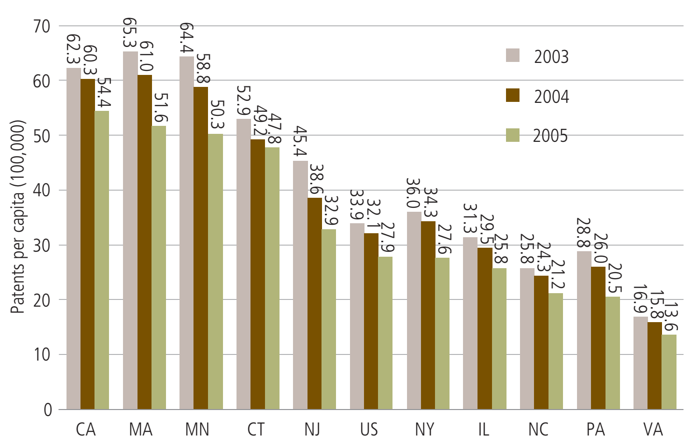
How Does Massachusetts Perform?

Massachusetts premier institutions of higher education, research, and medicine have empowered the Commonwealth to be a consistent leader in invention and discovery. For years, Massachusetts has excelled in patents per resident, invention disclosures, and patent applications from the state's academic institutions and research laboratories and patenting activity remains vigorous by Massachusetts firms and institutions. Although the Commonwealth lost its leading position to California in patents per capita, Massachusetts performance remains strong in second place with 51.6 patents per 100,000 residents. Patent disclosures are concentrated predominantly in Computer Hardware and Software (18.6%), Healthcare (26.7%) and Miscellaneous Industry & Transportation (21.8%). Relatively strong patent growth is witnessed between 2001 and 2005 when compared to 1995-1999 in the Computer Hardware & Software sector, a change from 14% to more than 18% of total. Similarly, in Telecommunications there is an increase from 6.7% to 9.6% of total.

Indicator #12 Key Takeaways:

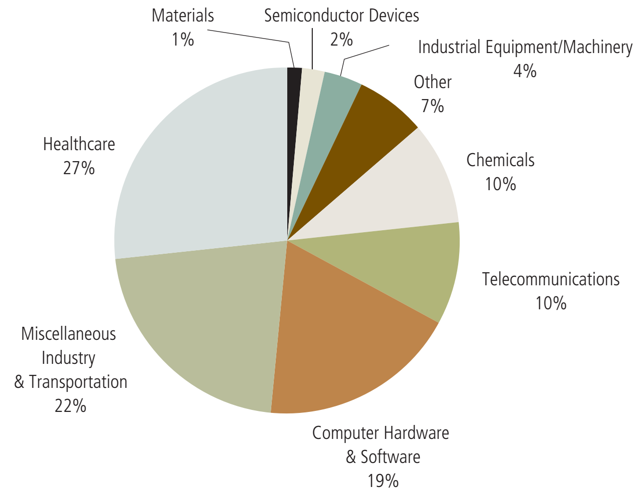
- Massachusetts no longer leads the LTS in patents per capita.
- More than 67% of patent disclosures in Massachusetts are limited to three industry sectors and show a decline in Materials, a critical foundation science.
- Patent growth rates in Massachusetts between 2001 and 2005 exceed those of 1995 to 1999 in certain sectors.
- There is a significant decline in patents in the Chemicals sector in Massachusetts.

Patents issued per capita, LTS, 2003–2005



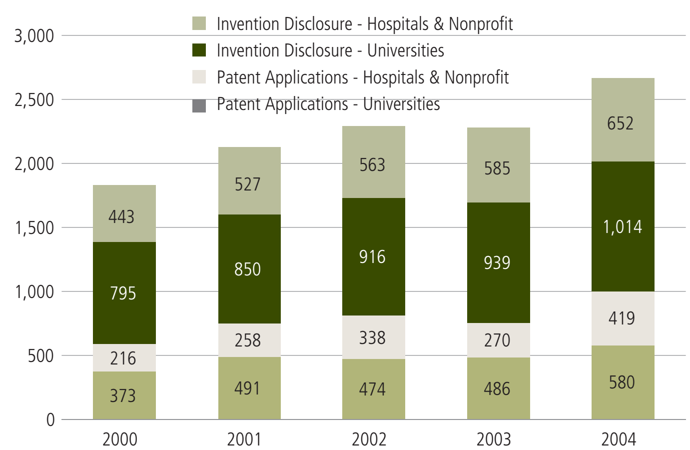
Source: US Patent & Trademark Office (USPTO)

Distribution of patents issued, Massachusetts, 2001–2005



Source: Adam Jaffe, Brandeis University and US Patent and Trademark Office

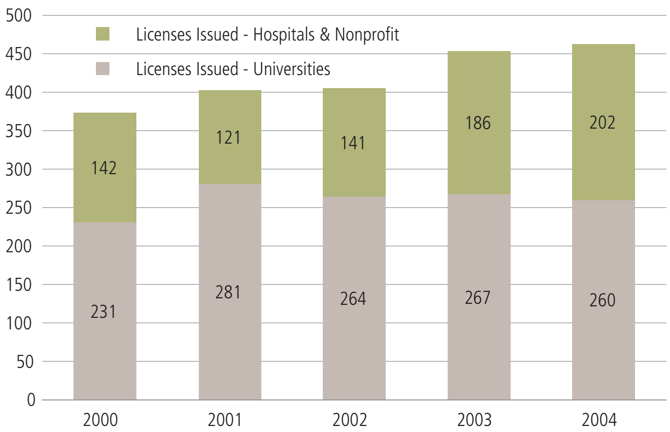
New patent applications and invention disclosures filed by Massachusetts universities, hospitals, and nonprofit research institutions, 2000–2004



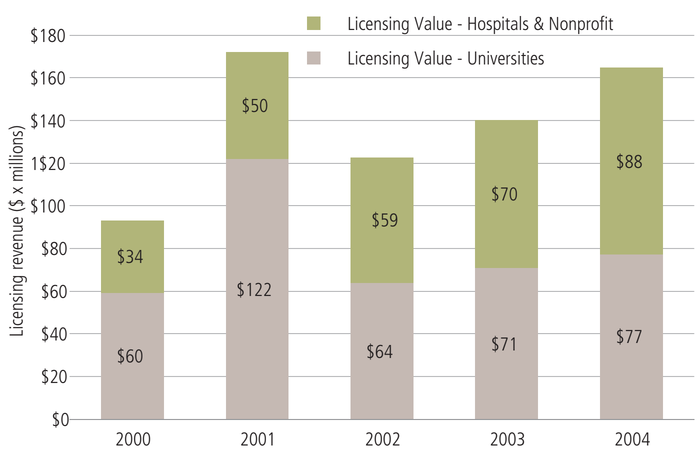
Source: US Patent & Trademark Office (USPTO)

Technology Licenses and Royalties

Technology licenses issued to major universities, hospitals, and other nonprofit research institutions, Massachusetts, 2000–2004



Technology licensing revenues for major universities, hospitals, and other nonprofit research institutions, Massachusetts, 2000–2004



Source of all data for this indicator: Association of University Technology Managers (AUTM)

Why Is It Significant?

Technology licenses provide a vehicle for the transfer of intellectual property (IP), patents and trademarks 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 also provide additional support for further research activities at the licensing institutions.

How Does Massachusetts Perform?

Massachusetts academic, medical, and research institutions continue to license technology in growing numbers with 462 licenses and $179.5M in total royalties in 2004. In particular, over the last five years, hospitals and nonprofit institutions have significantly increased their technology licenses. Institutional revenues from these licenses have increased by 260% over this period. This growth can be attributed to the strength and influence of the medical and life sciences sectors in the Massachusetts economy. In addition, this serves as an acknowledgement of and investment in the technology transfer function by the Commonwealth's institutions of higher education and medicine. The increase in royalties collected is important as a significant portion of this revenue is recycled back into R&D—feeding a cyclic process of innovation at universities, teaching hospitals, and other institutions.

Indicator #13 Key Takeaways:

- Revenue to research institutions in Massachusetts from licensing royalties continues to be strong.
- Growth in the number of licenses and royalties in Massachusetts is especially strong in the hospital and nonprofit research institutions.
- Massachusetts universities have recorded a relatively constant number of licenses from 2000 to 2004.

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 and direction of VC 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 "angel investors" can fill shortfalls that might exist in VC pools.

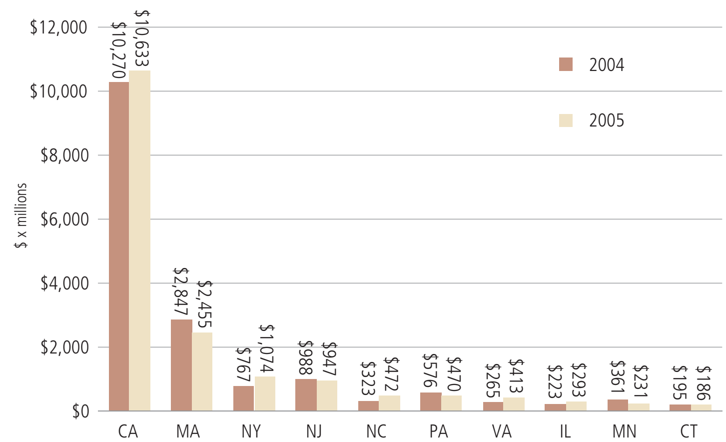
How Does Massachusetts Perform?

The largest shares of VC investment in Massachusetts are seen in Biotechnology (22.9%), Software (24.5%) and Communications (10.6%.) There is a declining share of investment in Networking and Equipment, from 12% in 2001 to only 4.7% in 2005. In 2005, Massachusetts experienced a decline in total VC investments while most other LTS recorded higher levels of VC investments. This marks the second consecutive year in which the Commonwealth has lost ground in its proportion of the nation's total VC investments. VC investment in Massachusetts declined 13.8% between 2004 and 2005 to a total of $2.5B while other LTS experienced an increase in VC investment. Following the trend of other LTS, later stage investments in Massachusetts now account for more than 50% of all investments, underscoring the recent shift and more cautious outlook of investment firms in Massachusetts.

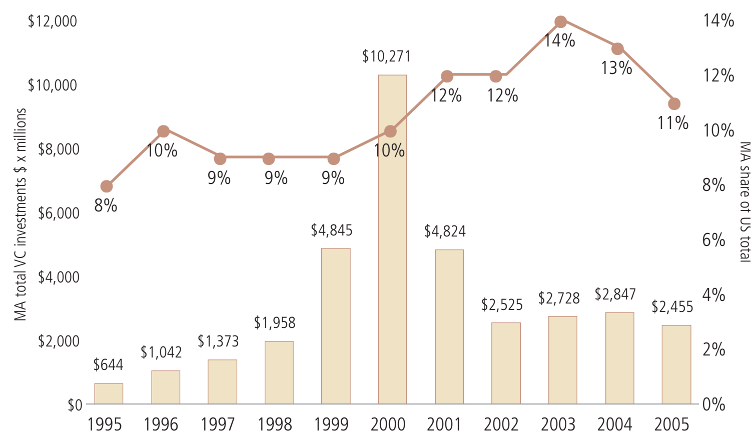
Indicator #14 Key Takeaways:

- Massachusetts has experienced a decline in its share of total US VC investment to the lowest levels since 1998.
- There are strong and growing VC resources for later stage companies across the LTS.
- VC investment in later stage companies in Massachusetts amount to more than the VC investments in all other stages combined.

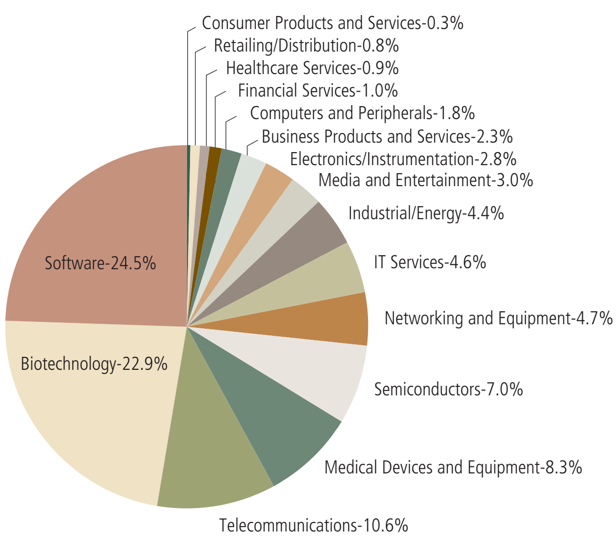
Venture capital investments, LTS, 2004–2005



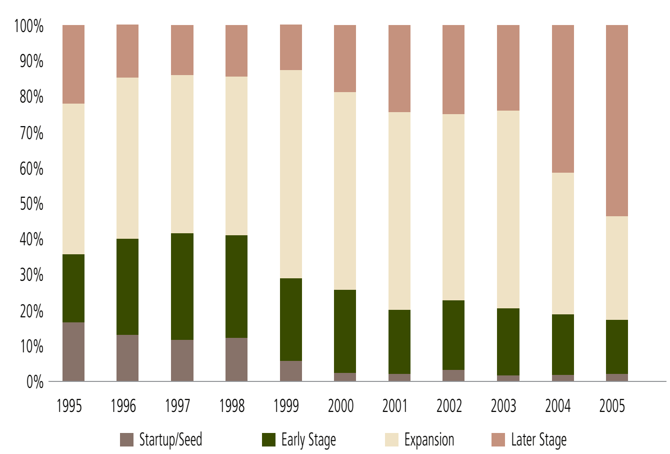
Venture capital investments In Massachusetts and as a share of total venture capital investment in the US, 1995–2005



Distribution of venture capital investments, Massachusetts, 2005



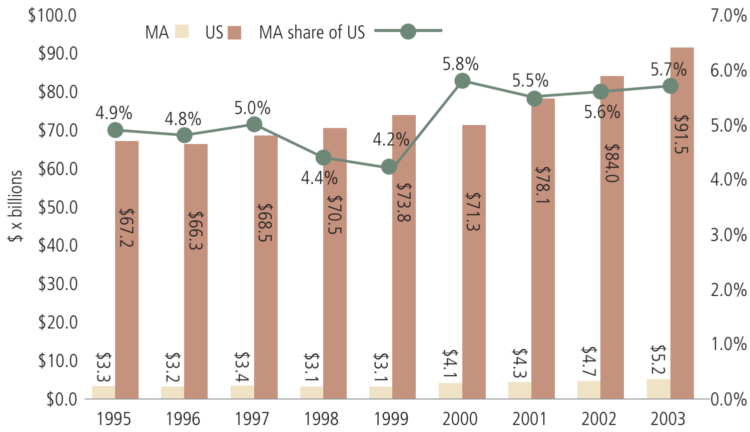
Venture capital investments by stage of financing, Massachusetts, 1995–2005



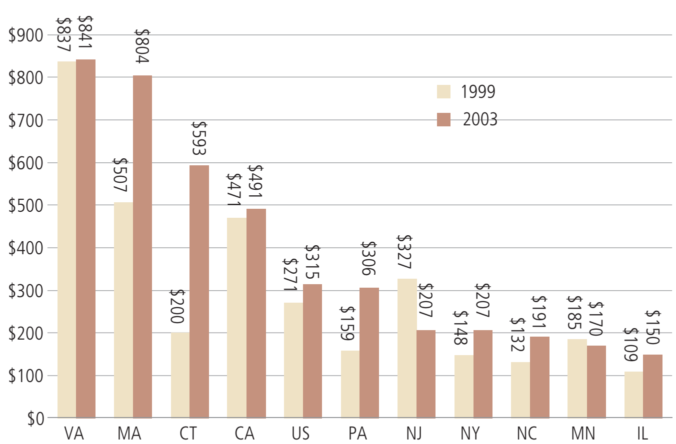
Source of all data for this indicator: PricewaterhouseCoopers/Thomson Venture Economics/National Venture Capital Association MoneyTree™ Survey

Federal Academic and Health Research and Development Expenditures

Federal research and development (R&D) expenditures, Massachusetts and Massachusetts' share of US, 1995–2003



Per capita federal R&D expenditures, LTS and US, 1999 and 2003



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. Research and development (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 cluster that is at the core of innovation in Massachusetts.

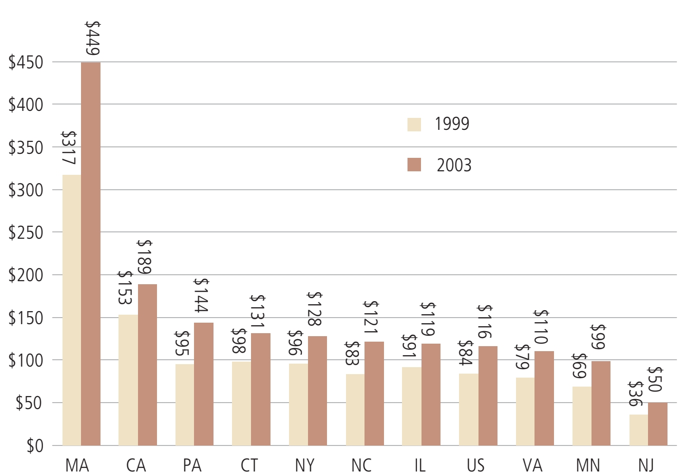
How Does Massachusetts Perform?

Massachusetts has consistently captured a relatively large proportion of federal funding for R&D. Massachusetts' share of federal R&D represents 5.6% of total federal R&D expenditures for 2003, and increased in absolute terms to a new high of $5.2B. Also in 2003, total federal R&D expenditures in the Commonwealth on a per capita basis continued its upward trend. For the five-year period ending in 2003, per capita federal R&D spending in Massachusetts increased by 58.6%. The Commonwealth also continues its leadership position among all LTS in both academic and health funding. The growth in all areas of federal R&D funding can be attributed in large part to the state's preeminent institutions of research, learning, and medicine.

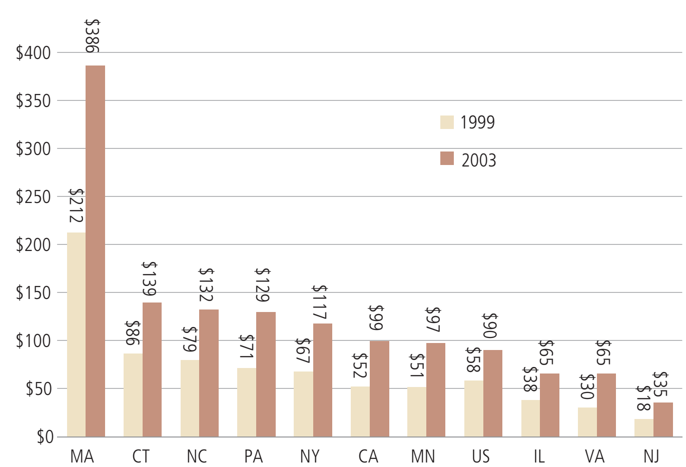
Indicator #15 Key Takeaways:

- Massachusetts continues to attract a large share of total US federal R&D investment.
- Massachusetts rivals Virginia's lead in federal R&D expenditures per capita.
- Massachusetts leads all LTS in per capita federal R&D expenditures by academic and research institutions and by the US Department of Health and Human Services.

Per capita federal R&D expenditures (academic and nonprofit research), LTS and US, 1999 and 2003



Per capita Health and Human Services R&D expenditures, LTS and US, 1999 and 2003



Source of all data for this indicator: National Science Foundation and US Census Bureau

Intended College Majors 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.

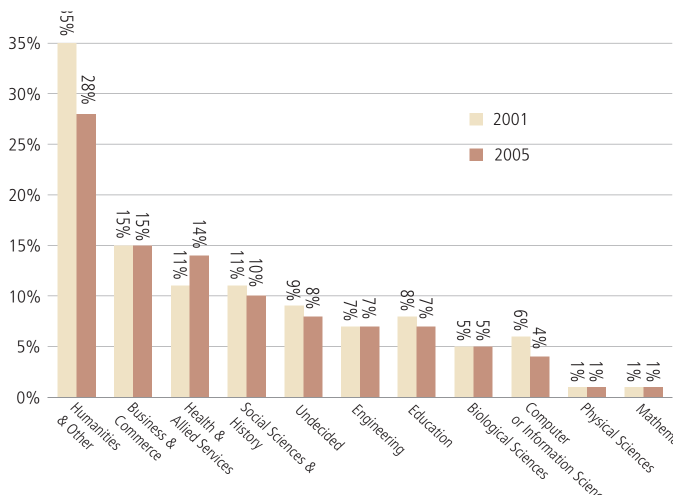
How Does Massachusetts Perform?

The distribution of intended college majors of high school students has varied little over the past five years. Two academic majors have experienced notable change from 2000 to 2005. Computer or Information Sciences fell from 6% to 4% while Health and Allied Services increased from 12% to 14% in the same period. The preferences of Massachusetts high school seniors are consistent with the overall US trend of a declining interest in Computer, Engineering, and Information Sciences as college majors. While all LTS recorded declines, the percentage of Massachusetts high school students who noted their intended majors as Computers, Engineering and Information Sciences is lower than in most of the other LTS and lower than the US average.

Indicator #16 Key Takeaways:

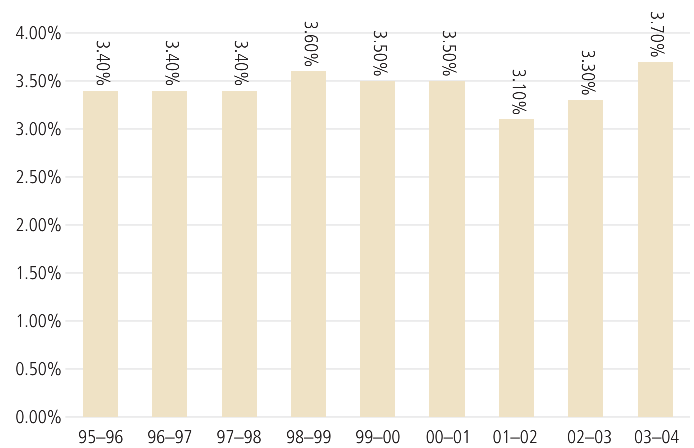
- Only 18% of Massachusetts high school seniors intend to pursue college majors in Science, Technology, and Mathematics.
- Other than in Health and Allied Services (from 12% to 14%), the distribution of Science and Technology intended majors has not changed in the past five years in Massachusetts.

Intended college majors, high school students taking the SAT, Massachusetts, 2001 and 2005



Source: The College Board

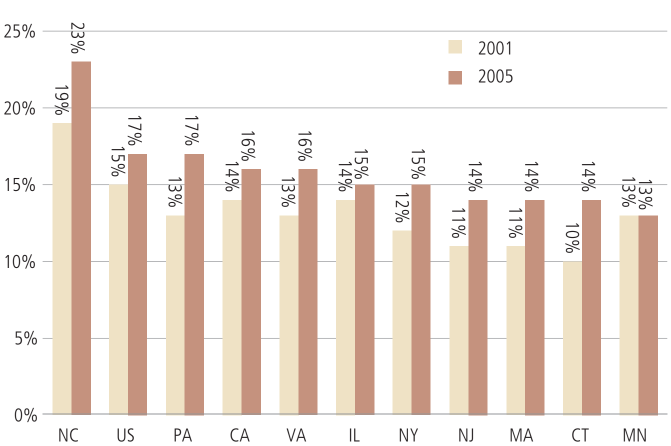
High school dropout rate, Massachusetts, FY 1999–2004



Note: Data for 2004–2005 not available at presstime.

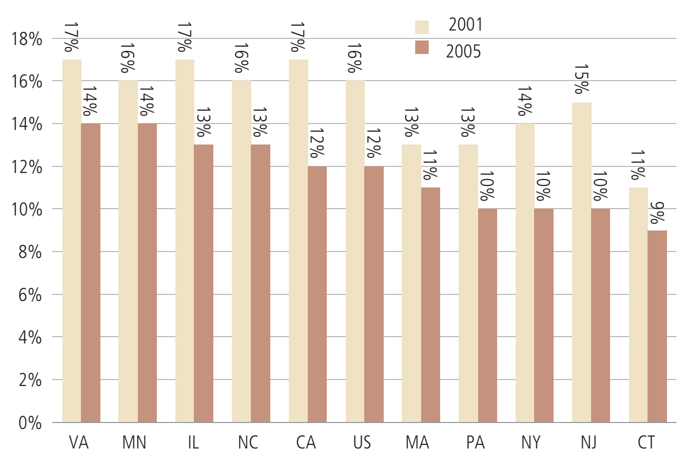
Source of data: Massachusetts Department of Education

Percent of all high school seniors taking the SAT planning to major in Health and Allied Services in college, LTS and US, 2001 and 2005



Source: The College Board

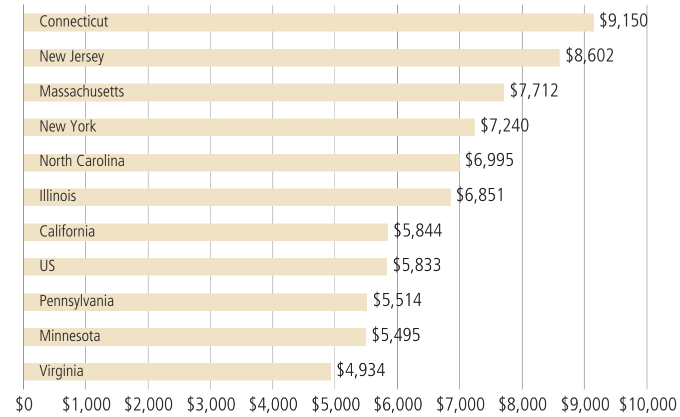
Percent of all high school seniors taking the SAT planning to major in Computer, Engineering, or Information Science in college, LTS and US, 2001 and 2005



Source: The College Board

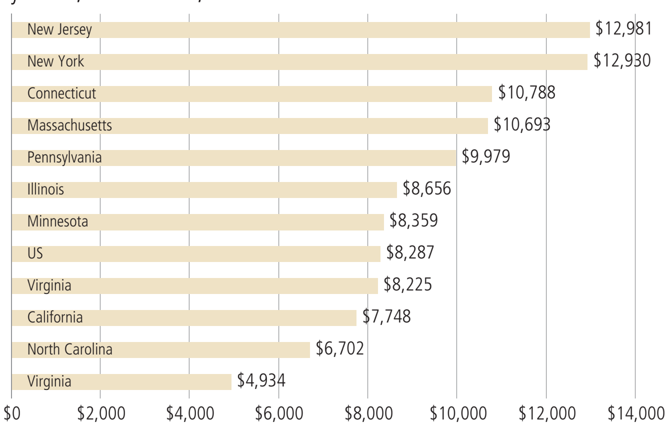
Public Secondary and Higher Education Expenditures and Performance

Higher education appropriations per full time equivalent (FTE), LTS and US, 2005



Source: National Information Center for Higher Education Policymaking and Analysis

Per pupil current spending of public elementary-secondary school systems, LTS and US, 2003–2004



Source: US Census Bureau, 2004 Public Education Finances Report

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 learning 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.

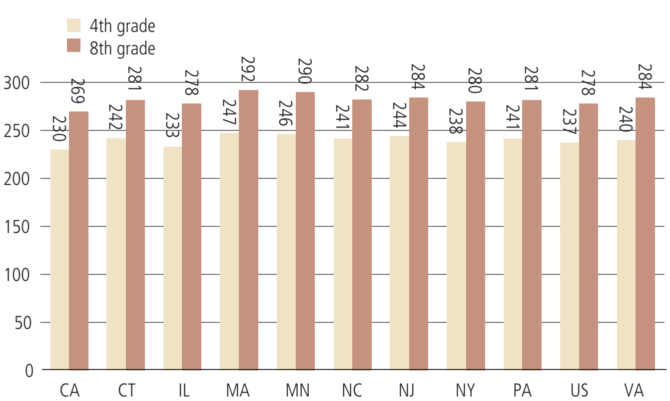
How Does Massachusetts Perform?

For 2005, Massachusetts ranks third among the LTS in terms of expenditure per full time equivalent student (FTE) at public institutions of higher education, spending nearly $8,000 per student. Similarly, at the secondary education level, Massachusetts ranks fourth among the LTS, spending well more than $10,000 per student. According to The Nation's Report Card, issued by the National Center for Education Statistics (NCES) within the US Department of Education, Massachusetts ranks first in the nation with best average assessment test scores for both grades four and eight in mathematics, first in eighth grade science scores, and second in fourth grade science scores, trailing only Virginia.

Indicator #17 Key Takeaways:

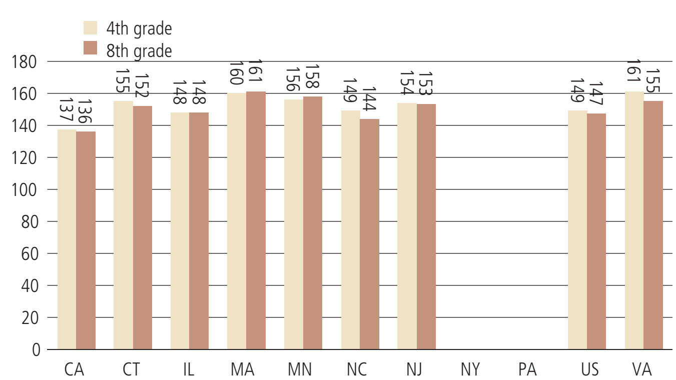
- Massachusetts ranks highly among the LTS in expenditure per student at the both the secondary and higher education levels.
- At the fourth-grade level, Massachusetts leads all LTS in achievement on standardized math tests and trails only Virginia at this grade level on standardized science test achievement.
- At the eighth-grade level, Massachusetts leads all LTS in achievement on standardized math and science tests.

Average 4th- and 8th-grade math NAEP scores, LTS, 2005



Source: US Department of Education, Institute of Education Sciences

Average 4th- and 8th-grade science NAEP scores, LTS, 2005



Note: NY and PA did not report for 2005.
Source: US Department of Education, Institute of Education Sciences

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.

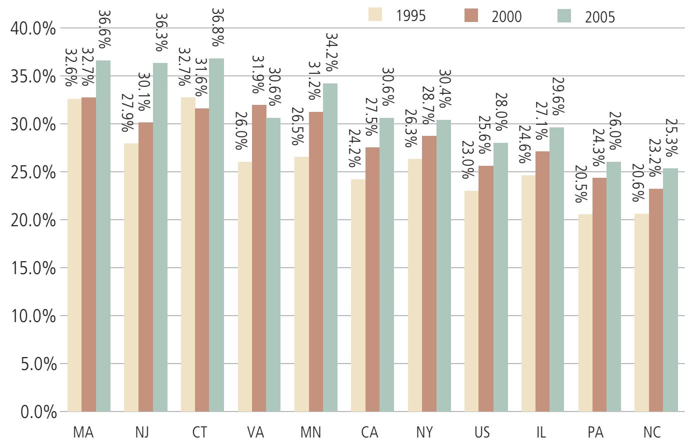
How Does Massachusetts Perform?

Massachusetts preeminent institutions of higher education traditionally draw the best and the brightest students from across the country and the world. Massachusetts continues to have the highest percentage of adult population with a bachelor's degree or higher, providing the Commonwealth's Innovation Economy with a distinct comparative advantage in human capital over other LTS. However, there is evidence that this advantage has narrowed over the last two years. Massachusetts universities and colleges are also producing a growing number of engineering graduates, especially in the advanced degrees (MS and PhD). As a result, Massachusetts graduates the highest percentage of engineers with advanced degrees compared to other LTS, 53% with BS and 47% with MS or PhD degrees, compared with 58% and 42% in California, and 60% and 40% in New York, respectively. Yet, while Massachusetts experienced a 7.0% increase in the number of engineering degrees awarded since 2001, there was a decline of 3.2% between 2004 and 2005 primarily in the BS and MS levels.

Indicator #18 Key Takeaways:

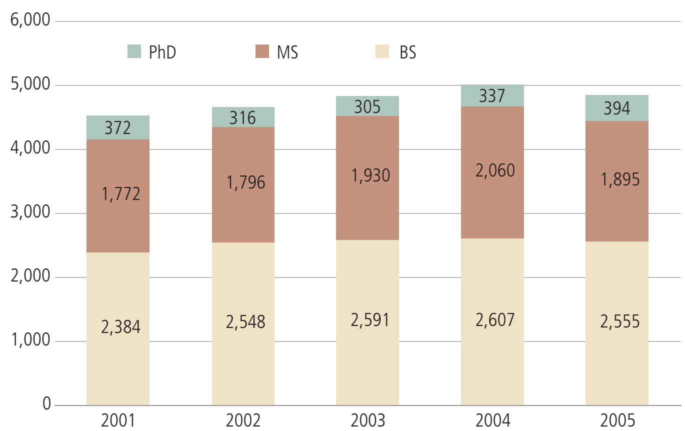
- Massachusetts still boasts relatively high levels of educational attainment, especially in the percentage of its citizens holding MS and PhD degrees.
- Massachusetts maintains a very high percentage of its population with a BS degree or higher.
- New Jersey and Connecticut have narrowed the attainment gap with Massachusetts in the last decade, with all three LTS now indicating 36% to 37% of their populations with a bachelor's degree or higher.

Persons 25 years old and over with a bachelor's degree or higher, LTS and US, 1995, 2000, 2005



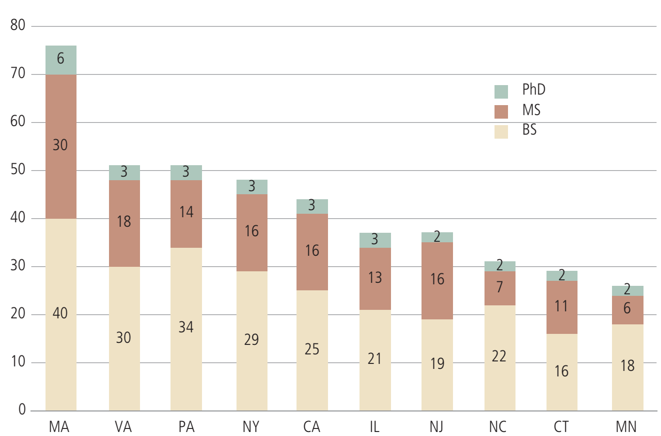
Source: US Census Bureau, Current Population Survey (CPS), 2005

Engineering degrees awarded, Massachusetts, 2001–2005



Source: American Association of Engineering Societies (AAES)

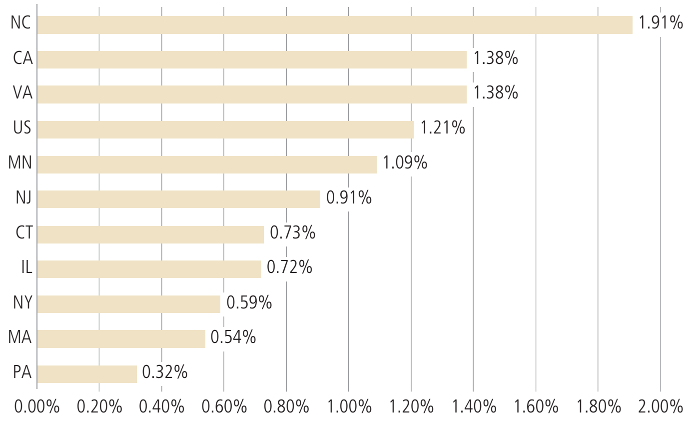
Engineering degrees awarded, per 100,00 residents, LTS, 2005



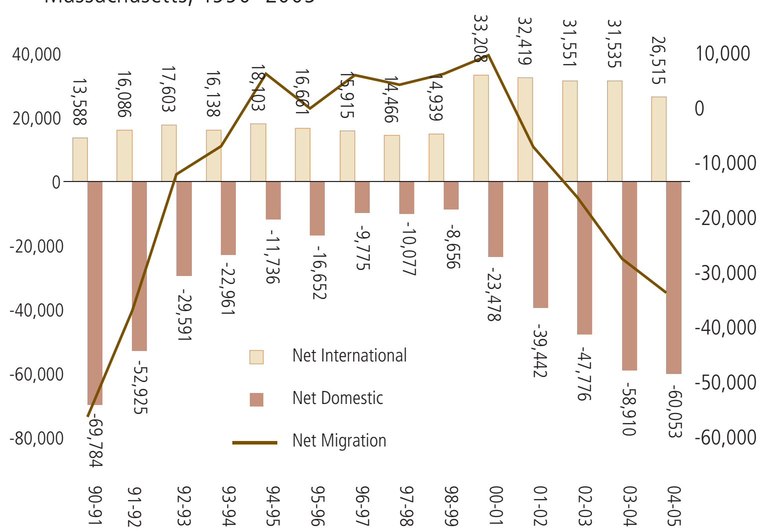
Source: American Association of Engineering Societies (AAES)

Population Growth Rate and Migration

Average annual population growth rate, LTS, and US, 1995–2005



International migration and net domestic migration, Massachusetts, 1990–2005



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 the state skills 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?

The particularly low growth rate of population in Massachusetts continues and poses a substantial obstacle to maintaining an available and innovative workforce. As importantly, the state's inability to keep pace with the population growth of other LTS could have a tangible negative impact on the development of companies in key industry clusters if their expansion plans are inhibited by a dearth of skilled workers. For some years, Massachusetts has experienced an alarming increase in out-migration; in 2005, the trend of decreasing in-migration and increasing out-migration continued unabated.

Indicator #19 Key Takeaways:

- Population loss in Massachusetts continues, only marginally offset by international in-migration.
- Massachusetts maintains extremely low population growth rates.
- Net out-migration continues to be high in Massachusetts. The state lost more than 60,000 people between 2004 and 2005, while gaining 26,000, resulting in a total net loss of over 33,000.

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

Why Is It Significant?

Affordable housing can help to attract and retain young, highly skilled workers who have 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.

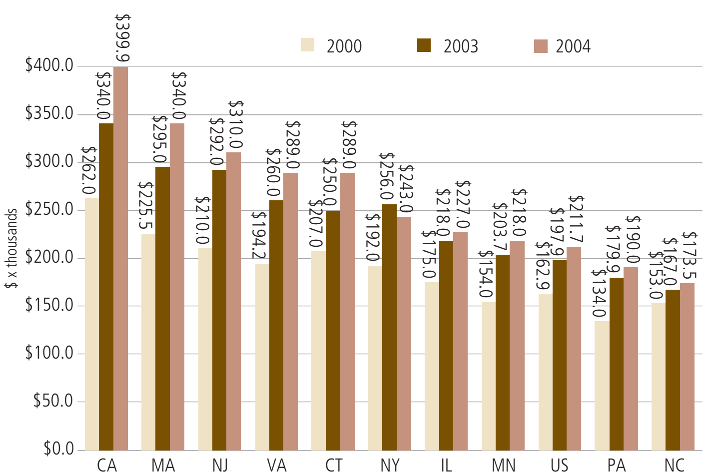
How Does Massachusetts Perform?

The home ownership rate in Massachusetts dropped slightly from 2004 to 2005, by approximately 0.5%. This anemic growth in home ownership rates is compounded by the state's record on new housing starts, as increasing the supply of housing yields more moderate home prices. Massachusetts ranks 7 out of 10 LTS in new housing starts with 3.8 starts per 1,000 residents, and is far less than the US average of 7.3.

Indicator #20 Key Takeaways:

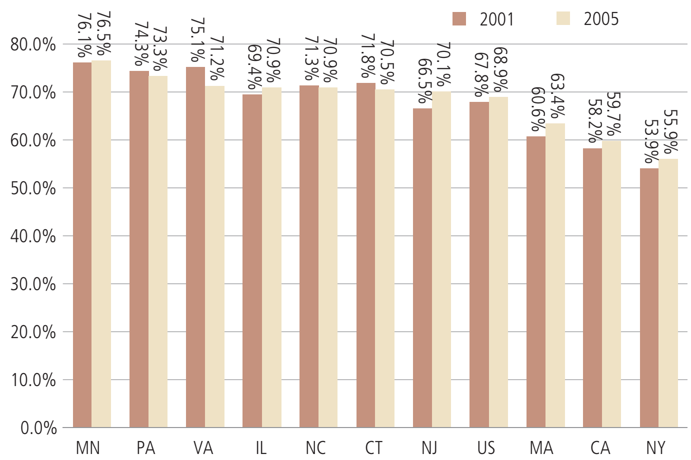
- Massachusetts continues to demonstrate high median housing prices.
- Massachusetts home ownership rate is maintained around 63%, one of the lowest among the LTS, while median cost of single family homes is among the highest.
- Per capita housing starts in Massachusetts increased compared to 2004 but remain significantly lower than total US.

Median home price, LTS and US, 2000, 2003 and 2004



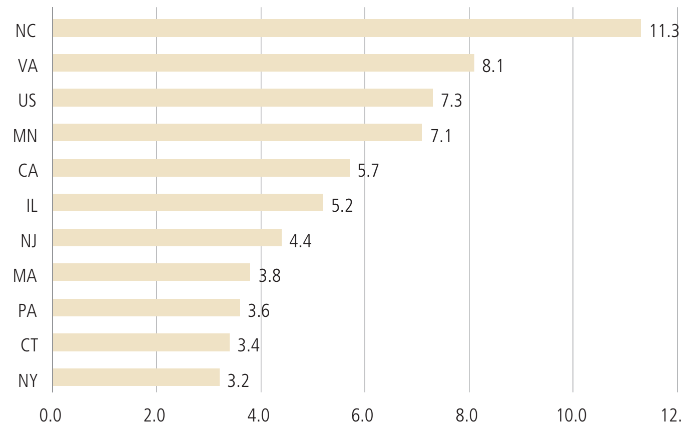
Note: 2005 data not available at press time.
Source: Federal Housing Finance Board

Home ownership rates, LTS and US, 2001 and 2005



Source: US Census Bureau

Per capita housing starts, per 1,000 residents, LTS and US, 2005



Source: US Census Bureau

DATA SOURCES FOR INDICATORS AND SELECTION OF LTS

Data Availability

For the *2006 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 ten key industry clusters having an employment concentration above the national level. States with employment concentration exceeding the national level in four 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. Using this measure, the Commonwealth of Virginia was added to the LTS for the 2006 edition.

Individual cluster employment ratio as compared to US cluster employment ratio, LTS, 2005

Cluster	MA	CT	NY	CA	IL	MN	NJ	NC	PA	VA
Business Services	0.98	1.12	1.20	1.06	0.96	0.88	1.06	0.66	0.97	1.24
Computer & Communications Hardware	1.62	1.23	1.07	1.83	0.89	1.57	0.76	1.29	0.92	0.56
Defense Manufacturing & Instrumentation	1.48	3.13	1.49	1.39	0.81	1.30	0.57	0.52	0.71	0.45
Diversified Industrial Support	1.12	1.24	0.79	0.33	1.50	1.19	0.83	1.27	1.21	0.72
Financial Services	1.40	1.73	1.52	0.87	1.23	1.22	1.12	1.00	1.10	0.93
Healthcare Technology	1.20	1.21	1.12	1.30	1.11	1.05	2.63	1.44	1.17	0.52
Postsecondary Education	2.84	1.54	1.91	0.91	1.02	0.89	0.80	0.95	1.87	0.73
Scientific, Technical, & Management Services	1.50	1.21	1.11	1.20	1.17	0.75	1.51	0.92	1.00	1.79
Software & Communications Services	1.35	0.88	1.11	1.12	0.88	0.94	1.39	0.81	0.92	2.03
Textiles & Apparel	1.08	0.37	1.11	1.66	0.51	0.42	0.77	3.40	1.07	1.23
Total Cluster Concentrations above 1.10	8	8	8	6	4	4	4	4	4	4

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

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 and 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 US-based, privately held independent—not subsidiaries or divisions of other companies—as of December 31, 2005, and have, 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 nonprofit research institution. Such institutions include federally funded research and development centers (for example, US Department of Energy national laboratories), universities, nonprofit hospitals, and other nonprofits.

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 and Development Expenditure, Publicly Traded Companies

Corporate research and 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 Grants, Invention Disclosures, and Patent Applications

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 US 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. Trajtenberg (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.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 US, 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 of, 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

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 B

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/naics

In 2003, the *Index* adopted the four-digit the North American Industry Classification System (NAICS) to study 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 four-digit NAICS code level. Industry data are analyzed through the following measures:

- Employment concentration relative to that of the nation
- Employment as a share of total state employment

Clusters are crafted from those interrelated NAICS code industries that have shown to be individually significant according to the above measures. The ten key industry clusters as defined by the *Index* reflect the changes in employment concentration in the Massachusetts Innovation Economy over time.

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
3364 Aerospace Product and Parts Manufacturing

Diversified Industrial Support
3222 Converted Paper Product Manufacturing
3259 Other Chemical Product and Preparation Manufacturing
3261 Plastics Product Manufacturing
3262 Rubber Product Manufacturing
3279 Other Nonmetallic Mineral Product Manufacturing
3314 Nonferrous Metal (except Aluminum) Production and Processing
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
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 Technology
3254 Pharmaceutical and Medicine Manufacturing
3256 Soap, Cleaning Compound, and Toilet Preparation Manufacturing
3391 Medical Equipment and Supplies Manufacturing
6215 Medical and Diagnostic Laboratories

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

Textiles & Apparel
3132 Fabric Mills
3133 Textile and Fabric Finishing and Fabric Coating Mills
3141 Textile Furnishings Mills
3149 Other Textile Product Mills
3152 Cut and Sew Apparel Manufacturing
3161 Leather and Hide Tanning and Finishing
3162 Footwear Manufacturing
3169 Other Leather and Allied Product Manufacturing

APPRECIATION

Special thanks to the following organizations that contributed data and expertise:

Advanced Technology Ventures

American Association of Engineering Societies

Association of University Technology Managers

Center for Devices and Radiological Health, US Food and Drug Administration

Center for Venture Research, University of New Hampshire

College Board

CommonAngels

Deloitte and Touche, LLP

Donahue Institute, University of Massachusetts

Federal Housing Finance Board

Federal Reserve Bank of Boston

Grapevine Center for the Study of Education Policy, Illinois State University

Inc. Magazine

Massachusetts Department of Education

Massachusetts Division of Unemployment Assistance

Massachusetts Institute of Technology, Sloan School of Management

Mergerstat

Moody's Economy.com

National Association of State Budget Offices

National Business Incubation Association

National Center for Education Statistics, US Department of Education

National Science Foundation

National Venture Capital Association

Navigator Technology Ventures

Office of the Secretary of the Commonwealth of Massachusetts

PricewaterhouseCoopers, LLP

Reference USA

Renaissance Capital

Small Business Administration

Standard & Poor's

The Kauffman Foundation

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US Census Bureau

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