2005

INDEX
OF THE MASSACHUSETTS INNOVATION ECONOMY

MASSACHUSETTS
TECHNOLOGY
COLLABORATIVE

John Adams Innovation Institute

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2005 INDEX OF THE MASSACHUSETTS INNOVATION ECONOMY

MASSACHUSETTS TECHNOLOGY COLLABORATIVE
John Adams Innovation Institute

Massachusetts Technology Collaborative

The Massachusetts Technology Collaborative (MTC) is the state's development agency for renewable energy and the Innovation Economy.

MTC acts as a catalyst between industry, government, and academia, bringing together leaders from each sector. The organization's major areas of work include support for renewable energy development, commercialization of emerging technologies, university-based research and development (R&D) with close industry involvement, regional knowledge-based economic development initiatives, and advanced technologies in healthcare which improve quality and lower costs.

Technology-driven innovation fuels our economy. By forming dynamic partnerships with key stakeholders, MTC is advancing technology-based solutions that lead to economic growth and a cleaner environment in Massachusetts.

The John Adams Innovation Institute

The John Adams Innovation Institute (Innovation Institute) is an operating division of the Massachusetts Technology Collaborative. Its mission is to promote growth of the Innovation Economy throughout the Commonwealth. The Innovation Institute does this by undertaking analyses of critical issues facing Massachusetts, identifying needed actions and resources, promoting collaboration among key stakeholders, supporting sound policymaking, and providing strategic investments for technology-based economic development.

The Innovation Institute is responsible for management of two public investment funds: 1) the Innovation Institute Fund (Regional Fund); and 2) the Massachusetts Research Center Matching Fund.

The Matching Fund is used to support efforts to enable university-based research centers to devote greater resources to developing and transferring technology to industry in the Commonwealth. The Regional Fund is used to support regional technology-based economic development initiatives across the Commonwealth.

The goals of the Innovation Institute are as follows:

- Enhance institutional and industry competitiveness throughout the Commonwealth.
- Promote conditions which enable growth throughout the Massachusetts Innovation Economy.
- Provide accurate and reliable information, data, and analysis to stakeholders in Massachusetts Innovation Economy that promotes understanding and informs policy at the federal, state, and local level.

Executive Summary

The Massachusetts economy as a whole is once again experiencing modest growth. However, this year's *Index of the Massachusetts Innovation Economy* underscores the fact that many of the industry clusters that have been mainstays of innovation-led growth in the past have not returned to their previous levels of economic strength or employment. The *Index* also demonstrates that the clusters in our Innovation Economy that are growing most steadily are those supported by our essential resources of innovation—scientific talent, public and private funding of research, a cadre of experienced entrepreneurs, and new venture capital. These are also the underpinnings of future economic growth and opportunity in the Commonwealth. The challenge for industry and academic leaders and for policymakers over the next few years is to translate these competitive strengths into the creation and expansion of new companies and the generation of new jobs.

While these resources for innovation provide a strong competitive foundation for the growth of our Innovation Economy, they are certainly necessary, but not sufficient. Innovative products and services are the result of an often complex and unpredictable process in which market demand, a supportive local environment, and a risk-taking, entrepreneurial mindset are essential. This year's *Index* offers a representative illustration of this complex process through the introduction of a new Framework for Innovation. It is our intention that this Framework inform the stakeholders in our Innovation Economy—industry, policymakers, academic leaders, investors, and the public as a whole—that realization of the full potential of our competitive assets demands investment in and alignment of these essential ingredients of innovation-led growth.

Key Issue Areas:

The *2005 Index* highlights a number of critically important trends and challenges in the Massachusetts Innovation Economy:

- Growing strength and influence of the life sciences cluster in the Innovation Economy.
- Importance of accelerating new business development for employment growth.
- Aggressive competition from other Leading Technology States (LTS).
- Conversion of research and development to sales and jobs.

Growing Strength and Influence of the Life Sciences Cluster in the Innovation Economy

A strong point for the Innovation Economy is the rapid pace of innovation in healthcare technology and the life sciences. Life science research has expanded rapidly in recent years as the federal government doubled funding for the National Institutes of Health from 1997 to 2003. This provided a substantial infusion of research funds into the Commonwealth's academic health centers. The result is reflected in the form of the increased pace of discovery, patent applications, and technology licenses emerging from the state's teaching hospitals and academic laboratories. Nearly all of the successful initial public offerings (IPOs) noted in this year's *Index* can be traced to biotechnology companies. Even given the fact that NIH funding has not continued to rise at the rate it has in the past, the Healthcare Technology cluster still creates the highest expectations and offers a real opportunity for rapid future growth in the Massachusetts Innovation Economy. While there may be substantial future potential for life sciences, this year's *Index* illustrates that the base of Healthcare Technology-related jobs in the state is relatively small compared to traditional clusters such as Financial Services and Computer & Communications Hardware. Overall job growth in the broad Healthcare Technology cluster has been flat, although scientific research jobs within the cluster have grown by over 20 percent since 2000.

Importance of Accelerating New Business Development for Employment Growth

After nearly four years of decline dating back to the 2000-2002 recession, the Massachusetts economy generated a net increase in jobs early in 2004. However, the innovation-based industry clusters tracked by the *Index* have not yet made a substantial contribution to these employment gains. Seven of the nine industry clusters lost jobs in 2004, with the only job gains registered by the Postsecondary Education and Innovation Services clusters. Job losses were especially severe in two sectors that have, in the past, served as engines of large-scale job growth in the Massachusetts economy—information technology and financial services. Job losses in these clusters are the product of both cyclical and secular forces (weakness in the stock market and global competition, for example) which are unlikely to disappear. Further, local mergers and acquisitions have been responsible for a loss of jobs. As jobs in the majority of industry clusters that the *Index* measures tend to have wages generally above the national average, the decline in cluster employment, especially in IT and Financial Services, has had a negative impact on median household income in the Commonwealth. Though Massachusetts' median household income still exceeds six of the LTS, it leveled off in 2003 and actually fell in 2004.

The declines in employment experienced by a significant majority of our industry clusters underscore the critical need for the Commonwealth to re-double its efforts to create a healthy environment for new business growth and sound economic conditions for business expansion. New for-profit business incorporations in Massachusetts are continuing at a significantly higher rate than in the years before the recession. As these small companies grow and produce new jobs to replace those that have disappeared, Massachusetts must be in a competitive position to capture that job growth and value. Initial public offerings are a means of measuring new ventures that have achieved the size and strength to sustain expansion. Massachusetts IPOs increased from three in 2003 to eight in 2004, certainly a positive indicator, but relative to the other competing LTS, this growth is insufficient.

Aggressive Competition from Other Leading Technology States (LTS)

While the Massachusetts Innovation Economy continues to demonstrate real strength in R&D and new business growth, other LTS are working aggressively and investing strategically to challenge our dominance in these areas of innovation and economic activity. The competitive gap that the Commonwealth has enjoyed for many years in innovation and technology is narrowing. In 2004, Massachusetts' rate of job losses in most clusters exceeded the rate of job losses in the other LTS. Over the past five years, only two occupational categories with above-average wages have had employment increases—Healthcare Services and Arts & Media—and they constitute only 10% of the state's total employment. The other area where competition has intensified is in sales growth. Of the nine LTS, Massachusetts' annual growth rate of corporate sales from 2000 to 2004 placed in the middle of the pack, at 3.8%. This compares unfavorably to growth rates of over 7% in Pennsylvania, California and Minnesota.

The highest growth rate in sales in Massachusetts has been in the Healthcare Technology cluster. However, this is the cluster that most of the other LTS have also identified as a major target for strategic planning and investment. Some states, like California, New Jersey and Connecticut have already thrown down the gauntlet in the form of proposals for, or the commitment of, substantial investments in life sciences and targeted funds for stem cell research. This poses a threat to the Commonwealth not only in the form of loss of economic potential from future discoveries through this research, but also in the allure of these massive sums for research and facilities in recruiting away some of our finest scientists. Massachusetts has enjoyed a longstanding competitive advantage in attracting and retaining the best and the brightest minds because of its large number of pre-eminent institutions of higher education and medicine. However, initiatives like those described above, combined with the high cost of living and the challenge of providing affordable housing in the Commonwealth, have significantly narrowed our competitive advantage.

Conversion of Research and Development to Sales and Jobs

Massachusetts companies continue to invest in research and development, and the Commonwealth has the highest corporate R&D expenditure per $1,000 of sales. However, Massachusetts' average annual growth in corporate R&D expenditures slowed dramatically from 2000 to 2004, to 1.9%, which is below the average LTS growth rate of 3.7%. R&D growth has been especially strong in the Healthcare Technology cluster, where the highest rate of R&D investment of all the LTS over the past five years has yielded the highest rate of sales growth. However, employment in the Healthcare Technology cluster in Massachusetts actually declined over the past five years, while the other LTS experienced a small positive growth rate. Biotechnology—the source of six of the eight 2004 IPOs—does not rapidly produce a large number of jobs. While companies in the Commonwealth have increased their acquisitions of patents and licenses, it is critical that the research represented by those patents and licenses is converted into commercially viable products with high market demand in order to generate larger increases in employment. Some steps have already been taken in the Commonwealth to accelerate the commercialization of research. The new Massachusetts Technology Transfer Center, authorized by the 2004 Economic Stimulus legislation, is one example of a prudent strategic initiative. The organization of Massachusetts technology transfer officers (MATTO) is another. But more is necessary. For example, the traditional barriers to strong working relationships between our research institutions and our life sciences and other technology companies could be overcome through the encouragement of more contract research and the creation of incentives for greater use of our academic health centers in performing the clinical trials for Massachusetts life sciences companies.

Meeting the Challenge of Job Growth

The Commonwealth certainly faces challenges in maintaining its strong leadership position in the Innovation Economy. However, there is a solid foundation on which to build future growth and some bright spots to support optimism. For example, 2004 recorded a recovery in demand for products in a wide range of industries, and market forecasts are for more of the same for 2005 and beyond. Areas of especially strong market demand include healthcare technology, biotechnology-based pharmaceuticals and medical devices in the life sciences sector; and PCs, networking equipment, and packaged software in the information technology sector. Improvements in market demand can stimulate new product ideas, which can then be introduced to the market in a more favorable economic environment. Profits from sales can then be re-invested to spur company growth and job expansion.

Such optimism, though, must be tempered by an understanding of the challenges that confront the Massachusetts economy—many of which are demonstrated by the data in this *Index*—and by a solid plan for addressing them. Many of our competitor states and countries have been working through public-private collaborations to develop long-term strategic plans for future investments to assure sustained economic prosperity, and many of these target the same sectors that constitute our Innovation Economy. Massachusetts has not had a recent collaborative effort to develop a strategic economic plan. Now is the critical time for industry and academic leaders in Massachusetts to join with policymakers in identifying, planning for and investing in our competitive assets and in developing a long term and integrated plan for the Commonwealth's future economic vitality.

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ABOUT the **2005 Index**

The Framework for Innovation

The John Adams Innovation Institute has adopted the National Science Foundation's definition of 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 Institute's Innovation Framework. The Framework, detailed in Figure 1, identifies a cluster's (or region's) capacity or potential for innovation as an enabler of the innovation process. The process, in turn, generates the desired economic outcomes.

The mechanism by which innovations are created in an economy is designated the **Innovation Process**. The Innovation Process represents the dynamic interaction between three components: *Research*, *Technology Development*, and *Business Development*. The Research component denotes the basic research and discovery that occurs during the Innovation Process. The knowledge created in basic research is primarily generic, without a specific focus on application and driven largely by academic curiosity, although frequently inspired by technological, market, or societal needs. Therefore, research as part of a loop which can occur at any point throughout the Innovation Process.

From the standpoint of new growth in the Innovation Economy, basic research that is both scientifically rigorous and market-oriented is critical. Promising research results feed into two parallel phases tracked in the Innovation Framework: Technology Development and Business Development. Technology Development signifies the process by which basic research is refined to be used in a specific application. The means by which the innovation is taken to market is represented in the Business Development component.

In order to assess the societal impact and outcomes that the Innovation Economy provides, the overall **Economic Impact** of the Innovation Process is examined. The Economic Impact is split into two components to differentiate between outcomes observed in the local Innovation Economy (*Cluster Level*) and in the overall state economy (*State Level*). Within both of these components, the results of the Innovation Process are evaluated through changes in employment and wages, and in business output.

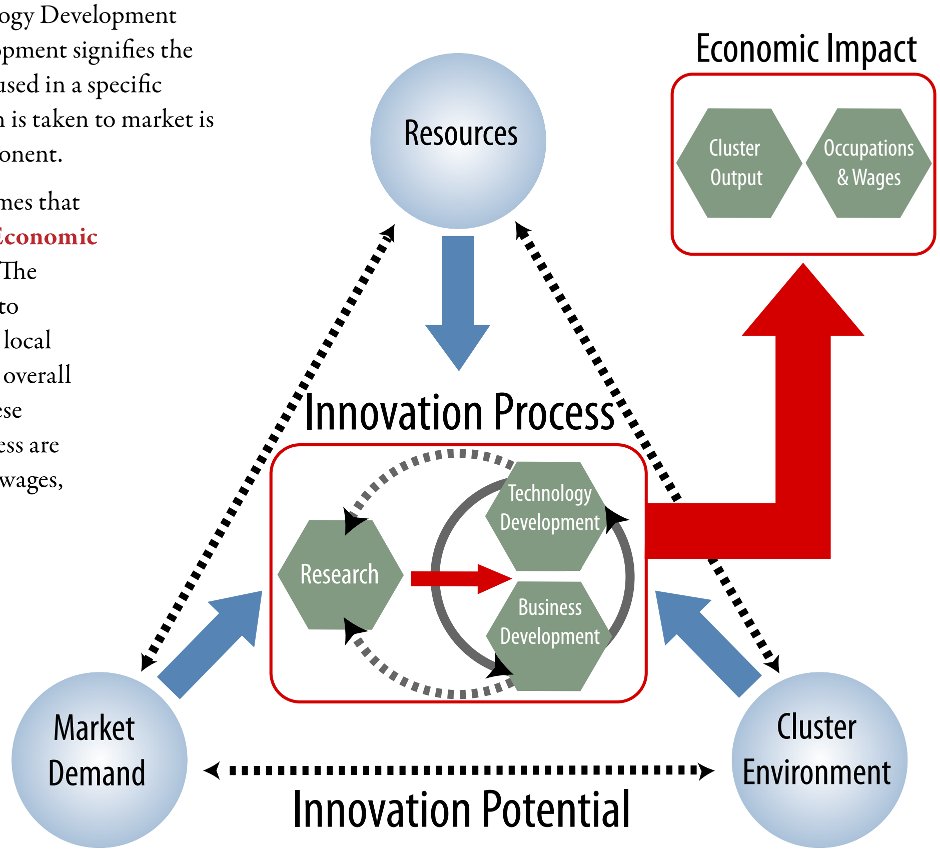
The Framework captures outside factors that have an influence on the overall success of the Innovation Process as well as enablers of the process. These factors include the *Resources* available, the prevailing *Market Demand*, and the *Cluster Environment*, all of which are collectively referred to as the **Innovation Potential** of a cluster or a region. The Resources component refers to the various sources of *capital* available in a cluster, as well as the *skilled labor* present and other *infrastructure* enablers. Market Demand signifies the strength of the demand for goods and services produced by the industries comprising the cluster. In many instances, Market Demand is one of the strongest drivers of the Innovation Process. Cluster Environment refers to the interaction between industries that are part of a specific cluster.

Indicator Selection

Indicators are quantitative measures of factors at work in the Massachusetts Innovation Economy. A rigorous set of criteria was applied to each potential indicator. All of the selected indicators:

- Are derived from objective and reliable data sources
- Are statistically measurable on an on-going basis
- Are bellwethers that reflect the fundamentals of economic vitality
- Can be readily understood by a wide variety of readers
- Measure conditions in which there is an active public interest

Figure 1



Benchmark Comparisons: Leading Technology States

Tracking the Massachusetts Innovation Economy over time is crucial for regularly assessing its strength and resilience. At the same time, benchmark comparisons can provide an important context for understanding how Massachusetts is doing in a relative sense. Thus, several indicators in the *Index* are compared with the national average or with a composite measure of eight competitive Leading Technology States (LTS). The eight LTS chosen for comparison throughout the *2005 Index* are: California, Connecticut, Illinois, Minnesota, New Jersey, New York, North Carolina, and Pennsylvania. Appendix A describes the methodology for selecting the LTS.

Nine Key Industry Clusters

The *2005 Index* monitors the impact of innovation through nine industry clusters that are highly concentrated in the Massachusetts economy. These clusters range from Postsecondary Education and Defense Manufacturing & Instrumentation, to industry clusters such as Software & Communications Services (which includes telecommunications), and Innovation Services (which includes engineering services and management consulting services). Appendix B provides a detailed definition for each of these clusters.

In recent years these nine clusters have accounted for about 25 percent of private (non-government) employment in Massachusetts. Government employment, which is not counted in the industry clusters analysis, includes federal, state, and local workers, postal workers, and education workers at the state and local level. As of the 2000 Census, 13.5% of total workers in Massachusetts were government workers.

Analysis of the Massachusetts Innovation Economy

The objective of this *Index* is to help the public and policymakers gauge the state's environment for innovation-led growth and to provide guidance in crafting specific actions the state can take to promote development. The Innovation System Framework detailed above highlights 'levers' for innovation (such as research) as well as the enabling environment that nurtures development. We use this Framework to group this year's indicators and render an overall assessment of the drivers, barriers, and opportunities that affect growth in the Innovation Economy.

The following section summarizes the indicators, and analyzes a number of variables that can assist in understanding causal affects of

ECONOMIC IMPACT

Economic Impact	*2005 Index* Indicators	Significant Trends
Cluster Employment	Seven of nine Massachusetts Innovation Economy clusters continued to shed jobs in 2004, and at a rate faster than competitor Leading Technology States (LTS). However, commercial research and development jobs (the so-called "Scientific R&D" industry classification) grew by 21% 2000–2004. This growth includes a number of biotechnology jobs otherwise classified within the state's Innovation Services cluster.	Continued contraction and consolidation in Information Technology (IT)-related clusters (Computer & Communications Hardware and Software), and in Financial Services. Continued flat job creation in Healthcare technology overall.
Corporate Sales	Sales by publicly-traded firms in Massachusetts grew at an average annual rate of 3.8% between 2000 and 2004 representing only average growth among all LTS.	Sales by the state's IT-related clusters declined significantly from 2000 to 2004 (Software 32%, Hardware 32.5%). Healthcare Technology sales grew by about 163% in the same period.
Occupations and Wages	Among larger occupational categories, only healthcare employment has grown in Massachusetts in the 2000–2004 period (0.7%).	Losses in both production and professional/technical jobs outpaced the overall rate of job decline in the state in 2000–2004.
Median Income	Median income growth in Massachusetts slowed in 2003 and declined in 2004.	Decline in Massachusetts median income follows similar decline among LTS.
Manufacturing Exports	Massachusetts second only to Minnesota among LTS in growth of manufacturing exports 2000–2004 (1.6%) but manufacturing as a share of the state's economy (GSP) declined at the same time.	Continued erosion of manufacturing in Massachusetts.

such indicators. Strengths and weaknesses of the Innovation Process are provided as a summary analysis of each part of the process.

Over the past five years, employment levels have continued to fall in all but two of nine key industry clusters in the Massachusetts Innovation Economy. From 2003 to 2004 alone the Innovation Economy lost over 15,000 jobs, while Massachusetts' overall employment declined by only 5,000 jobs. This brings the total number of jobs lost in the Innovation Economy between 2000 and 2004 to 113,000 jobs.

Massachusetts was not alone in suffering such losses. Many of the LTS experienced similar declines, for reasons that have been widely reported: radical restructuring and consolidation in the global IT and telecommunications markets, similar restructuring in the Financial Services industries, and a continuing trend towards outsourcing and the transfer of jobs off-shore. In Massachusetts, however, the employment decreases have been deeper than in the LTS.

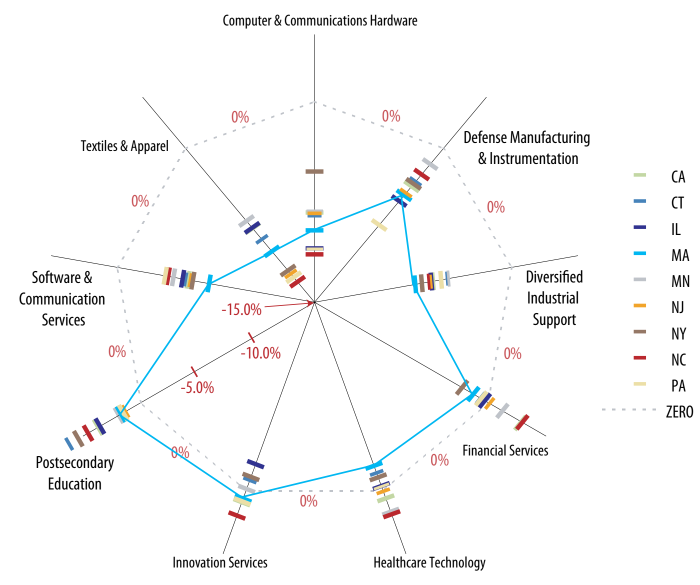
Moreover, while all of the LTS have suffered declines in employment within their key clusters on an aggregate basis, some clusters in some of the LTS have not only fared better than their counterparts in Massachusetts, but have actually grown. (See Figure 1.1)

The overall employment decline in Massachusetts' nine key industry clusters is especially troublesome for the state's economic welfare, as jobs in these clusters typically pay higher than average wages, as shown in Figure 1.2. Of the seven key industry clusters to lose jobs since 2000, all but one provide jobs with above-average wages.

Computer & Communications Hardware

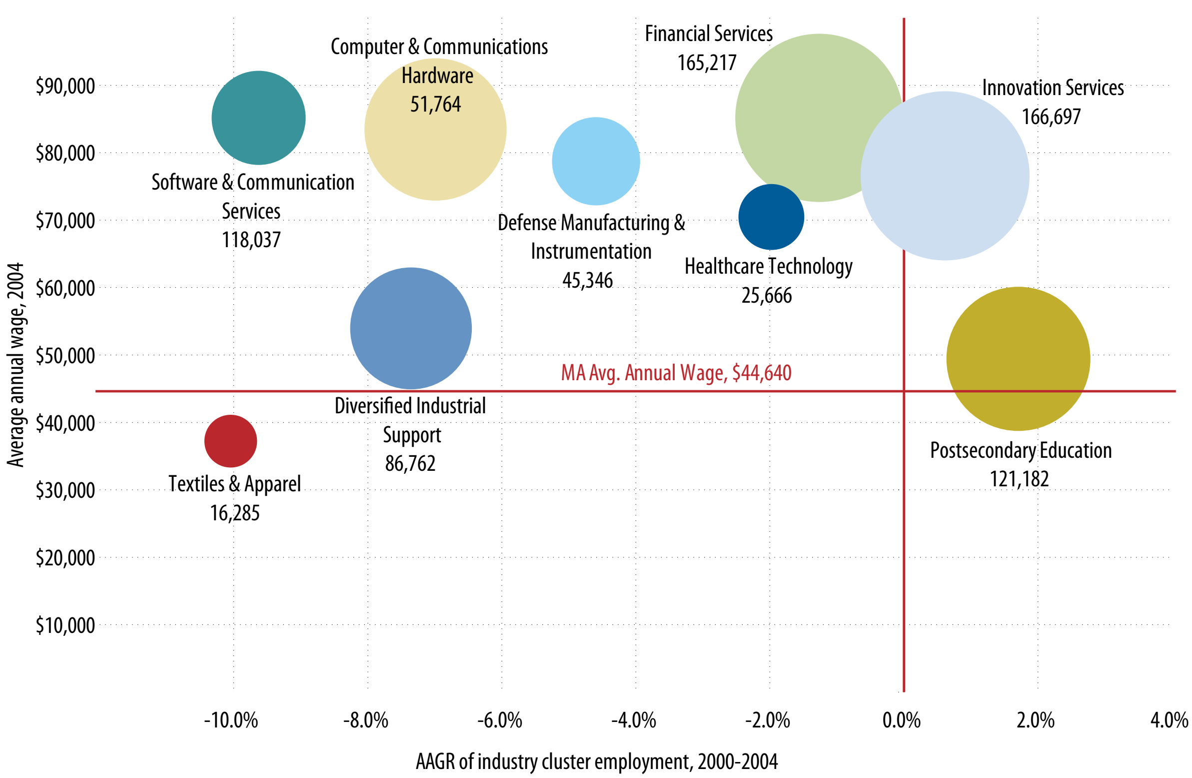
Massachusetts lost over 25,800 jobs in the Computer & Communications Hardware cluster from 2000 to 2004, at an average

Figure 1.1 Average annual growth rate (AAGR) of industry cluster employment, Massachusetts and other LTS, 2000–2004



Source of data: Bureau of Labor Statistics and Economy.com

Figure 1.2, Portfolio of nine key industry clusters by average annual growth rate (AAGR) of employment and average annual salary, Massachusetts, 2004



Note: Numeral below name of industry cluster is total employment
Source of data: Bureau of Labor Statistics and Economy.com

Table 1.1, Computer & Communications Hardware employment, 2003–2004		
Rank	State	% Change
1	MN	-1.2%
2	NJ	-2.1%
3	CA	-2.6%
8	MA	-5.0%

salary of $85,100. This loss was largely in the Communications Equipment Manufacturing and Semiconductor & Other Electronic Component Manufacturing industries, which lost over 9,600 and 9,400 jobs respectively. No state among the LTS experienced a positive employment change in this cluster from 2000 to 2004. New York had the smallest decline, with an average annual growth rate (AAGR) of -5.2% during that period.

This trend continued from 2003 to 2004 in both Massachusetts and all of the LTS, but to a lesser extent than in the past. While Massachusetts saw a smaller percentage decline in the past year, it was still significantly greater than the rest of the LTS, as shown in Table 1.1.

Table 1.2, Defense Manufacturing & Instrumentation employment, 2003–2004		
Rank	State	% Change
1	MN	0.7%
2	CA	-0.1%
3	NY	-0.2%
9	MA	-5.4%

Defense Manufacturing & Instrumentation

Within the Defense Manufacturing & Instrumentation cluster, Massachusetts saw a decrease of over 9,300 jobs, with an average annual wage of $78,700, from 2000 to 2004. Driving this decline was the Navigational, Measuring, Electromedical, and Control Instruments Manufacturing industry group, which lost over 5,800 jobs. All of the LTS experienced declines in employment within their Defense Manufacturing & Instrumentation clusters from 2000 to 2004, with Minnesota having the smallest rate of decline during this time period (-1.5%).

As in the IT-related clusters, job losses in the Defense Manufacturing & Instrumentation cluster persisted in the majority of the LTS in 2003-2004, but to a lesser degree. Massachusetts was the only state in the LTS to actually experience a larger percentage decline than its five-year AAGR, at -5.4% versus the LTS average of -4.6%.

Diversified Industrial Support

Table 1.3, Diversified Industrial Support employment, 2003–2004		
Rank	State	% Change
1	MN	0.5%
2	CT	-1.3%
3	PA	-2.1%
7	MA	-3.3%

Over 31,000 jobs at an average annual wage of $53,900 were lost in the Diversified Industrial Support cluster in Massachusetts from 2000 to 2004. This decline was observed uniformly across all the industries within the cluster. Among the LTS, Connecticut and Minnesota observed the smallest rates of employment decline in this cluster, with AAGRs of -4.9% and -4.8% respectively, over this time period.

Job losses in the Diversified Industrial Support cluster moderated in 2004 in all the LTS, (jobs actually increased slightly in Minnesota). Here again, however, the rate of job losses in Massachusetts, while slower, was still among the highest of all the LTS.

Table 1.4, Financial Services employment, 2003–2004		
Rank	State	% Change
1	CA	1.1%
2	NC	1.1%
3	NY	0.3%
8	MA	-2.1%

Financial Services

The Financial Services cluster in Massachusetts lost roughly 8,600 jobs at an average salary of $85,100 from 2000 to 2004. This decrease can largely be attributed to a 4,800 job decline in the Securities & Commodity Contracts Intermediation and Brokerage industries. In contrast, the Financial Services clusters in California and North Carolina expanded, with AAGRs of 2.8% and 3.0%, respectively.

Between 2003 and 2004, employment in the Financial Services Cluster in Massachusetts declined at an even faster pace. Employment growth in this cluster also lagged in 2004 in other LTS. As shown in Table 1.4, California and North Carolina both experienced slower growth rates over the past year relative to their five year AAGRs.

Healthcare Technology

Table 1.5, Healthcare Technology employment, 2003–2004		
Rank	State	% Change
1	MN	4.6%
2	CA	2.3%
3	NY	0.3%
8	MA	-3.0%

The state's Healthcare Technology cluster saw a decrease of roughly 2,100 jobs, at an average salary of $70,400, from 2000 to 2004. Approximately 1,600 jobs were lost in the Medical Equipment and Supplies Manufacturing industry alone. Over this same time period, North Carolina and Minnesota enjoyed employment growth in their respective Healthcare Technology clusters of 1.9% and 1.7% (AAGRs).

In the 2003-2004 period, jobs declined in the Massachusetts Healthcare Technology cluster at an even faster rate than the five-year average (or at -3.0% vs. -2.0% AAGR). This one-year rate of loss was one of the largest such declines among the LTS.

This recent history of job loss in the Healthcare Technology cluster is moderated somewhat by steady growth in jobs in private sector research and development related to biotechnology. These jobs, which are collected in statistical categories that fall under the Innovation Services cluster (below), have increased by over 20 % in the last five years, and reflect steady growth within the biotechnology industry.

Table 1.6, Innovation Services employment, 2003–2004		
Rank	State	% Change
1	NC	3.2%
2	MA	1.7%
3	PA	1.5%

Innovation Services

The Innovation Services cluster is one of only two clusters to grow in employment in Massachusetts between 2000 and 2004, gaining approximately 4,000 jobs at an average salary of $76,500. While the Advertising and Related Services industry lost 400 jobs during this time period, the decline was more than offset by gains in other industries within the cluster. In particular, the Scientific Research & Development Services industry saw a gain of 6,400 jobs. Among the LTS, North Carolina saw the highest employment growth rate in its Innovation Services cluster from 2000 to 2004, with a 2.0% AAGR.

The five-year growth trend in the Innovation Services cluster continued in 2003 to 2004, with Massachusetts experiencing a 1.7% increase in cluster employment. Massachusetts experienced one of the highest percentage increases among the LTS.

Postsecondary Education

The Postsecondary Education cluster is one of the two clusters to grow employment from 2000 to 2004 with an increase of 7,900 jobs, at an average annual wage of $49,400. Among the LTS, two other northeastern states, Connecticut and New York, enjoyed the highest AAGRs in this cluster from 2000 to 2004, growing at rates of 6.2% and 5.4%, respectively.

Table 1.7, Postsecondary Education employment, 2003–2004

Rank	State	% Change
1	IL	4.7%
2	NY	3.4%
3	CA	3.2%
7	MA	1.0%

In 2003- 2004, Massachusetts again experienced employment growth in the postsecondary education cluster, (see Table 1.7). However, the rate of growth in the cluster in Massachusetts was among the lowest of the LTS during the same period.

Software & Communication Services

The Massachusetts Software & Communication Services cluster experienced the largest employment decrease of all nine key industry clusters from 2000 to 2004, losing more than 39,600 jobs at an average wage of $83,400. This cluster saw declines in all of its constituent industries, with the largest losses in the Computer Systems Design & Related Services sector (-17,000 jobs), and the Software Publishers sector (-5,800 jobs). While all of the LTS experienced negative average annual growth rates in this cluster from 2000 to 2004, North Carolina and Pennsylvania had the lowest rates of decline, with AAGRs of -3.9% and -3.7% respectively. North Carolina and Pennsylvania also happen to be the two states among the LTS with the lowest concentration of Software & Communication Service firms as a proportion of their state economies.

Table 1.8, Software & Communication Services employment, 2003–2004

Rank	State	% Change
1	IL	-0.7%
2	CT	-0.9%
3	MN	-1.1%
8	MA	-3.9%

Employment decline persisted in Massachusetts from 2003 to 2004, although at a lower rate (-3.9%). As shown in Table 1.8, Massachusetts also experienced one of the larger percentage declines relative the other LTS over the same year.

Textiles & Apparel

While it has been declining within Massachusetts and the overall U.S. economy for many years now, the Textiles & Apparel cluster remains relatively highly concentrated in Massachusetts. The cluster lost more than 8,500 jobs, at an average annual wage of $37,200, between 2000 and 2004. This decline was distributed uniformly across all industries in the cluster. All of the LTS experienced negative AAGRs in this cluster from 2000 to 2004, with Minnesota having the smallest negative growth rate (-7.1%).

Table 1.9, Textiles & Apparel employment, 2003–2004

Rank	State	% Change
1	IL	0.9%
2	CT	-3.8%
3	NY	-4.1%
8	MA	-10.1%

Job losses in the Massachusetts Textiles & Apparel cluster continued between 2003 and 2004, at a rate comparable to the AAGR seen over the past five years. When compared to the other LTS, Massachusetts observed one of the larger percentage declines in cluster employment, as is seen in Table 1.9.

THE INNOVATION PROCESS

While global trends—most particularly, global market conditions —are the dominant influence on jobs and job growth in the Massachusetts Innovation Economy in any given year, the underlying mechanisms for innovation within the state's industries can have just as large an effect. The rapid, technology-led growth the state enjoyed in the 1980s and 1990s is testament to this. Thus, the Innovation Process is a critical element in the *Index*.

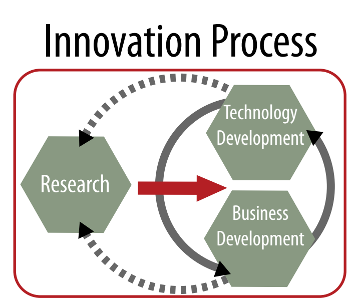


Figure 1.3

The Innovation Process outlined in the *Index* encompasses dynamic interrelationships between Research, Technology Development, and Business Development, as detailed in Figure 1.3. This non-linear process is a rough representation of the causal links that result in the desired economic outcomes.

Critical inter-relationships and dynamic dependencies that influence innovation are unique to each cluster. For example, innovation in the Healthcare Technology cluster differs from the innovation process at work in the Financial Services industries. A detailed analysis of the process in each cluster (including multivariable analysis of sectoral data) is beyond the scope of the *Index*. However, the following assessment provides valuable insights into economic impact described above.

Innovation Process: Research

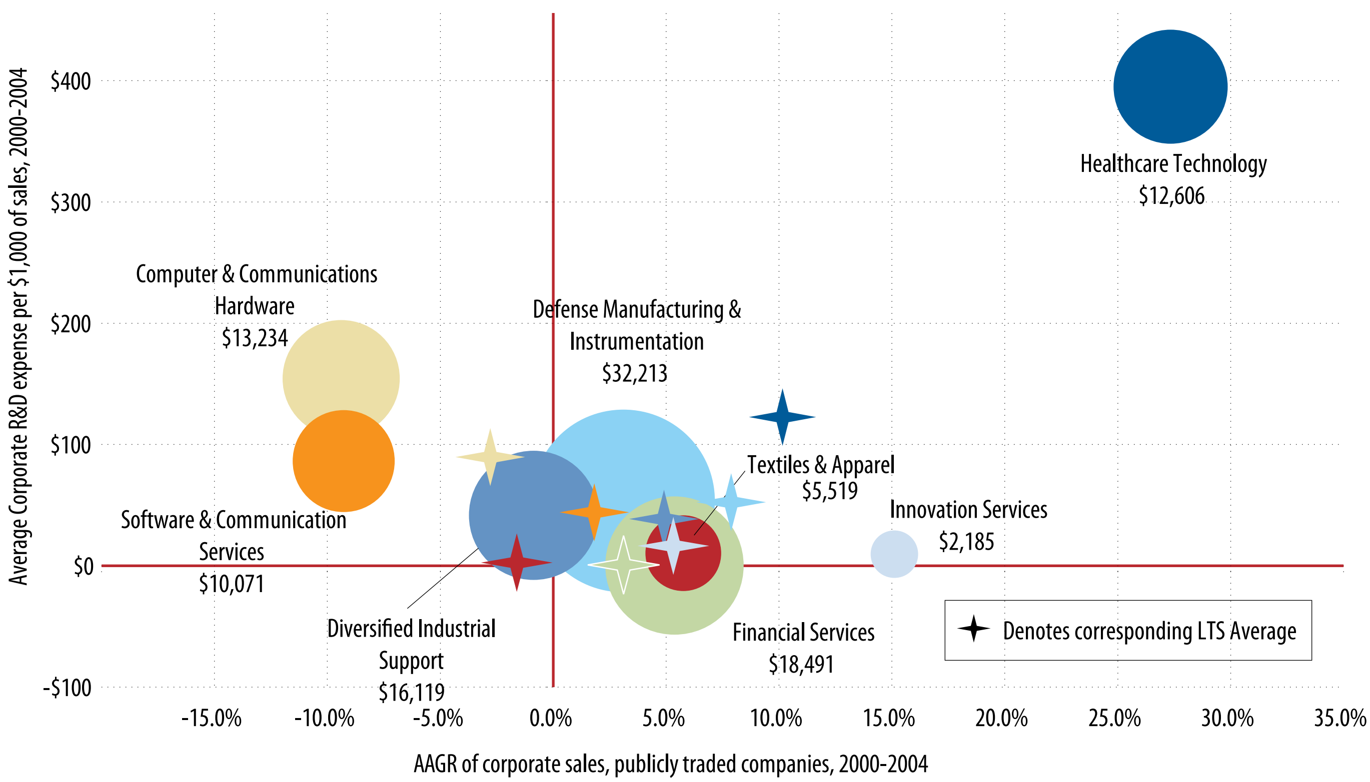
Innovation Process: Research	*2005 Index* Indicators	Significant Trends
Corporate R&D (publicly-traded firms)	Corporate R&D among public companies in Massachusetts holds steady in 2004 at levels twice as high as ten years ago. Massachusetts public firms lead LTS in corporate R&D per $1,000 in sales.	Massachusetts' strength in corporate R&D is led by heavy R&D investment among healthcare technology firms. R&D investment by publicly-traded healthcare technology firms reported a 75% increase between 2000 and 2004.
Patents and Inventions	Invention and patent activity continues to increase in Massachusetts. Massachusetts maintains a modest lead over Minnesota in patents issued per capita.	Strong growth in Massachusetts patent activity continues to emanate from hospitals and non-university research institutions.
Technology Licenses and Royalties	Overall technology licensing holds steady among Massachusetts institutions in 2002. Hospitals and nonprofit research centers account for nearly 75% of patent activity but less than 40% of licensing activity, and about 47% of royalty stream.	Sustained growth in hospital/nonprofit invention and patent activity have not yet translated into sustained growth in technology licensing.

Corporate R&D Expenditure, Publicly-traded Companies

Massachusetts continues to play host to an exceptionally high volume of research, including research that is both federally-funded and privately sponsored (see Indicator 15). The generally high levels of research underway in the state's publicly-traded corporations does not automatically correlate to high levels of short-term growth, however—a challenge and a testament to the complexity and risks of translating research results into new products and new jobs.

Figure 1.4 illustrates publicly-traded corporate R&D expense per $1,000 of sales, along with the AAGR of corporate sales (2000-2004) for each of the nine key industry clusters in Massachusetts and the LTS average.

Figure 1.4 Portfolio of average corporate R&D expense per $1,000 of sales and average annual growth rate (AAGR) of corporate sales, publicly-traded companies, Massachusetts, 2000-2004



Note: Numeral below name of cluster is 2004 total sales, in millions of dollars.

Source of data: Standard and Poor's

The **Healthcare Technology** cluster, although small, invested heavily in R&D over the past five years, investing $395 per $1,000 of sales. The cluster has experienced an AAGR of sales of 27% between 2000 and 2004. On average, the same cluster in the Leading Technology States invests only $122 per $1,000 of sales, and has had a significantly lower AAGR (10%) over this time period. Employment in the Healthcare Technology cluster in Massachusetts, however, had an AAGR of -2.0% over the past five years, (albeit offset by the increase in commercial R&D jobs noted above), while the LTS average experienced a positive AAGR of 0.1%.

The **Defense Manufacturing & Instrumentation** cluster, which has the highest sales volume among the innovation clusters, invested only $53 per $1,000 of sales in R&D. The defense clusters in the other LTS invested about the same amount in R&D per dollar of sales, yet on average the defense clusters in the other LTS experienced a higher AAGR in corporate sales over this period (8%). As with the Healthcare Technology cluster, the Defense Manufacturing & Instrumentation cluster had negative employment growth over the past five years with an AAGR of -4.6% despite positive sales growth.

The **Computer and Communications Hardware** cluster in Massachusetts invested $154 per $1,000 of sales on average over the past five years and had an average annual decline in sales of -9%. The LTS, on the other hand, experienced on average a smaller decline (-3%), while investing only $89 per $1,000 of corporate sales during this period. The Computer and Communications Hardware cluster in Massachusetts had an AAGR of -9.6% in employment over the past five years.

Research Summary

Strengths	Weaknesses
• Corporate R&D is healthy. Firms are investing heavily relative to other states in nearly all sectors. • Healthcare Industry is investing heavily and yielding positive results. (Growth in sales, patents, royalties).	• Short term corporate sales growth is lagging, notwithstanding relatively high levels of R&D. • The Healthcare Technology cluster has not, as yet, translated high levels of R&D into a sustained, high level of job creation.

Innovation Process: Technology Development

Innovation Process: Technology Development	*2005 Index* Indicators	Significant Trends
Small Business Innovation Research (SBIR) Awards	Massachusetts continues to lead LTS in SBIR awards-per-population by a four-to-one margin, trailing only California in absolute numbers of grants and dollars. Massachusetts firms lead in both Phase I (research) and Phase II (pre-commercialization) phases	Massachusetts has had rapid growth in U.S. Department of Defense-funded SBIR grants, but now lags California in securing SBIR grants from the National Institutes of Health.
FDA Approvals: Medical Devices and Biotech Drugs	New FDA approvals for medical devices from Massachusetts firms dips in 2003 (most recent data available)—paralleling similar decline in other LTS Biotech drug approvals hold steady for Massachusetts firms in 2003—Massachusetts still second behind California.	New healthcare technology continues to build strength in Massachusetts but California reasserts a commanding lead.

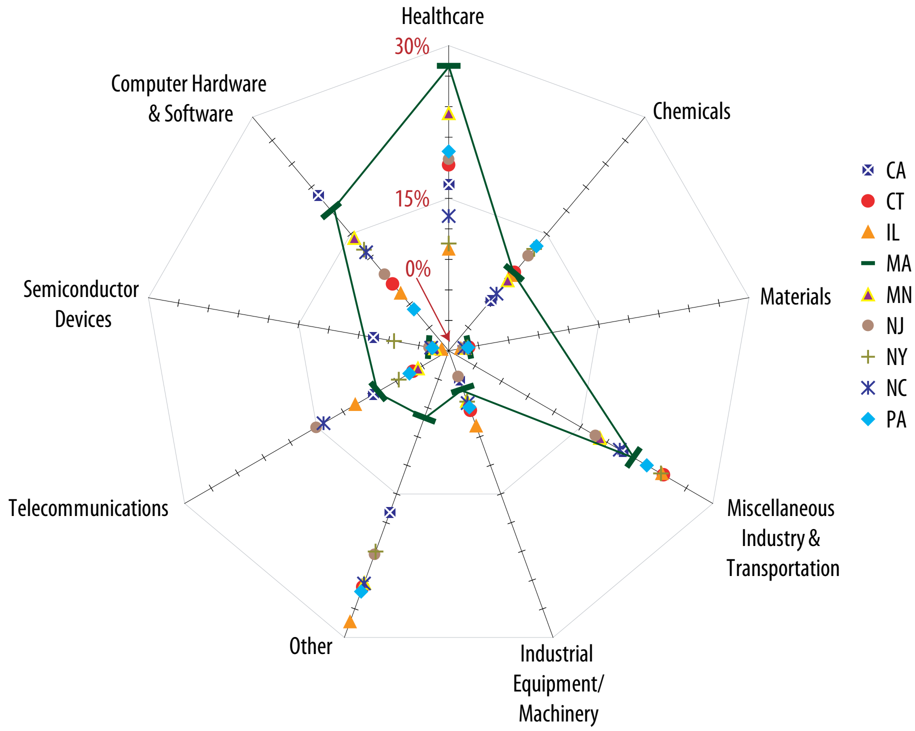
Research and Technology Development: Patents

Patents can provide a measure of outcomes from the Research and Technology Development components of the Innovation Process. The distribution of patents by industry sectors is provided in Figure 1.5. Patent awards in Massachusetts are heavily weighted towards healthcare (28% of total), computer hardware and software (18%) and chemicals (10%). When comparing this distribution to the other LTS, it is apparent that Massachusetts is not as diversified in its intellectual property creation as others. Among the LTS with high patent generation, California stands out as having a more diversified portfolio of patent creation. As shown in Figure 1.5, California is somewhat more evenly distributed across a number of critical industries: healthcare (16%), computer hardware and software (20%), semiconductor devices (8%), telecommunications (9%), and chemicals (6%).

Technology Development Summary

Strengths	Weaknesses
• SBIR Awards—strong federal support for technology development in Massachusetts. • Healthcare/Medical Technology pipeline—still very strong.	• Relative lack of diversity of technology. • Strong competition from other states.

Figure 1.5 Distribution of patents issued by industry, Massachusetts and other LTS, 1999-2003



Source: Adam Jaffe *et al*: "The NBER U.S. Patent Citations Data File: Lessons, Insights, and Methodological Tools" and The U.S. Patent and Trademark Office

Innovation Process: Business Development

Innovation Process: Business Development	***2005 Index* Indicators**	**Significant Trends**
New Business Incorporations	New for-profit business incorporations in Massachusetts continue at a significantly higher rate than in pre-recession years, averaging 20,600 from 2002–2004 vs. 13,695 from 1999–2001.	New business growth adds jobs and provides additional tax revenues to the state.
Initial Public Offerings (IPOs) and Mergers & Acquisitions (M&A)	The IPO market rebounded in nearly all LTS in 2004; Massachusetts IPOs increased from 3 (2003) to 8 (2004). M&A activity increases in all LTS.	Six of seven Massachusetts IPOs are in biotechnology.
Corporate Headquarters in Massachusetts, Tech Fast 500 and Inc. 500 Firms	Massachusetts is second among LTS for proportion of corporate headquarters per total business establishments but the number of large firm corporate headquarters in Massachusetts (500+ employees) continued a three year decline in 2004. Number of fast growth firms in Massachusetts holds steady in 2004 (28 firms on Fast 500 list).	Sales of large Massachusetts-headquartered firms to out-of-state or foreign firms continue.

Business Development Summary

Strengths	Weaknesses
• Volume of IPOs.	• Number of IPOs in other LTS is growing faster than Massachusetts.
• Strong rate of new business incorporations.	• Number of corporate headquarters located in MA continues to decline.
• Biotechnology generating a stream of IPOs and growth firms.	• Increased M&A often leads to job losses.

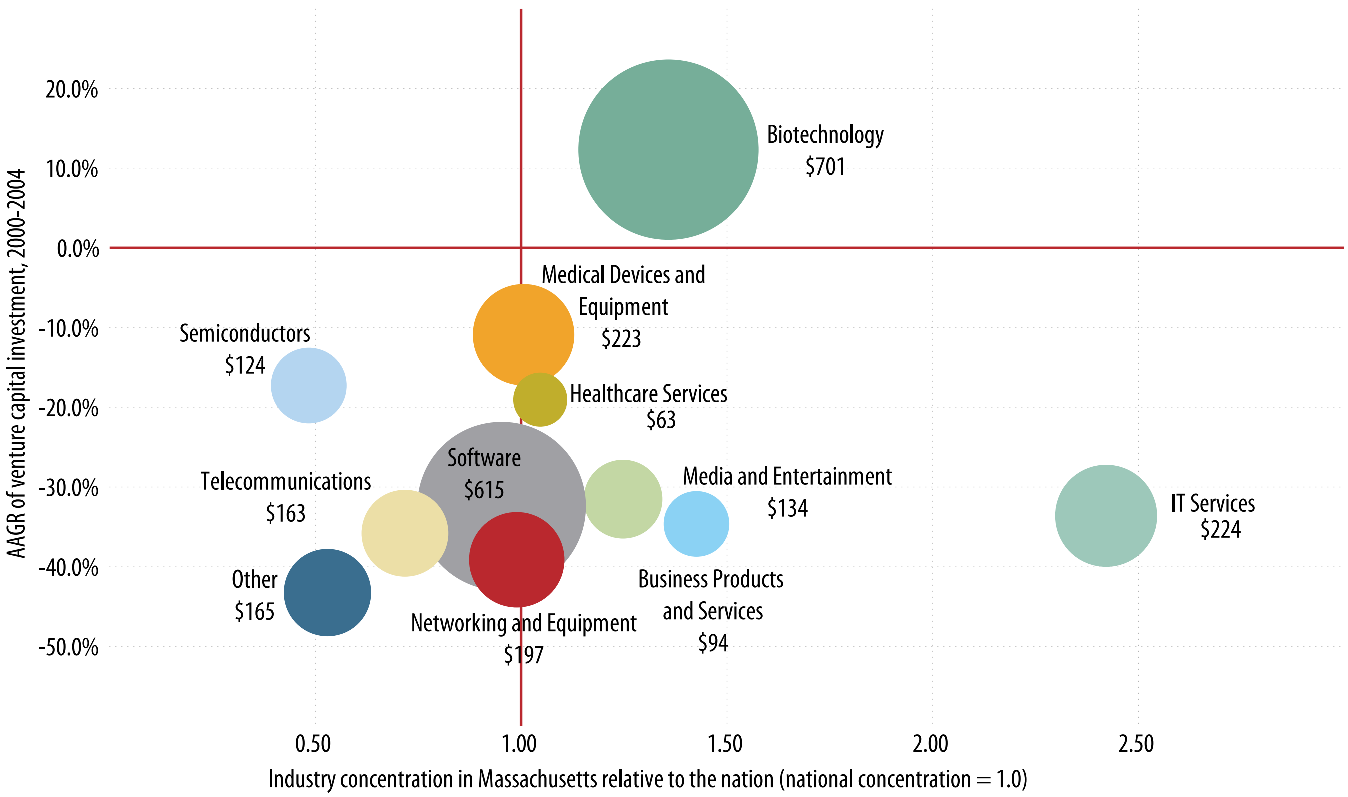
Innovation Potential: Resources

Innovation Potential: Resources	*2005 Index* Indicators	Significant Trends
Investment Capital	Venture capital flows in Massachusetts hold steady in 2004; Massachusetts retains second position behind California. Venture capital flows remain more strongly focused on later-stage investments than 10 years ago; focus on early stage firms diminishes.	Massachusetts venture capital flows are increasingly driven by biotech investment.
Federal R&D Healthcare-Related R&D	Federal R&D spending in Massachusetts continues upward climb in 2002. Growth is led by academic institutions and spending in healthcare-related R&D.	Massachusetts' share of federal R&D spending is climbing back towards Cold War level, based on new healthcare-related spending and rebound in defense research.
Intended College Majors High School Dropout Rate	Business and health continue to rank as most popular declared choices for fields of study among college-bound students in Massachusetts—twice as popular as science and engineering majors. High school dropout rate increased slightly.	Massachusetts needs a well-educated workforce to participate in growth industries.
University Enrollment Public Higher Education Spending	Massachusetts continues to rank last among LTS in public higher education spending, per capita and per student.	The large number of private higher education institutions in the state somewhat offsets this weakness.
Educational Attainment Engineering Degrees Awarded	Massachusetts continues to lead LTS in percentage of population with college degrees, but growth rate of the college-educated population modestly lags that of the LTS and the U.S. population. Massachusetts registers modest increase in engineering degrees awarded in 2004—remains fourth among LTS.	Slow population growth in Massachusetts and expansion of higher education systems elsewhere is slowly eroding Massachusetts' lead in college-educated population. Massachusetts retains strength in engineering graduates.
Population Growth Migration	Massachusetts is number seven out of nine LTS in population growth. Domestic out-migration from Massachusetts accelerated in 2004.	Accelerating domestic out-migration is partly offset by increase in immigration.
Median Housing Price Home Ownership Housing Starts	Median housing price continues strong upward trend in Massachusetts in 2004. Massachusetts lags only California among LTS for price inflation. Home ownership rate trails U.S. and most LTS. Housing starts increase at strongest rate in years, but continue to lag far behind U.S. average.	Lack of affordable housing remains a factor in population loss and the attraction of talent to the Innovation Economy.

Innovation Potential: Venture Capital Resources

As shown in Figure 1.6, biotechnology continues to attract the largest share of venture capital among the industry sectors comprising the key industry clusters of the Innovation Economy. In fact, since 2000 it is the only sector that has consistently drawn an increasing volume of investment.

Figure 1.6 Portfolio of venture capital investment by industry concentration and average annual growth rate (AAGR), Massachusetts, 2004



Note: Numeral below name of industry is 2004 venture capital investment in millions of dollars.
Source of data: PricewaterhouseCoopers, Thomson Venture Economics, National Venture Capital Association, Money Tree[SM] Survey

Innovation Potential: Market Demand

A brief summary of 2004 performance and current forecasts illustrates a resumption of growth in global markets for the goods and services produced by the Commonwealth's key clusters.

With respect to technology products, U.S. gross domestic product (GDP) data indicate that demand resumed in 2003 and continued to expand in 2004, creating nationwide employment growth of 3.4% from 2004 through mid-2005. Market research sources indicate that the computer and communications hardware industries exhibited growth rates in 2004 ranging from 4.3% in networking equipment and 14.7% in personal computers to 26% in semiconductor capital equipment. Packaged software grew 6.2% in 2004 and is expected to grow at a similar rate in 2005 (sources for hardware and software estimates are IDC via Business Week Online and the Gartner Group for semiconductor capital equipment estimate). While trade association analysis (IT Association of America) claims that hiring has improved in software and communications services, it is important to note that one out of every two new IT-related jobs is expected to be globally outsourced.

With respect to financial services, OECD analysis shows modest but resilient growth in global capital markets; with foreign markets outpacing the U.S. Boston firms have a leading position in this industry, with global managed assets equivalent to $14.4 trillion (Source is Deloitte Global Asset Management Outlook 2005). However, the consumer-oriented mutual fund industry is no longer dominated by Boston-based firms, and employment growth will be affected by the growth of the stock market and by global back-office outsourcing trends.

In healthcare technology, the $554 billion global market for biotechnology products and pharmaceuticals is projected to grow 8.2% per year from 2004 to 2011. In medical devices, the $63.7 billion market is expected to grow approximately 12% annually through 2011. (Source for data is Frost and Sullivan via Medical Patent Week, 7/31/05). Demographics and the continued expansion of new products and applications remain very strong growth drivers.

Finally, in the defense industry, U.S. defense spending continues to increase at an annual rate of 7% or more, although chronic budget deficits may eventually force cutbacks.

Indicator 1

Industry Cluster Employment and Wages

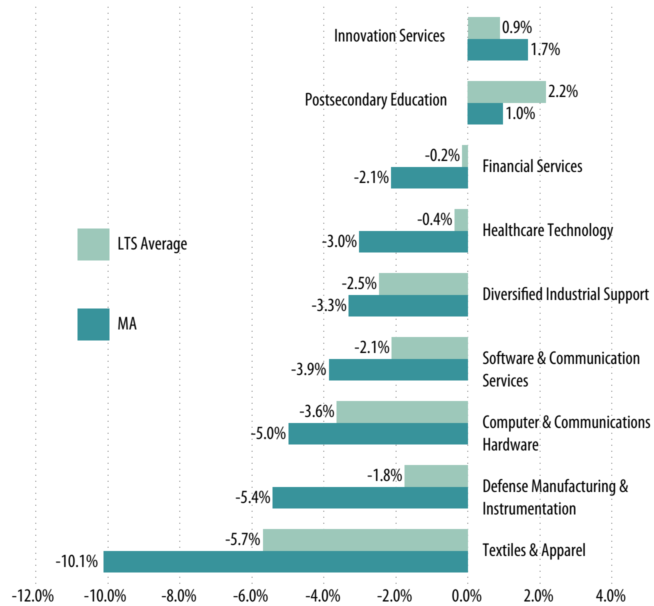
Why Is It Significant?

The nine key industry clusters consist of geographic concentrations of interdependent industries, comprising 25% of all non-government jobs in Massachusetts. Each cluster is more highly concentrated within the Massachusetts economy than similar clusters on average in the U.S. Such high concentration is a reflection of current or past competitive advantages that helped the cluster grow in the state. Typically, these clusters have higher paying jobs than the rest of the economy.

What Does This Mean?

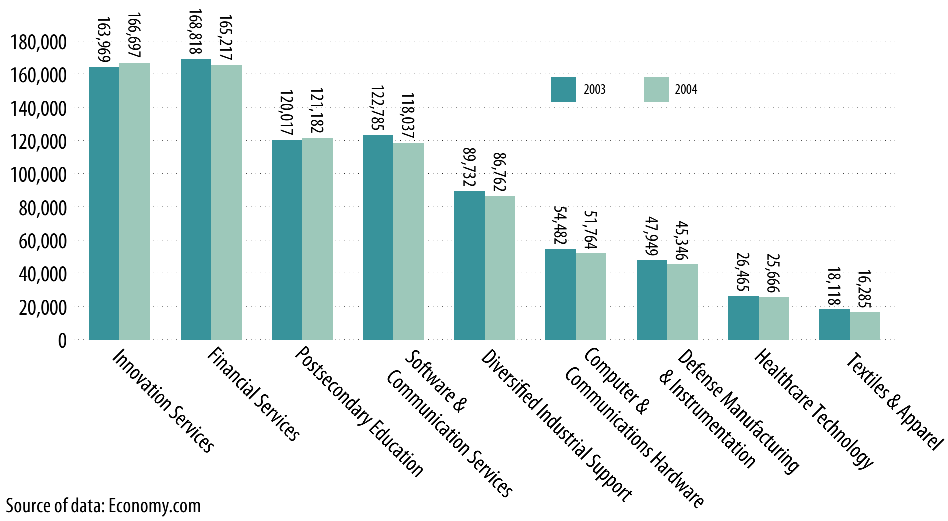
Even though employment in two large clusters, Innovation Services and Postsecondary Education, increased slightly, the majority of Massachusetts' industry clusters continued to lose jobs at a rate greater than the LTS average. Due to the decline in industry cluster employment, the nine key clusters now comprise only 25.1% of the state's total employment, down from 27.4% in 2000. As the majority of industry clusters have jobs with above-average wages, the overall decline in cluster employment has had a negative impact on median household income. The decline in cluster employment is a function of cyclical and secular factors. Specifically, the technology sector has not returned to demand and employment levels of the late 1990s, and many jobs have gone offshore in an effort by companies to reduce costs.

Percent change in cluster employment, Massachusetts and other LTS average, 2003–2004



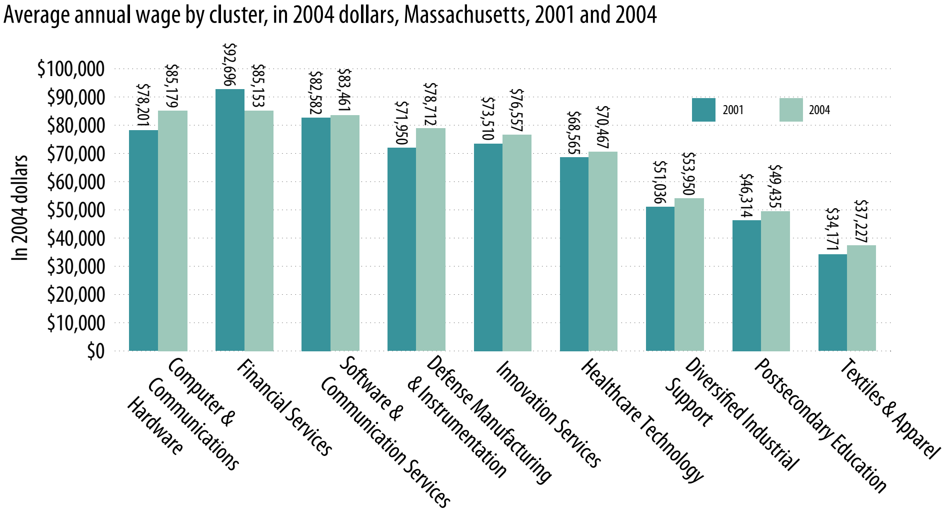
Source of data: Economy.com

Total employment by cluster, Massachusetts, 2003 and 2004



Source of data: Economy.com

Average annual wage by cluster, in 2004 dollars, Massachusetts, 2001 and 2004



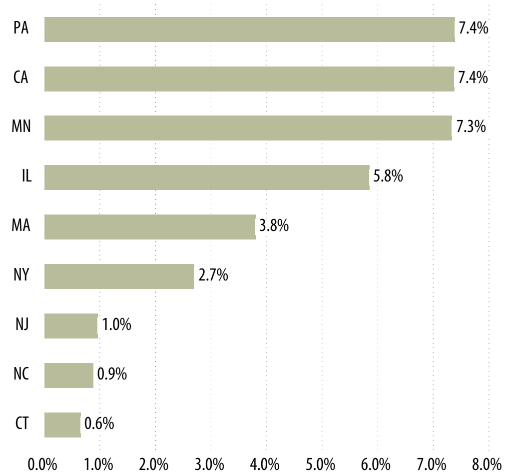
Source of data: Bureau of Labor Statistics and Economy.com

Economic Impact

Indicator 2

Corporate Sales, Publicly-Traded Companies

Average annual growth rate of corporate sales, publicly-traded companies, Massachusetts and other LTS, 2000–2004



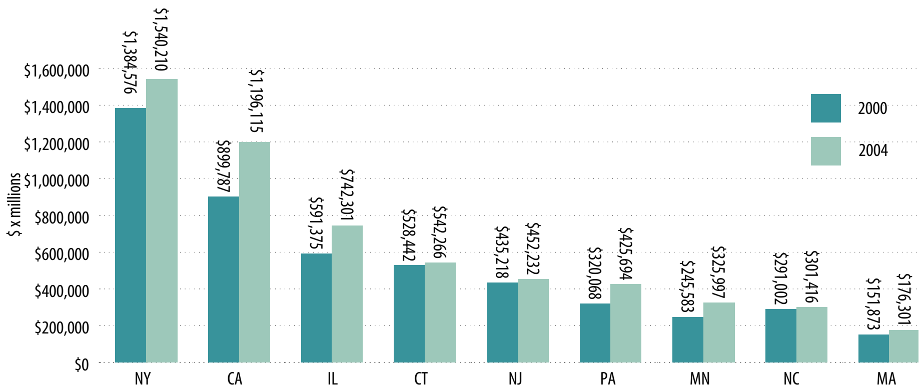
Why Is It Significant?

The amount of corporate sales of publicly-traded companies is a measure of the vitality of the industries present in a cluster. Looking at corporate sales data across both the LTS and the United States can provide insight into the patterns of a cluster's market demand.

What Does This Mean?

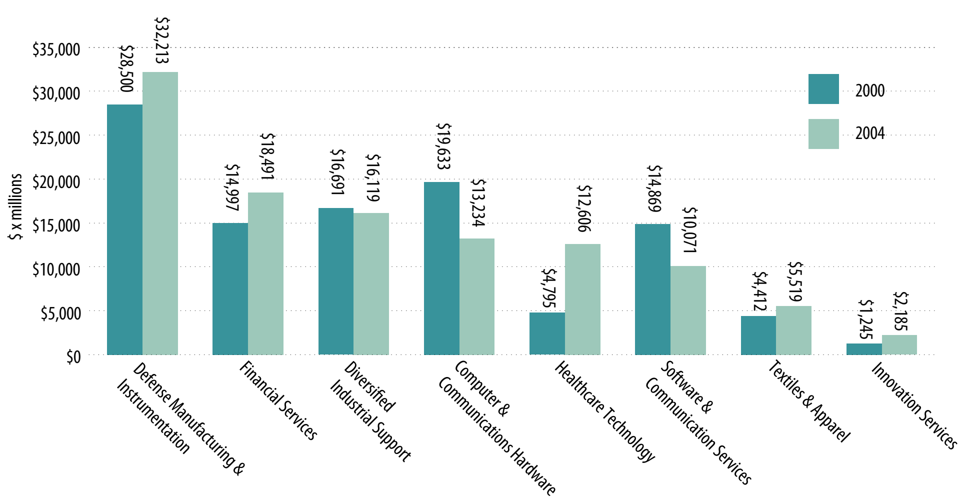
Of the nine LTS, Massachusetts' annual growth rate of corporate sales from 2000 to 2004 was right in the middle, at 3.8%. This compares negatively to growth rates of over 7% in Pennsylvania, California and Minnesota and positively to growth rates of less than 1% in North Carolina and Connecticut. Massachusetts corporate sales improved 16% from 2000 to 2004. From 2000 to 2004, sales grew in the Defense Manufacturing, Financial Services, Healthcare Technology, Textiles and Innovation Services clusters. In contrast, the decline of sales within the Computer & Communications Hardware and Software & Communication Services clusters is a reflection of ongoing weakness in market demand for the goods and services sold by these clusters. Similarly, the large increase in sales within the Healthcare Technology cluster suggests a strengthening of market demand in Massachusetts in this cluster.

Corporate sales, publicly-traded companies, Massachusetts and other LTS, 2000 and 2004



Note: Corporate sales are allocated to corporate headquarters.

Corporate sales by cluster, publicly-traded companies, Massachusetts, 2000 and 2004



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

Economic Impact

Indicator 3

Occupations and Wages

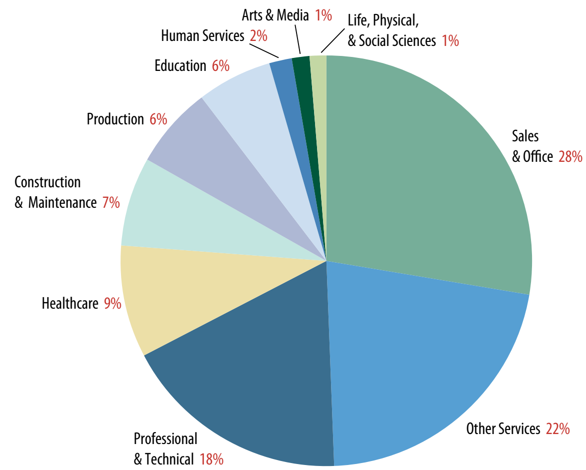
Why Is It Significant?

Occupational employment and wages are important indicators in understanding both the types of job opportunities created by a region's economy and the financial benefits they provide to a state's labor force. The mix of occupations in a state can show the levels of educational attainment and professional experience needed in the local economy.

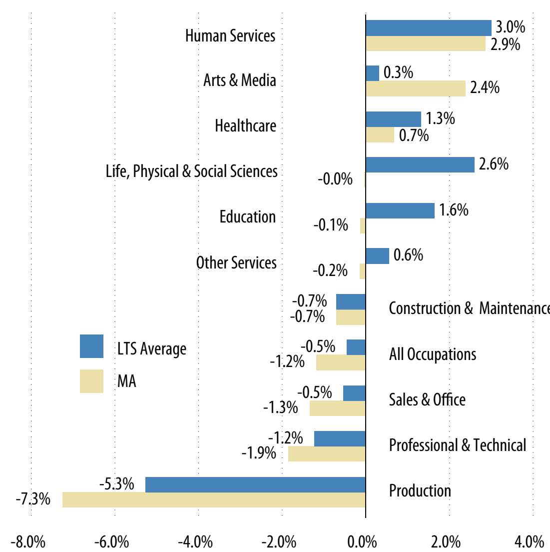
What Does This Mean?

Over the past five years, Massachusetts has experienced greater declines in employment than the LTS average, as well as smaller employment gains, with the exception of Arts & Media. Only two occupational categories with above-average wages have had employment increases over the past five years. These are Healthcare and Arts & Media, which together make up only 10% of the total state employment. Accounting for 18% of the state's total employment and paying the state's highest average wage, Professional & Technical employment has been declining at a rate faster than the state average. Industries located within these clusters tend to produce higher value-added goods and services, which increases their ability to pay higher wages. Thus, job loss in the clusters reduces the number of high-paying jobs within the state. Strategies should be considered to support increased innovation within the industry clusters, which will provide additional specialized goods and services, leading to more high-wage jobs.

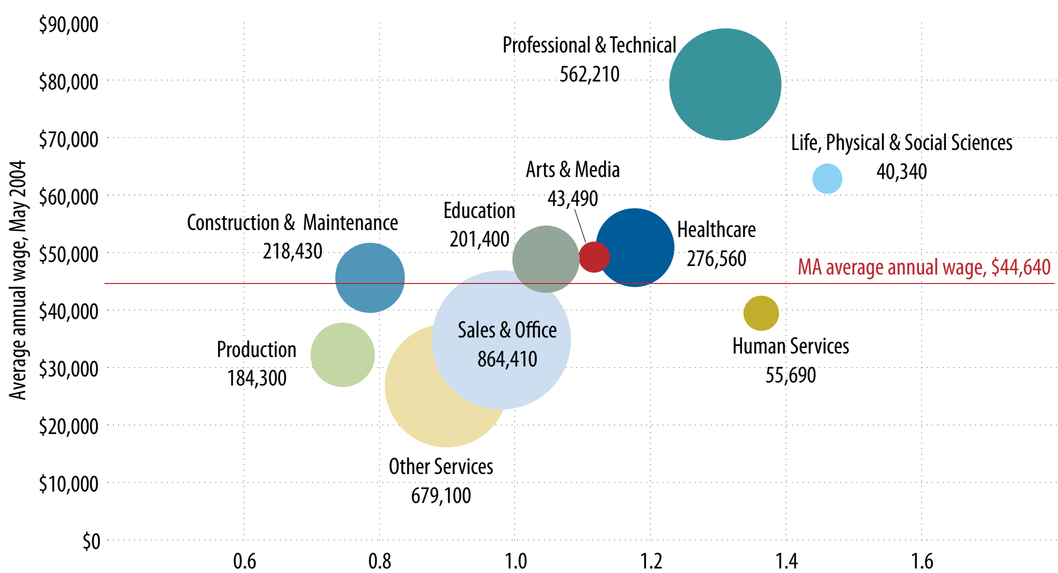
Distribution of occupations, Massachusetts, May 2004



Average annual growth rate by occupational category, Massachusetts and other LTS average, 2000–May 2004



Portfolio of occupations by employment concentration and average annual wage, Massachusetts, May 2004



Employment concentration in Massachusetts relative to the nation (national concentration = 1.0)

Note: Numeral below name of occupational category is May 2004 total employment

Source of all data for this indicator: Occupational Employment Statistics, Bureau of Labor Statistics

Indicator 4

Median Household Income

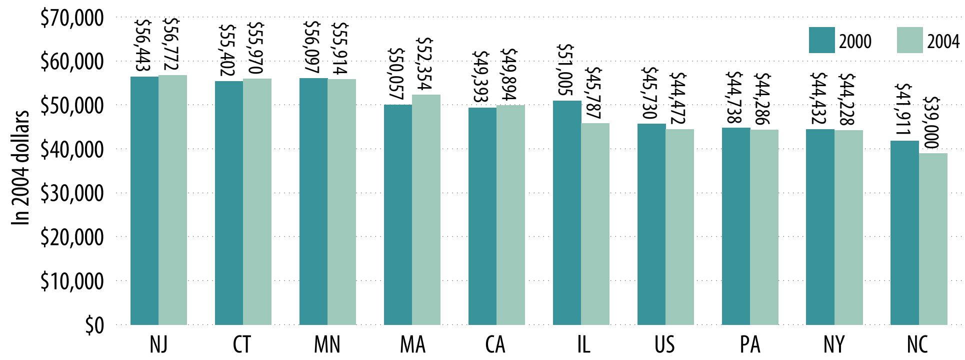
Why Is It Significant?

The median household income yields information about the financial position of citizens within a state. Rising incomes reflect a region's ability to provide wages that outpace inflation and the rising cost of living, resulting in an increase in a region's overall standard of living.

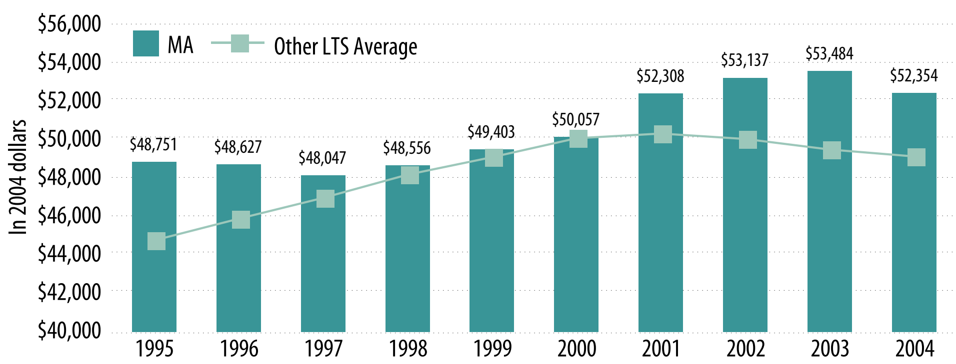
What Does This Mean?

The median household income in Massachusetts exceeds that of the U.S. as whole as well as six of the LTS. Massachusetts is also the only state of the LTS to experience an increase in median household income from 2000 to 2004. However, after strong growth from 1997 to 2002, the median household income leveled out in 2003 and declined in 2004. While one year is not a trend, it is important to monitor the situation to ensure that this decline does not continue.

Three-year average median household income, in 2004 dollars, Massachusetts, other LTS, and U.S., 2000 and 2004



Three-year average median household income, in 2004 dollars, Massachusetts and other LTS average, 1995–2004



Source of all data for this indicator: U.S. Census Bureau

Economic Impact

Indicator 5

Manufacturing Exports

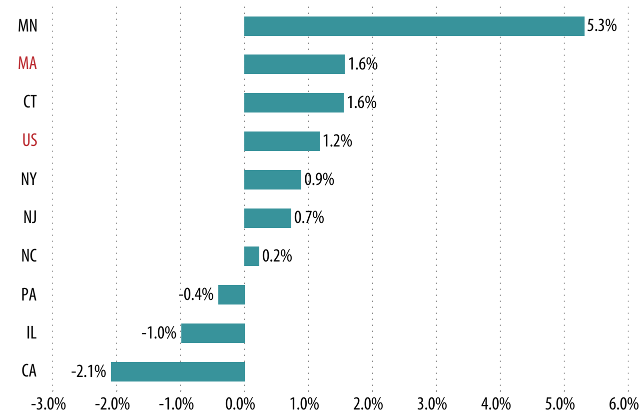
Why Is It Significant?

Exports are an important indicator of Massachusetts' global competitiveness. Serving global markets bolsters growth in employment, sales, and market share for innovation-intensive companies. Moreover, a diversity of markets can create a countercyclical hedge against a downturn in any particular international region.

What Does This Mean?

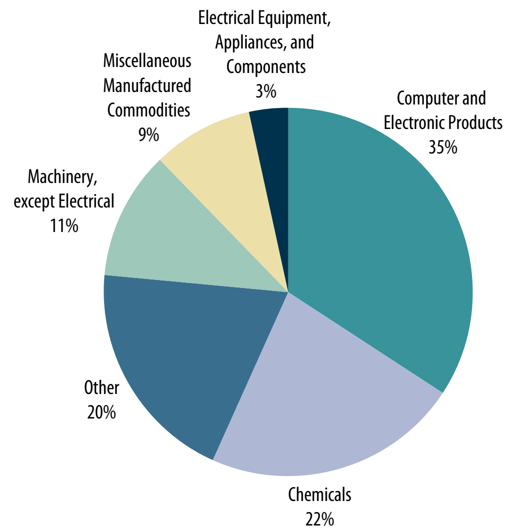
Slightly more than half of Massachusetts' manufacturing exports in 2004 were computer and electronic products and chemicals. The chemicals category includes pharmaceutical output. Between 2000 and 2004, the average annual growth rate of manufacturing exports in Massachusetts, 1.6%, was the highest of all LTS states with the exception of Minnesota. Nevertheless, as with all LTS states except Minnesota, Massachusetts experienced a drop in manufacturing exports per $1,000 Gross State Product (GSP) in 2004. As manufacturing exports are highly important to the Massachusetts economy, it is important for the state to continue to support growth in sectors with strong export potential.

Average annual growth rate of manufacturing exports, Massachusetts, other LTS, and U.S., 2000–2004



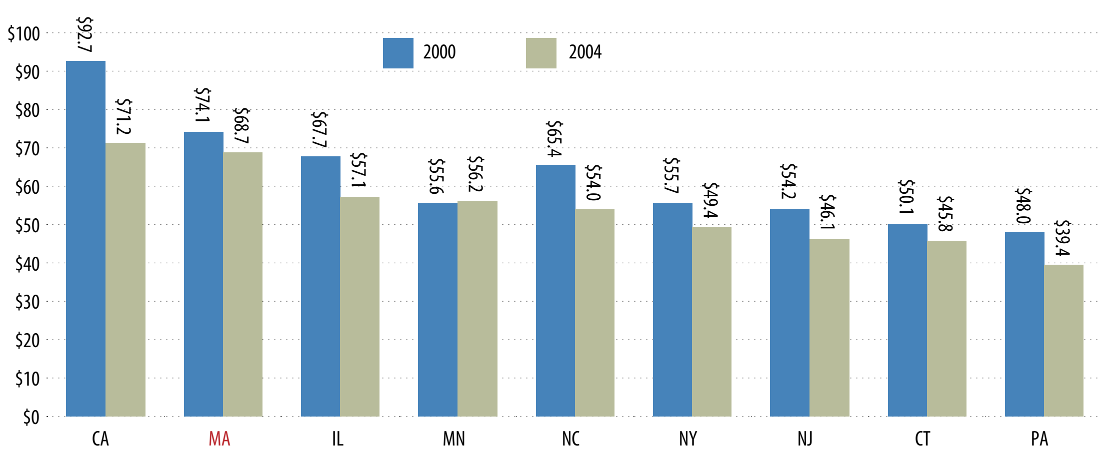
Source of data: U.S. Census Bureau

Distribution of manufacturing exports, Massachusetts, 2004



Source of data: U.S. Census Bureau

Manufacturing exports per $1,000 GSP, Massachusetts and other LTS, 2000 and 2004

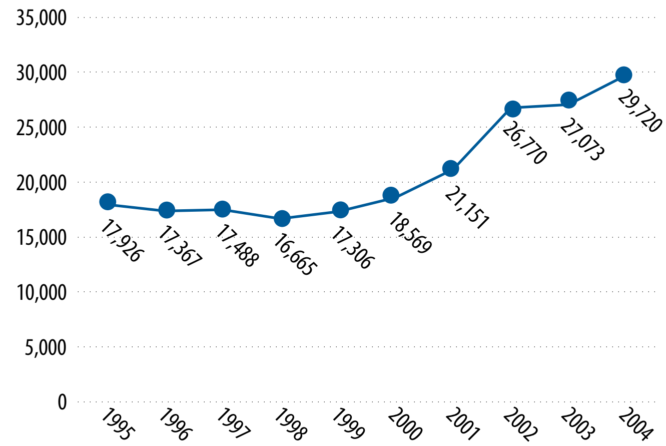


Source of data: U.S. Census Bureau and Bureau of Economic Analysis

Indicator 6

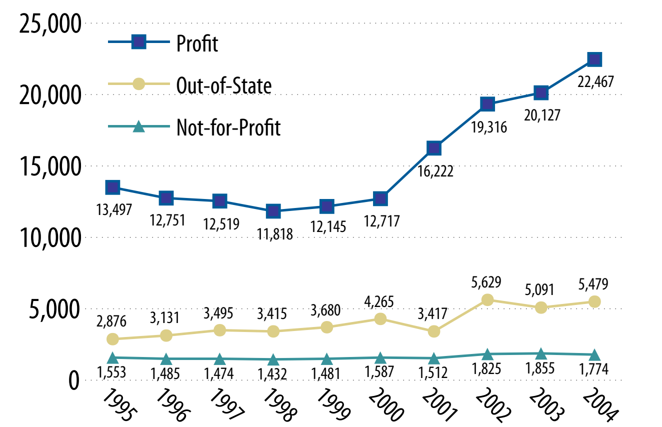
New Business Incorporations and Business Incubators

Number of new business incorporations, Massachusetts, 1995–2004



Source of data: Secretary of Commonwealth of Massachusetts

Number of new business incorporations by category, Massachusetts, 1995–2004



Source of data: Secretary of Commonwealth of Massachusetts

Why Is It Significant?

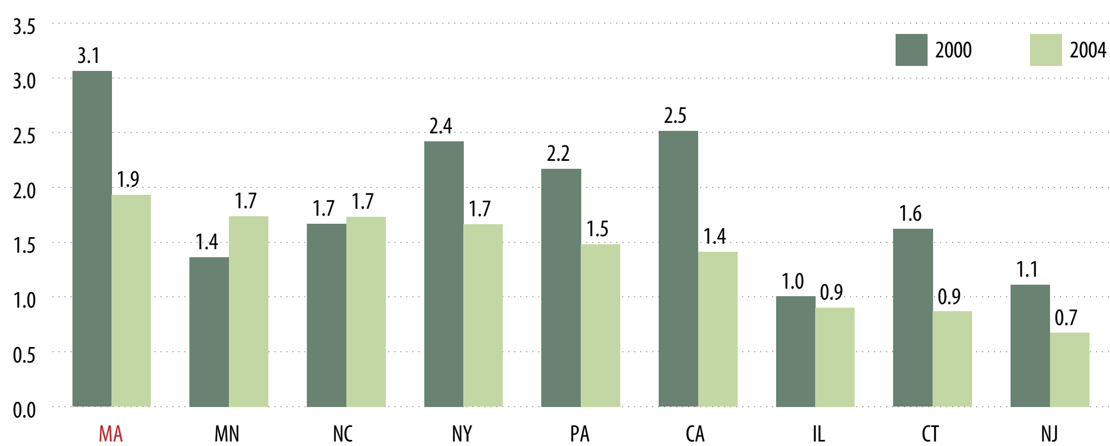
The number of new business incorporations is a key indicator of a robust economy. High numbers of new business starts typically indicate an economic environment capable of supporting the creation of entrepreneurial ventures and fostering risky and innovative ideas. Successful new companies provide jobs, goods, and services as well as create increased demand for new ideas, products, and services from related companies and institutions.

Business incubators are widely accepted as a practical method for creating new jobs by facilitating the successful creation or expansion of thriving businesses. A large number of business incubators in a region is indicative of an environment that is actively promoting and fostering entrepreneurship.

What Does This Mean?

The number of new business incorporations remained relatively steady in Massachusetts throughout the late 1990s; however, from 2000 on, there has been an increase each year. Some of this can be attributed to a number of people who became unemployed during the recession choosing to start their own businesses. There has been a drop in the total number of business incubators per 10,000 business establishments in Massachusetts and all but two of the other LTS. This can be attributed to a decline in the number of Internet and software start-up companies.

Total number of business incubators per 10,000 business establishments, Massachusetts and other LTS, 2000 and 2004



Source of data: National Business Incubation Association and U.S. Census Bureau

Indicator 7

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

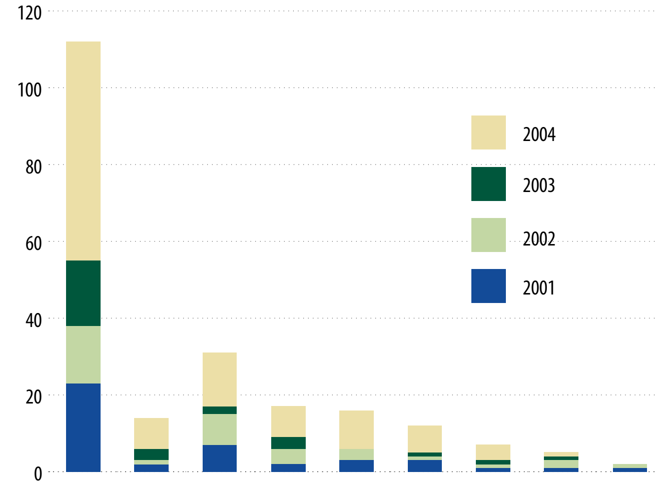
Why Is It Significant?

The number of initial public offerings (IPOs) is one indicator of future high-growth companies. “Going public” raises significant capital to invest and stimulate next-stage growth in a company. A successful IPO reflects investors’ confidence that a company can increase in value, sustain growth, and produce satisfactory returns on investment. Mergers and acquisitions (M&As) are another important avenue to liquidity for entrepreneurs and investors in rapidly growing companies. Innovation-based companies may be attractive to other firms seeking to diversify, accelerate new product development, or expand sales or market share. The risk connected with a large number of mergers and acquisitions is that there will be a loss of jobs due to the elimination of duplicated functions.

What Does This Mean?

In 2004, California led the LTS in terms of the number of IPOs, followed by New York and Pennsylvania, with Massachusetts tied for fourth place. In contrast, in 2000, Massachusetts was second only to California. Massachusetts had six IPOs in biotech-related industries, which was 75% of the total. The other LTS with significant percentages of total IPOs in biotech-related industries were California (23), Pennsylvania (3) and New Jersey (2). In 2004, half of the LTS had fewer mergers and acquisitions than in 2000, including Massachusetts. However, in 2004, all LTS experienced an increase in mergers and acquisitions from 2003. Massachusetts mergers and acquisitions increased 16%, impacting overall employment in the state.

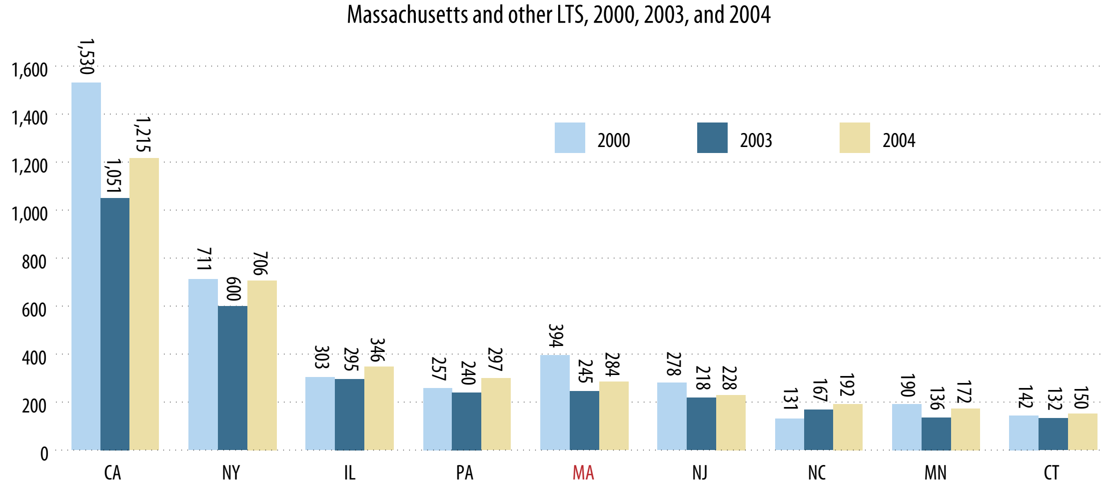
Total number of initial public offerings (IPOs), Massachusetts and other LTS, 2001–2004



	CA	MA	NY	IL	PA	NJ	MN	CT	NC
2004	57	8	14	8	10	7	4	1	0
2003	17	3	2	3	0	1	1	1	0
2002	15	1	8	4	3	1	1	2	1
2001	23	2	7	2	3	3	1	1	1

Source of data: Renaissance Capital’s IPOHome.com

Total number of mergers and acquisitions (M&As) by location of acquired company, Massachusetts and other LTS, 2000, 2003, and 2004



Source of data: Mergerstat

Indicator 8

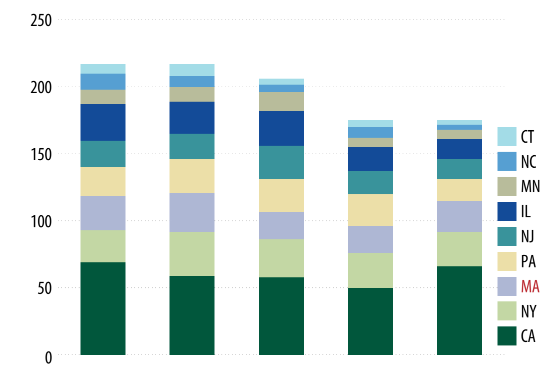
Corporate Headquarters, Technology Fast 500 Firms, and Inc. 500 Firms

Why Is It Significant?

Corporate headquarters are important "anchors" for a region, as corporations typically keep their key strategists and development-related activities near their headquarters. They are sources of new business generation and acquisition, and corporate headquarters tend to have greater community ties, including philanthropic support, than do branch offices.

The Technology Fast 500 list by Deloitte and Touche, LLP and the Inc. 500 list by *Inc. Magazine* each give an indication of the number of rapidly growing firms in a region. The Technology Fast 500 specifically measures technology 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.

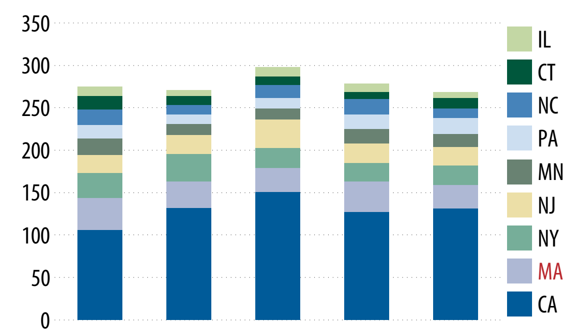
Total number of Inc. 500 companies located in Massachusetts and other LTS, 2000–2004



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

Source of data: *Inc. Magazine*

Total number of Technology Fast 500 firms located in Massachusetts and other LTS, 2000–2004



	2000	2001	2002	2003	2004
IL	11	7	11	10	7
CT	16	11	10	9	13
NC	18	11	15	18	11
PA	16	11	13	17	19
MN	20	13	13	17	15
NJ	21	22	33	23	22
NY	29	33	24	22	23
MA	38	31	28	36	28
CA	106	132	151	127	131

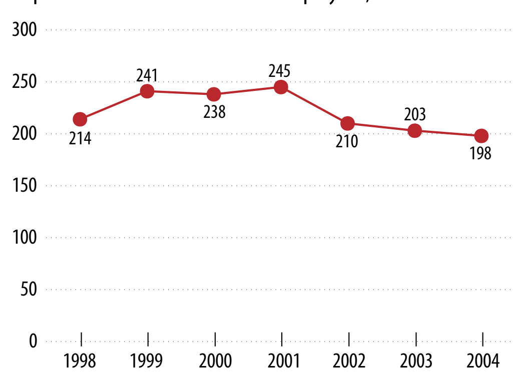
Source of data: Deloitte and Touche, LLP

What Does This Mean?

With the exception of 2001, Massachusetts has seen a steady decrease in the number of corporate headquarters of companies with 500 or more employees. Massachusetts has lost or is losing several Fortune 500 companies to mergers with the acquirer headquartered outside the Commonwealth, including John Hancock Financial Services, Inc., Fleet Boston Financial Corporation, Gillette, and Reebok. Although Massachusetts has experienced a gradual decrease in the number of large company headquarters, it still has a relatively high number per business establishment (11.3) when compared to the other LTS.

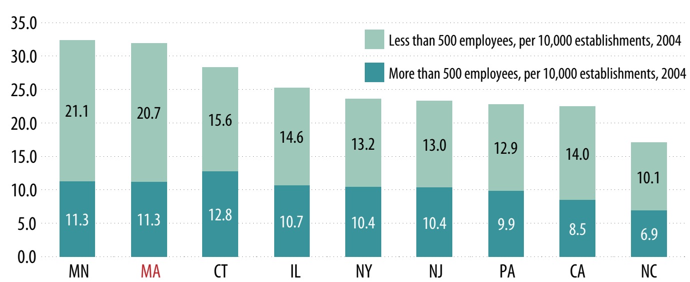
Between 2000 and 2004, the overall distribution of Technology Fast 500 and Inc. 500 companies among the LTS has remained relatively stable. While the LTS continue to host roughly the same number of Technology Fast 500 companies, the number of Inc. 500 companies located in the LTS has decreased, representing an overall decline in the number of rapidly-growing companies in the technology sector.

Number of corporate headquarters located in Massachusetts, corporations with 500 and more employees, 1998–2004



Source of data: Reference U.S.A

Distribution of corporate headquarters per 10,000 business establishments, Massachusetts and other LTS, 2004



Source of data: Reference U.S.A and U.S. Census Bureau

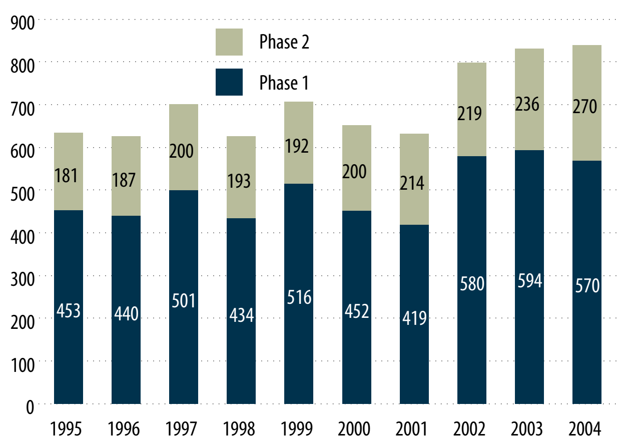
Indicator 9

Small Business Innovation Research (SBIR) Awards

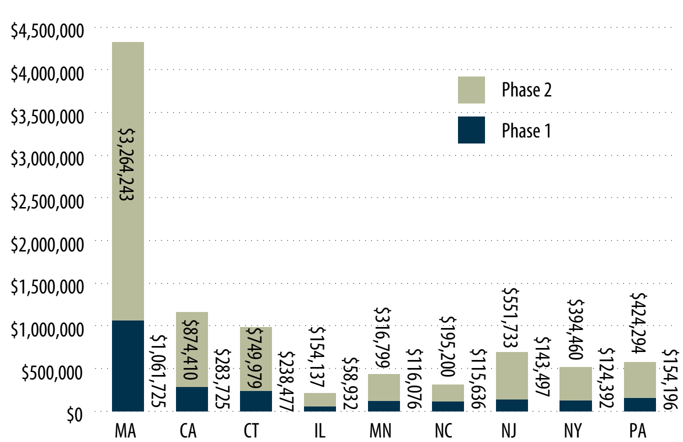
Why Is It Significant?

The Small Business Innovation Research (SBIR) Program provides competitive grants to entrepreneurs seeking to conduct "Phase I" proof-of-concept research on the technical merit and feasibility of their ideas, and "Phase II" prototype development to build on those findings. The federal SBIR program is reputed to be the world's largest seed capital fund for development of new products and processes, and often provides the initial source of financing for start-up companies. Nationally, companies that receive funding from Phase II of the SBIR program significantly outperform similar companies that do not receive such support. 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.

Number of SBIR Awards to Massachusetts companies by Phase, 1995–2004



Dollar Value of SBIR Awards for Massachusetts and LTS, per 100,000 people, 2004

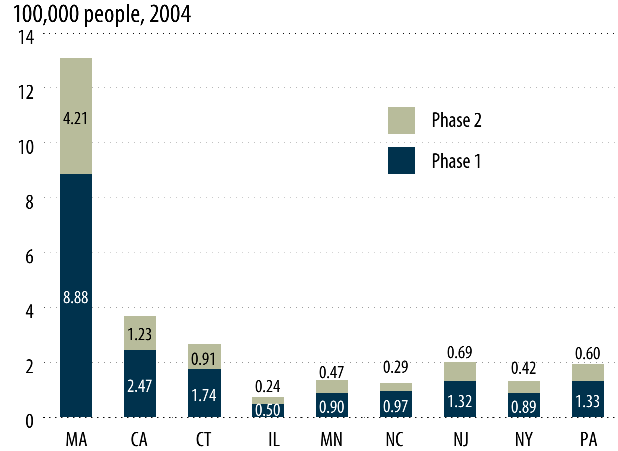


What Does This Mean?

Massachusetts continues to attract a major share of the R&D funding available from the federal government through the Small Business Innovation Research (SBIR) program. Massachusetts has ranked second (to California) in absolute number and dollar amount of awards every year since the inception of the program. Massachusetts technology entrepreneurs continued to receive record numbers of awards in both Fiscal Years 2003 and 2004. This performance becomes even more impressive when viewed on a per capita basis. Massachusetts outperformed its closest competitor (California) by almost four to one, both in the number of awards received and the dollar value of those awards.

That said, Massachusetts continues to lose market share in the program, dropping from 15.3% to 13.8% between FY2000 and FY2004. California, by comparison, has slightly increased its market share during this period. Both states have experienced rapid growth in funding from the Department of Defense. Massachusetts, however, has significantly lagged California in securing SBIR grants from the National Institutes of Health (NIH). SBIR awards from the NIH to California companies grew by 55% between FY2000 and FY2004, compared to 17% in Massachusetts. Proposals from Massachusetts companies have consistently had a higher success rate than those from California, particularly at the NIH. The issue, therefore, appears to be one of the overall level of commercialization activity in the Massachusetts life science sector.

Number of SBIR Awards to Massachusetts and other LTS companies by phase, per 100,000 people, 2004



Source of all data for this indicator: Small Business Administration

Indicator 10

FDA Approval of Medical Devices and Biotech Drugs

Why Is It Significant?

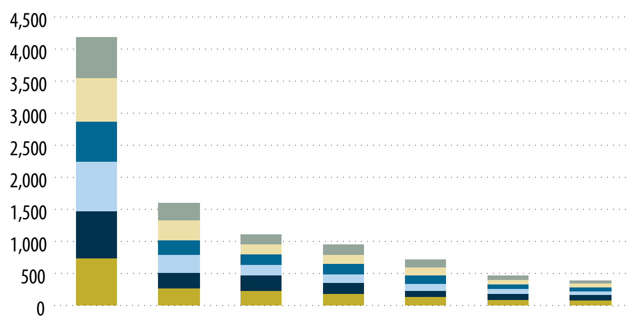
The U.S. Food and Drug Administration (FDA) classifies medical devices into two primary categories during the approval process. Premarket approvals (PMAs) are designated for the more sophisticated devices and 510(k)s for less sophisticated instruments or product improvements. Approval rates reflect innovation in medical device design and manufacturing as well as important linkages to the teaching hospitals where many of these instruments undergo clinical investigation. According to MassMEDIC, the association of medical device manufacturers in the state, there were 221 medical device companies based in Massachusetts in 2003 with combined annual shipments of more than $5 billion.

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

What Does This Mean?

Massachusetts continues to be very competitive in the biotechnology and medical devices industries. Biotech drug approvals represent the end result of years of research and investment, and a positive growth trend in the number of biotech drug approvals encourages additional investment by universities, hospitals, research institutions and companies in life science research. From 1999 through 2003, Massachusetts had a total of 1,339 510(k) approvals and 11 premarket approvals. The Commonwealth ranked second to California in 510(k) approvals and third, after California and Minnesota, in PMAs during the same time period. The development of new biotechnology drugs in the U.S. is highly concentrated. California has had the largest number of new drug approvals from 2000 to 2004, followed by Massachusetts and New Jersey. In 2004, Massachusetts had 11 biotech drug approvals, down one from 2003, while New Jersey had five fewer approvals in 2004 than in 2003. In contrast, California's new drug approvals rose 46% from 2003 to 2004.

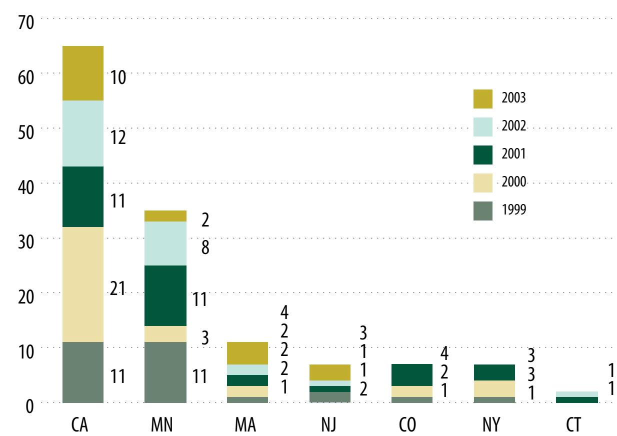
Total number of 510(k) approvals, Massachusetts and other LTS, 1998–2003



	CA	MA	NJ	NY	MN	CO	CT
1998	735	263	227	181	124	91	73
1999	734	244	242	165	100	88	93
2000	769	277	162	139	117	74	56
2001	628	230	164	161	131	72	58
2002	682	317	164	143	128	70	67
2003	641	271	146	155	122	70	43

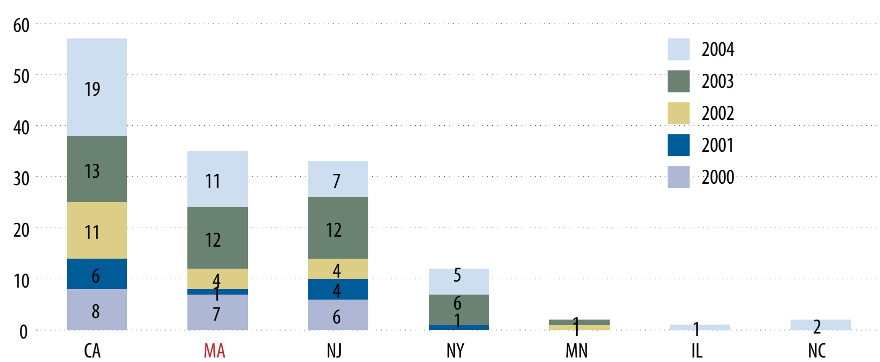
Source of data: Food and Drug Administration

Total number of premarket approvals, Massachusetts and other LTS, 1999–2003



Source of data: Food and Drug Administration

Total number of new biotechnology drug approvals by the Food and Drug Administration (FDA), Massachusetts and other LTS, 2000–2004



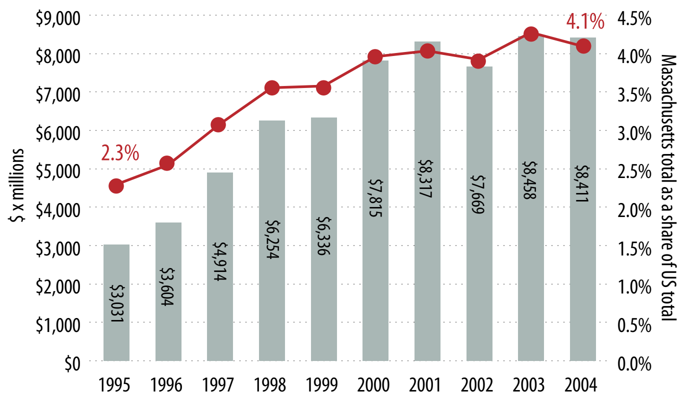
Source of data: FDA

Innovation Process: Technology Development

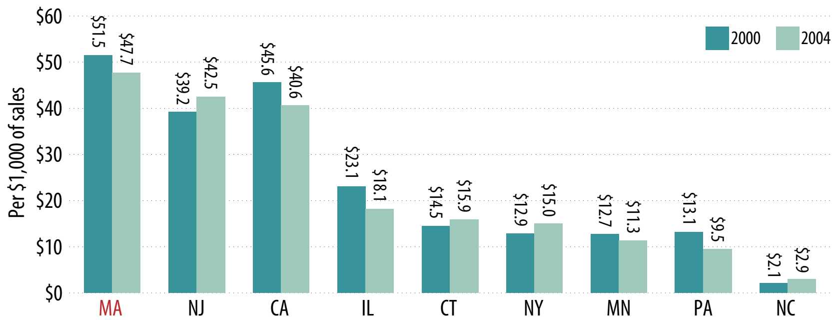
Indicator 11

Corporate Research & Development Expenditure, Publicly-Traded Companies

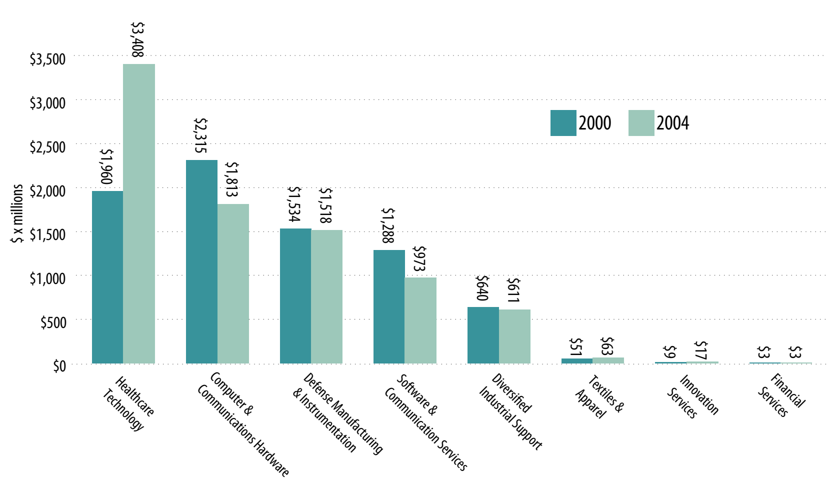
Corporate research and development (R&D) expenditure and as a percent of total U.S. corporate R&D expenditure, publicly-traded companies with R&D expenditures, Massachusetts, 1995–2004



Corporate research and development (R&D) expenditure per $1,000 of corporate sales, publicly-traded companies with R&D expenditures, Massachusetts and other LTS, 2000 and 2004



Corporate research & development (R&D) expenditure by cluster, publicly-traded companies with R&D expenditures, Massachusetts, 2000 and 2004



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

Why Is It Significant?

Corporate research and development (R&D) is essential for developing innovative new products and services that help companies remain competitive. This indicator tracks corporate R&D spending at publicly-traded companies headquartered in a state. Given the importance of corporate R&D, looking at R&D expenditure in publicly-traded companies provides an indication of corporations' investments for the long-term, as well as in the future of their industry.

What Does This Mean?

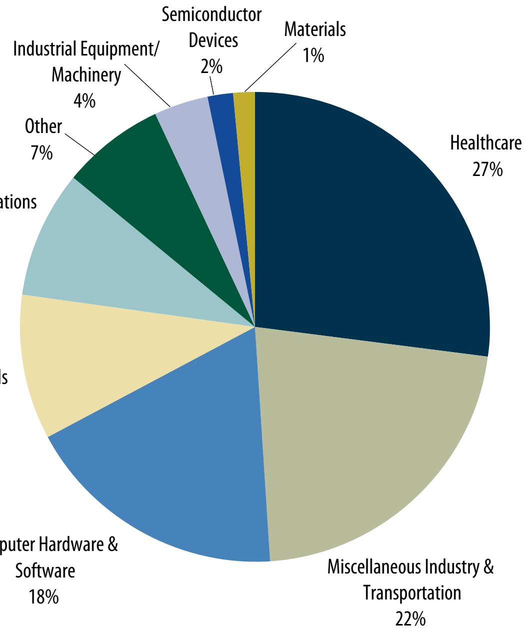
In the late 1990s, Massachusetts experienced impressive growth in corporate R&D expenditure with an average annual growth rate (AAGR) of 20.9% from 1995 to 2000. This was well above the LTS average AAGR (13.3%) and the U.S. AAGR (8.4%). This situation has changed significantly since 2000. Massachusetts' AAGR from 2000 to 2004 has slowed to 1.9%, which is now below the average LTS AAGR (3.7%) although still above the U.S. AAGR (1.0%). Part of the lower growth rate in Massachusetts can be attributed to the decrease in the amount of corporate R&D expenditure per dollar of sales over this same time period, coupled with a decline in corporate sales in critical sectors such as software, communications services, and computer hardware over the same time period. Massachusetts still leads the LTS with the highest corporate R&D expenditure per $1,000 of sales. Some states, however, such as New Jersey and North Carolina, have experienced AAGRs in corporate R&D expenditure above the average LTS (6.6% and 9.6% respectively).

Patents, Invention Disclosures, and Patent Applications

Why Is It Significant?

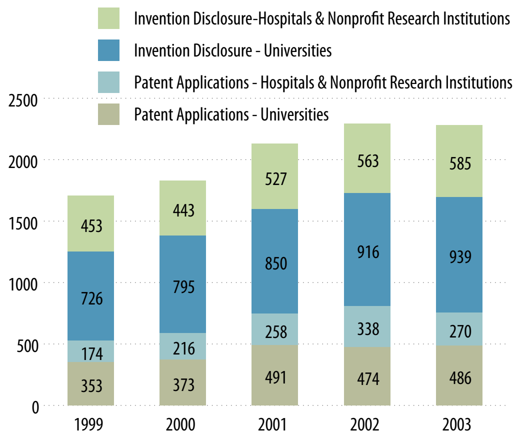
Patents reflect the initial discovery and legal protection of innovative ideas. Massachusetts universities, hospitals, and research institutions are important sources of innovative ideas. Individual inventors formally disclose innovations to their sponsoring institutions to initiate the complex process toward patent registration. The next major step following disclosure is the formal patent application to the U.S. Patent and Trademark Office. The number of invention disclosures and formal patent applications reflect the amount of R&D activity in a state, as well as the initial registration of innovative ideas or inventions with commercial potential. Strong patent activity usually reflects significant institutional conduct of research and development with potential commercial relevance.

Distribution of patents issued, Massachusetts, 2000–2004



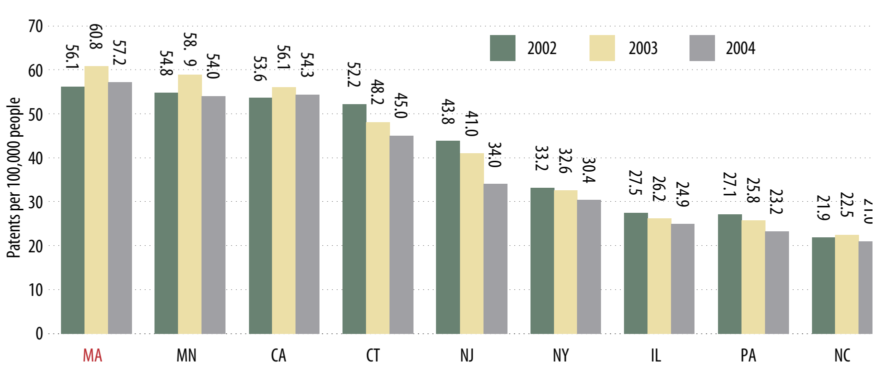
Source of data: Adam Jaffe *et al*: "The NBER U.S. Patent Citations Data File: Lessons, Insights, and Methodological Tools" and U.S. Patent and Trademark Office

Total number of new patent applications and invention disclosures filed by Massachusetts universities, hospitals, and nonprofit research institutions, 1999–2003



Source of data: Association of University Technology Managers (AUTM)

Number of patents issued to state residents, per capita, Massachusetts and other LTS, 2002–2004



Source of data: U.S. Patent and Trademark Office and U.S. Census Bureau

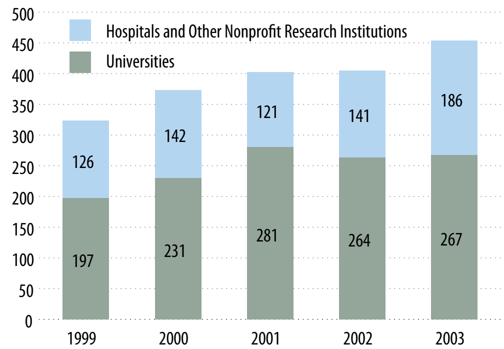
What Does This Mean?

Massachusetts' superior track record in patents is a key component of the Innovation Economy. Massachusetts has the largest number of patents issued to state residents on a per capita basis of all LTS. The total number of new patent applications and invention disclosures filed by Massachusetts universities, hospitals, and nonprofit research institutions increased 34% between 1999 and 2003 but flattened from 2002 to 2003. In terms of distribution of patents, from 2000 to 2004 the largest number of patents issued in Massachusetts was in the healthcare industry, followed by miscellaneous industry and transportation and computer hardware and software. The distribution of patents has not changed significantly from the 1995–1999 time period to 2000–2004, with the exception of computer hardware and software (from 14% of the total in 1995–1999 to 18% in 2000–2004) and chemicals (from 12% to 10%, respectively).

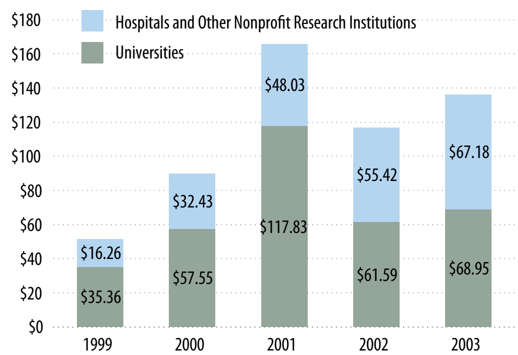
Indicator 13

Technology Licenses and Royalties

Number of technology licenses issued by major universities, hospitals, and other nonprofit research institutions, Massachusetts, 1999–2003



Value of gross licensing by major universities, hospitals, and other nonprofit research institutions, Massachusetts, 1999–2003



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 (e.g., patents, trademarks) from universities, hospitals, and other research organizations to companies that will commercialize the technology. The number of new technology licenses and gross royalties received are measures of the success of technology transfer efforts by universities, hospitals, and research institutions. Royalties from these licenses reflect both the perceived value of the intellectual property in the commercial marketplace, as well as the actual income stream generated by the sales of products and services embodying the licensed intellectual capital. In return, royalties and license fees support further research activities in the licensing institutions.

What Does This Mean?

The number of technology licenses issued by universities, hospitals and nonprofit research institutions rose 12% from 2002 to 2003 (most recent available data). Licenses issued by hospitals grew 32%, while licenses issued by universities only grew 1%. The value of gross licensing received by major universities, hospitals, and nonprofit research institutions rose 16%, with higher growth in hospitals than universities (22% versus 12%). This reflects the strength of medical research in Massachusetts and supports the strong growth of the Healthcare Technology cluster. Growth in technology licenses reflects a critical element in commercializing research and increased emphasis by Massachusetts research institutions to move discovery out to the marketplace—an important aspect of the innovation process.

Indicator 14

Investment Capital

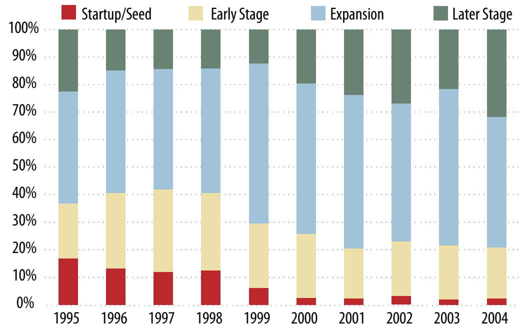
Why Is It Significant?

Professional venture capital firms are one of the primary sources of funds for the creation and development of new companies and jobs in the Innovation Economy. Venture capital firms often fund novel high-tech companies, which tend to be riskier investments. Private investment capital also comes from other sources that can pick up shortfalls in venture capital funding, often from an entrepreneur's own funds or from angel investors.

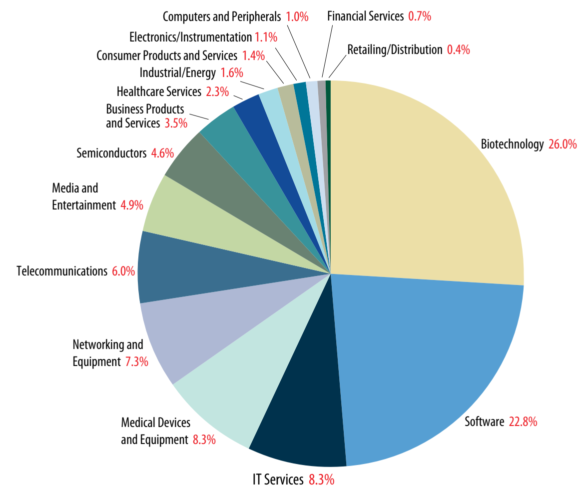
What Does This Mean?

Over the past five years, Massachusetts has been increasingly successful in attracting a large share of venture capital funding in the U.S. The only other LTS to see a similar trend is California, which increased its share of total venture capital in the U.S. from 41% to 46% over this same time period. Much of this increase in the share of U.S. venture capital funding to Massachusetts can be attributed to the steady growth of the biotechnology industry, which has been able to attract an additional $261 million over this short time period. Massachusetts has proved to be a good environment for biotechnology start-ups contributing to the large and successful life sciences cluster. The infrastructure and talent needed to start a company are available in Massachusetts, and competitive strategies should be undertaken to ensure that this continues as other states become more aggressive in growing this cluster.

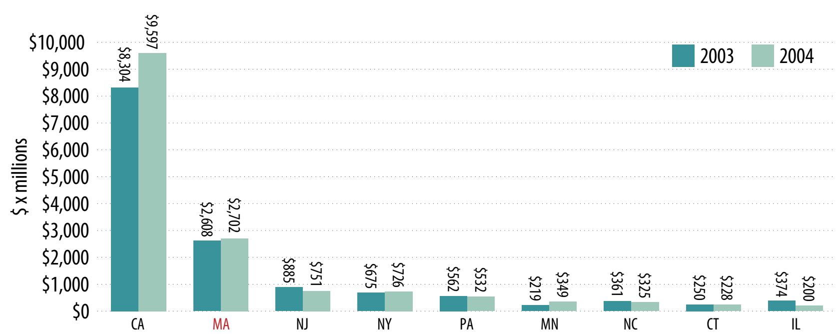
Distribution of Massachusetts venture capital investments, by stage of financing, 1995–2004



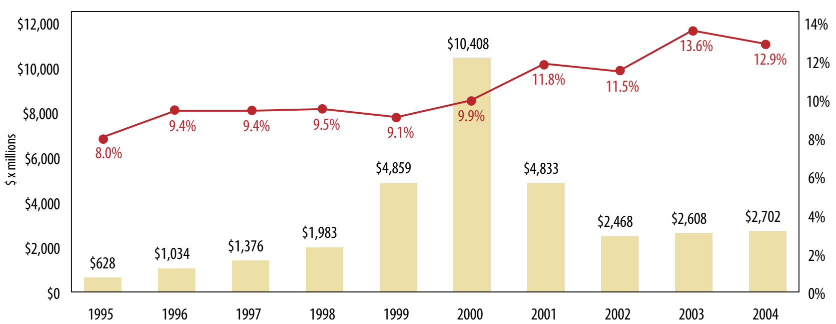
Distribution of venture capital investments, Massachusetts, 2004



Total venture capital investments, Massachusetts and other LTS, 2003 and 2004



Venture capital investments received by companies and as a percent of total U.S. venture capital investments, Massachusetts, 1995–2004

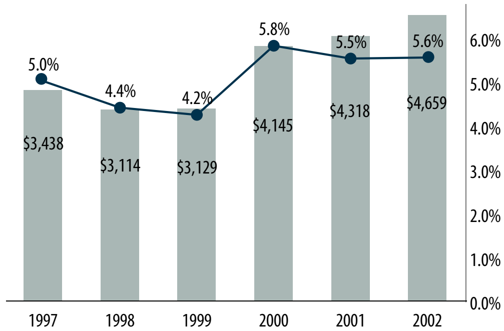


Source of all data for this indicator: PricewaterhouseCoopers/Thomson Venture Economics/National Venture Capital Association MoneyTree™ Survey

Indicator 15

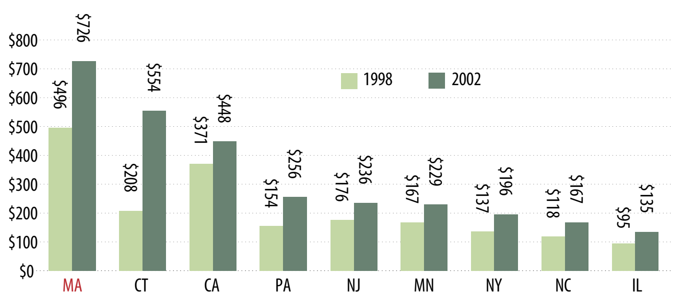
Federal Research & Development Expenditure and Health Research & Development Expenditure

Federal R&D expenditures ($ millions) and as a percent of total U.S. federal R&D expenditures, Massachusetts, 1997–2002 (latest available data)



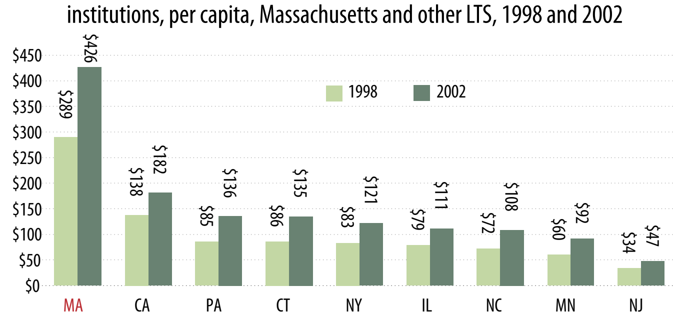
Source of data: National Science Foundation

Total federal R&D expenditures, per capita, Massachusetts and other LTS, 1998 and 2002



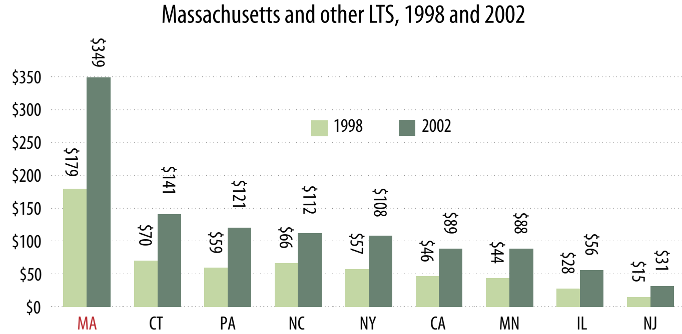
Source of data: National Science Foundation and U.S. Census Bureau

Federal R&D expenditures in academic and nonprofit research institutions, per capita, Massachusetts and other LTS, 1998 and 2002



Source of data: National Science Foundation and U.S. Census Bureau

U.S. Department of Health and Human Services R&D expenditures, per capita, Massachusetts and other LTS, 1998 and 2002



Source of data: National Science Foundation and U.S. Census Bureau

Why Is It Significant?

The primary source of funds for academic research 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 further development. Research and development conducted by academic institutions also has a pronounced effect in stimulating private sector R&D investments.

The National Institutes of Health (NIH) is the major source of funds for health-related research in the United States. It is the largest source of federal funding for non-defense research. NIH-funded research is a critical driver for Massachusetts biotechnology, medical device, and health services industries. More than 95% of the U.S. Department of Health and Human Services (HHS) R&D expenditure occurs through the NIH.

What Does This Mean?

Total R&D per capita has increased across all of the LTS. A large portion of this growth can be attributed to the increase in funding from HHS. In 2002, the majority of R&D funding awarded to Massachusetts institutions from HHS was directed to nonprofit and academic research, amounting to 47% and 30%, respectively, of the total HHS funds awarded to the state. These federal funds foster breeding grounds for talent and new ideas, which are vital to the creation of Innovation Economy businesses.

Indicator 16

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

Why Is It Significant?

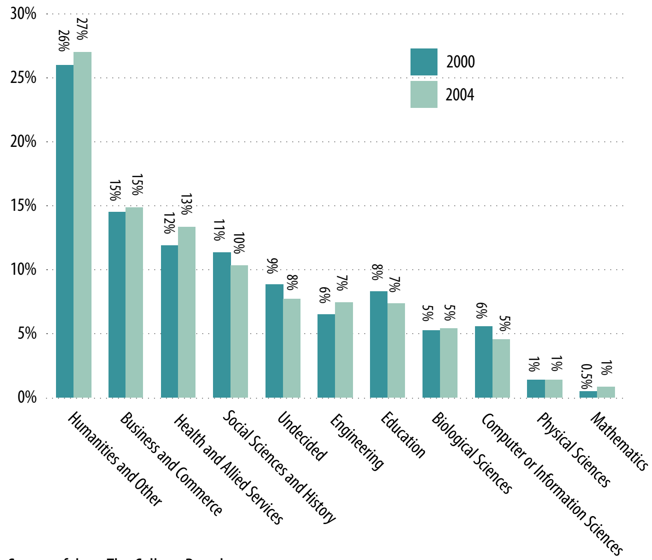
Most colleges and universities require the SAT Reasoning Test as part of their admissions requirements. The profile of intended majors of college-bound seniors who take the SAT indicates the interest of high school students in those fields that are critical to the growth of the Innovation Economy.

The high school dropout rate is a risk measurement 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 is especially critical given Massachusetts' historically low population growth rate.

What Does This Mean?

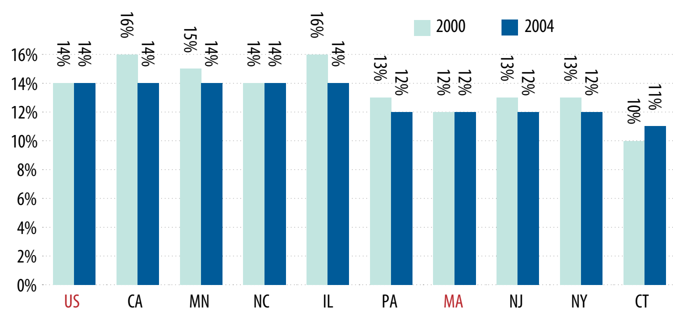
The distribution of intended college majors of high school students has varied little over the past five years. The percentage of all Massachusetts high school seniors taking the SAT planning to major in computers, engineering or information science in college has remained stable between 2000 and 2004, at 12%. In contrast, California and Illinois saw a decline from 16% to 14% in the same time period. The percentage of high school seniors taking the SAT planning to major in health and allied services in Massachusetts increased from 12% in 2000 to 13% in 2004. This is relatively low compared to other LTS. As the Innovation Economy demands workers with backgrounds in science and engineering, it would be beneficial for Massachusetts to stimulate more interest in these fields at the middle school and high school levels. The high school dropout rate has increased since its recent low in 2002. It is important to monitor this situation and be prepared to address it if it continues.

Distribution of intended college majors, high school students taking the SAT Reasoning Test, Massachusetts, 2000 and 2004



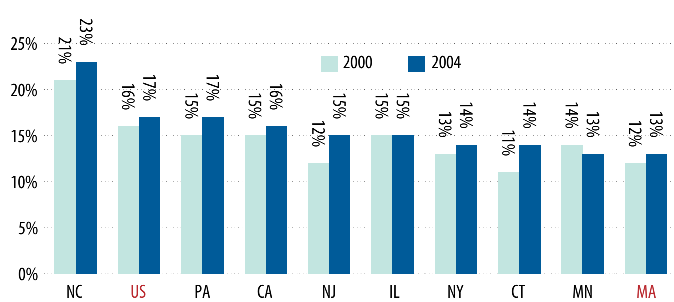
Source of data: The College Board

Percent of all high school seniors taking the SAT planning to major in Computer, Engineering, or Information Science in college, Massachusetts, LTS, and U.S., 2000 and 2004



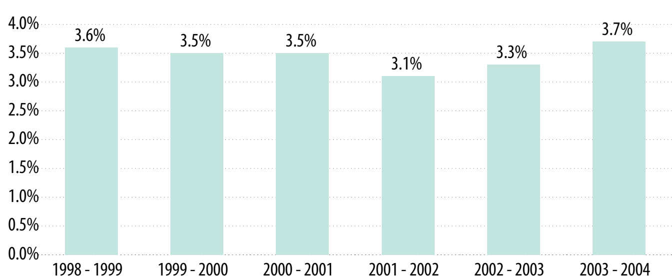
Source of data: The College Board

Percent of all high school seniors taking the SAT planning to major in Health and Allied Services in college, Massachusetts, LTS, and U.S., 2000 and 2004



Source of data: The College Board

High school dropout rate, Massachusetts, 1998–2004



Source of data: Massachusetts Department of Education

Indicator 17

University Enrollment and Public Higher Education Expenditure

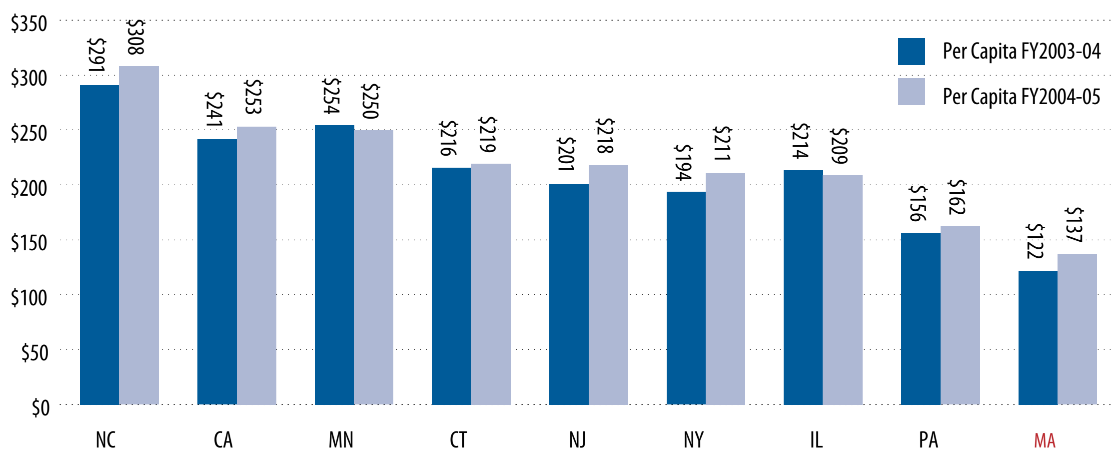
Why Is It Significant?

Investing in the quality of postsecondary education is important in increasing the institutions' ability to attract talented students from both in-state and out-of-state. Investments in the state's higher education system are important to strengthening the region's innovation infrastructure. Local colleges and universities help create a diverse and well-educated population, and provide the learning and skills needed by the workforce for jobs in the Innovation Economy. Many graduates choose to reside and work in the region where they received their degree because they have developed connections with the community.

What Does This Mean?

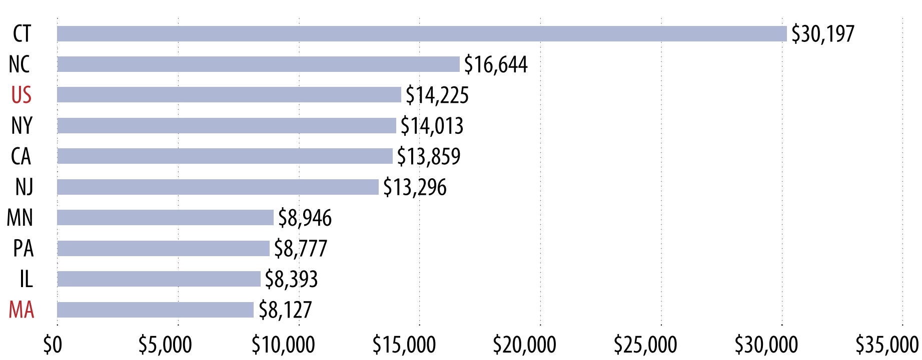
Although Massachusetts has seen an increase in the appropriations for operating expenses of public higher education from FY2004 to FY2005, it still is far below the other LTS. Massachusetts also had the lowest higher education expenditure per full time equivalent (FTE) student of all the LTS in 2003 (most recent and available data). The weakness in Massachusetts' funding of higher education is partially offset by the large number of excellent private institutions of higher education. However, it means that there may not be enough spaces in public institutions for students who cannot afford private school tuition. These are students who could be the future workers in the Innovation Economy, and whose talents may not be realized without public funding of their education.

Appropriations of state/local tax funds for operating expenses of public higher education, per capita, Massachusetts and other LTS, fiscal years 2004 and 2005



Source of data: Grapevine Center for the Study of Education Policy

State higher education expenditures per full time equivalent (FTE) student, Massachusetts, other LTS, and U.S., 2003



Source of data: National Association of State Budget Officers and National Center for Education Statistics

Innovation Potential: Resources

Indicator 18

Educational Attainment and Engineering Degrees Awarded

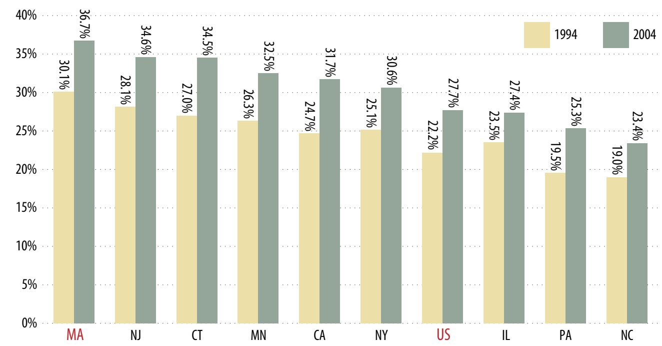
Why Is It Significant?

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 offer an indication of future workforce resources.

What Does This Mean?

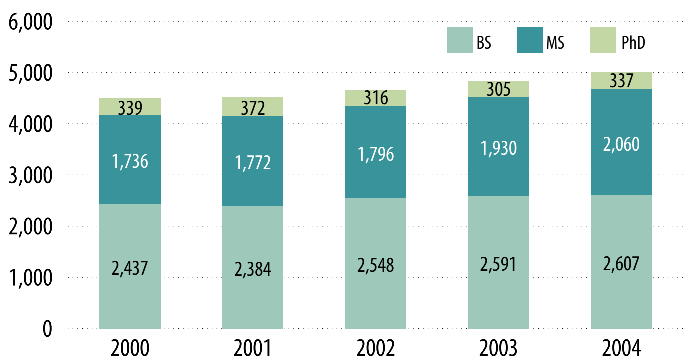
Massachusetts continues to have the highest percentage of adult population with a bachelor's degree or higher, giving the Innovation Economy a distinct advantage in human capital over other LTS. Reinforcing this advantage, the reputation of Massachusetts' higher education institutions draws talented students from across the United States and the world. Massachusetts has experienced an 11% increase in the number of engineering degrees awarded since 2000, with 7% growth at the undergraduate level, 19% growth at the masters level and no growth at the PhD level.

Percent of adult population with a bachelor's degree or higher, Massachusetts, other LTS, and U.S., 1994 and 2004



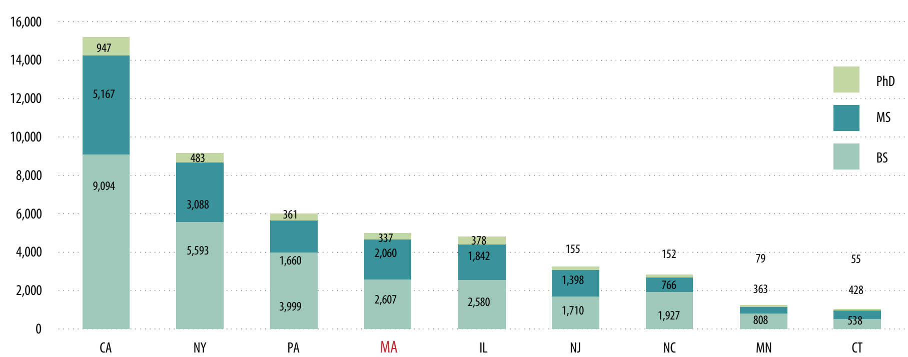
Source of data: U.S. Census Bureau

Number of engineering degrees awarded by Massachusetts institutions, 2000–2004



Source of data: American Association of Engineering Societies

Number of engineering degrees awarded by Massachusetts and other LTS institutions, 2004



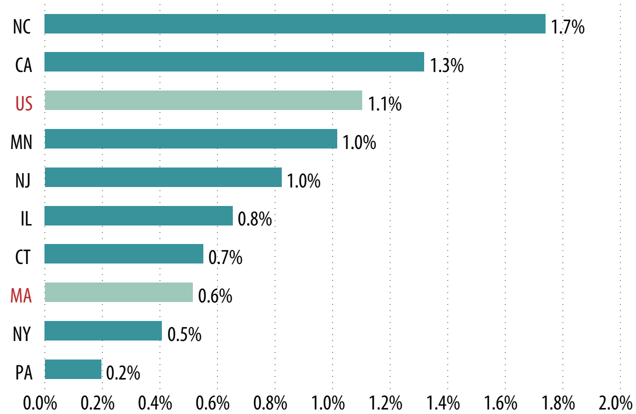
Source of data: American Association of Engineering Societies

Innovation Potential: Resources

Indicator 19

Population Growth Rate and Migration

Average annual population growth rate, Massachusetts, other LTS, and U.S., 1994–2004



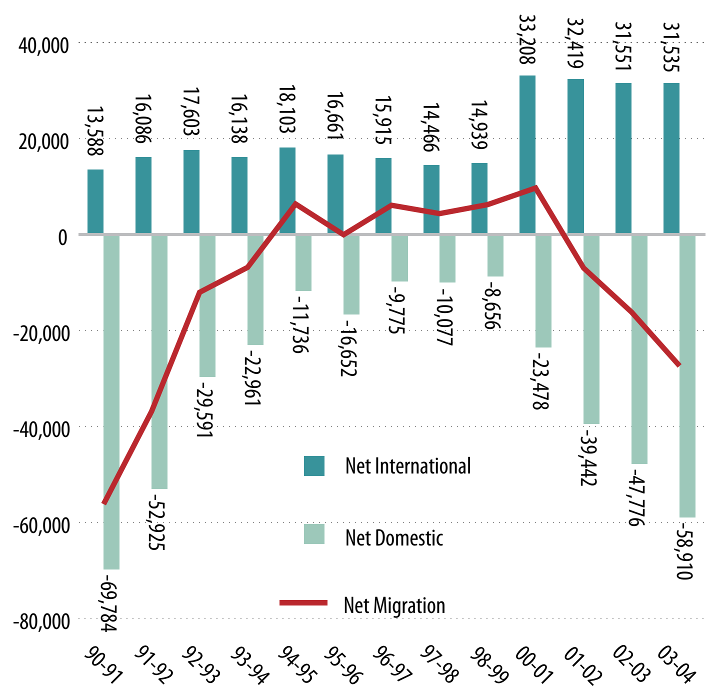
Why Is It Significant?

A low population growth rate can constrain the expansion of a state's workforce and may inhibit business growth and economic development. In-migration can help sustain innovative industries by bringing into the state skills and educational backgrounds that are in demand.

What Does This Mean?

From 1994–2004, Massachusetts has had the third-lowest population increase of the LTS. In fact, from 2000 through 2004, Massachusetts experienced a net loss of population. This loss would have been even larger than it appears if not for the large number of immigrants choosing to relocate to the state. It is important that Massachusetts retain and attract people with the education and skills to participate in the Innovation Economy. It also means that the state should attempt to address the factors that might encourage residents to leave the state, such as high housing costs.

International migration and net domestic migration, Massachusetts, July 1990–July 2004



Source of all data for this indicator: U.S. Census Bureau

Innovation Potential: Resources

Indicator 20

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

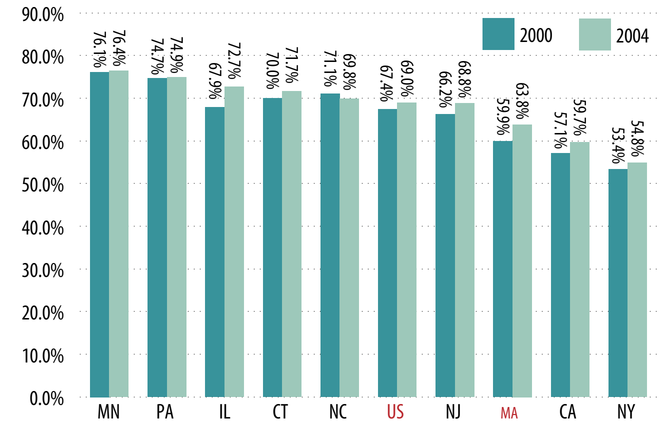
Why Is It Significant?

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, since 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.

What Does This Mean?

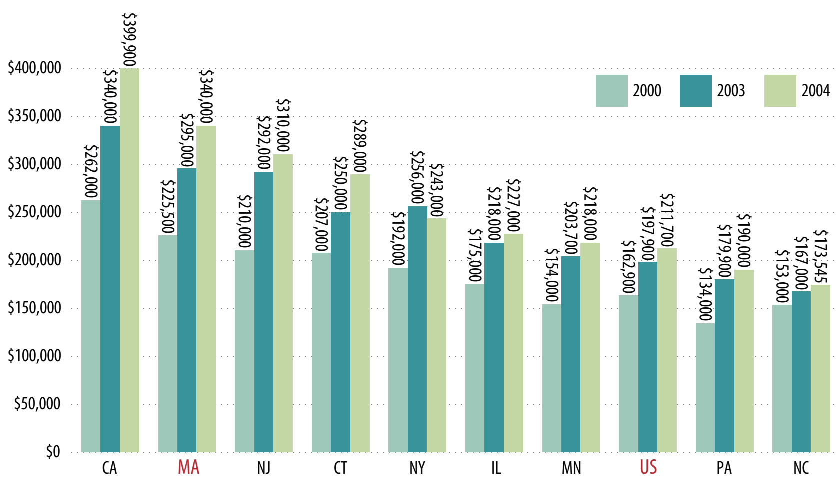
The median single-family home price continues to rise rapidly in Massachusetts. In 2004, California, Connecticut, and Massachusetts saw their largest one-year percentage increase of the past five years. While all three of these states have high home prices, only California has a relatively high number of housing starts per capita. High home prices make it difficult for young families to purchase their own homes, which might discourage them from permanently locating in Massachusetts. This could result in more people with the skillsets needed by the Innovation Economy leaving the state after they graduate from college.

Home ownership rates, Massachusetts, other LTS, and U.S., 2000 and 2004



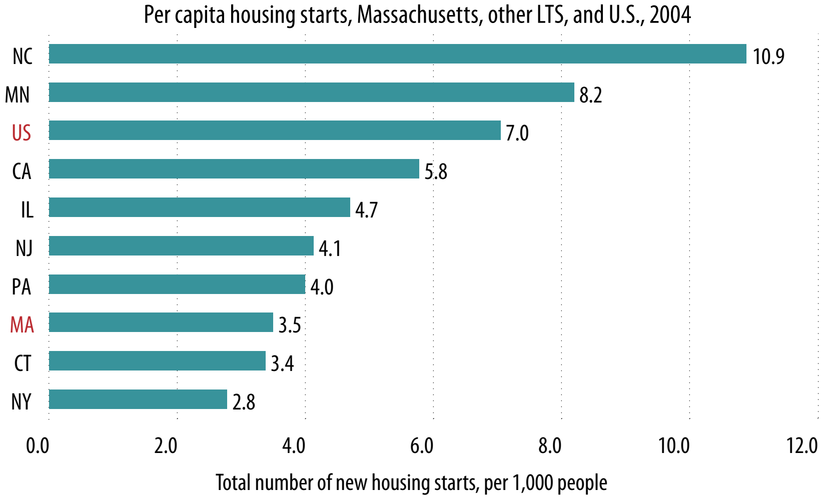
Source of data: U.S. Census Bureau

Median price of single-family homes, Massachusetts, other LTS, and U.S., 2000, 2003, and 2004



Source of data: Federal Housing Finance Board

Per capita housing starts, Massachusetts, other LTS, and U.S., 2004



Source of data: U.S. Census Bureau

APPENDIX A:

Data Sources for Indicators and Selection of LTS

Data Availability

For the *2005 Index*, indicators were developed from existing secondary sources. Indicators from these sources usually required the reconfiguration of existing datasets. These groupings of data were derived from a wide range of sources; consequently, there are variations in the time frames used and in the specific variables that define the indicators being measured. This appendix provides notes on data sources for each indicator. MTC intends to continue updating and refining the *Index* report in future years, so that it can serve as an effective monitoring system.

I. Selection of Leading Technology States (LTS) for Benchmarking Massachusetts' Performance

To provide context, a goal of the *Index* is to measure Massachusetts' performance on various indicators in comparison with appropriate benchmarks. Because the *Index* focuses on the Massachusetts Innovation Economy, states with similar economic strengths were selected for comparison. In addition to Massachusetts, the LTS includes California, Connecticut, Illinois, Minnesota, New Jersey, New York, North Carolina, and Pennsylvania.

The LTS are selected based on the total number of nine key industry clusters having an employment concentration above the national level. In this way, the selected LTS are comparable to Massachusetts in having the same breadth of innovative clusters. For the *2005 Index*, the states that make up the LTS were changed as some states failed to meet this requirement. Colorado, which was included in the LTS in the past, has been dropped for that reason. Illinois, North Carolina, and Pennsylvania were added to the LTS in the 2005 *Index* due to their comparable cluster employment concentration ratios.

For several indicators in the document, Massachusetts is compared to an LTS average. This average is always the mean of each state's reported data, not including Massachusetts. It is not the mean of all LTS data aggregated together.

II. Notes on Data Sources for Individual Indicators

ECONOMIC IMPACT

1. Industry Cluster Employment and Wages

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 U.S. Bureau of Labor Statistics (BLS). Data does 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 BLS' Quarterly Census of Employment and Wages (QCEW). This survey uses 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

This dataset is from Standard & Poor's COMPUSTAT database. These data are derived from publicly-traded corporations' annual 10k report filings with the 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 U.S. 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 covers all full-time and part-time wage and salary workers in non-farm industries.

Individual cluster employment ratio as compared to U.S. cluster employment ratio, Massachusetts and other LTS, 2004

Cluster	MA	CT	CA	MN	PA	IL	NY	NJ	NC
Computer & Comm. Hardware	1.95	1.09	1.96	1.44	0.98	0.87	0.91	0.64	1.41
Defense Manufacturing & Instrumentation	1.50	2.95	1.49	1.25	0.68	0.86	0.55	0.60	0.65
Diversified Industrial Support	1.20	1.39	0.77	1.21	1.27	1.55	0.79	0.85	1.11
Financial Services	1.40	1.68	0.91	1.16	1.15	1.26	1.42	1.27	0.84
Healthcare Technology	1.16	1.92	1.23	1.08	1.47	1.16	0.96	2.74	1.43
Innovation Services	1.27	0.93	1.12	0.83	1.04	1.09	1.17	1.17	0.75
Postsecondary Education	2.59	1.43	0.86	0.95	1.96	1.02	2.20	0.81	0.96
Software & Communication Services	1.36	1.11	1.13	1.03	0.87	0.93	1.01	1.27	0.81
Textiles & Apparel	1.08	0.36	1.63	0.42	1.02	0.44	1.19	0.89	3.71
Total Above-Average Cluster Concentrations	9	7	6	6	6	5	5	4	4

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 this 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:

1. Arts & Media: Arts, design, entertainment, sports, and media occupations
2. Construction & Maintenance: Construction and extraction occupations; Installation, maintenance, and repair occupations
3. Education: Education, training, and library occupations
4. Healthcare: Healthcare practitioner and technical occupations; Healthcare support occupations
5. Human Services: Community and social services occupations
6. Life, Physical, & Social Sciences: Life, physical, and social science occupations
7. Professional & Technical: Management occupations; Business and financial operations occupations; Computer and mathematical occupations; Architecture and engineering occupations; Legal occupations
8. Production: Production occupations
9. Sales & Office: Sales and related occupations; Office and administrative support occupations
10. 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 U.S. Census Bureau, March Current Population Survey. As recommended by the U.S. Census Bureau, a 3-year average is used to compare the relative standing of states. Income is in 2003 dollars.

http://www.census.gov

5. Manufacturing Exports

Manufacturing exports data are from the U.S. 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 physical movement of merchandise out of the United States.

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.

http://www.state.ma.us/sec

Data on business incubators are from the National Business Incubation Association.

http://www.nbia.org/

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

The total number and distribution by industry sector of filed initial public offerings (IPOs) by state and for the U.S. are provided by Renaissance Capital's IPOHome.com, Greenwich, Connecticut. Industry classifications for IPOs are based upon the *Index's* definition of the nine key industry clusters.

http://www.ipohome.com

Data on total number of mergers and acquisitions (M&As) by state and the U.S. are provided by Mergerstat. M&A data represents all entities that have been acquired by another for all years presented in the indicator.

http://www.mergerstat.com

8. Corporate Headquarters, Technology Fast 500 Firms, and Inc. 500 Firms

Data on total number of corporate headquarters by state are provided by Reference U.S.A.

http://www.referenceusa.com

Data on location of Technology Fast 500 companies located in Massachusetts and the LTS are provided by Deloitte and Touche, LLP. To be eligible for the Technology Fast 500 list, a company must be a technology company, defined as follows: own proprietary technology that contributes to a significant portion of the operating revenues, or devote a significant proportion of revenues to R&D of technology; 1999 operating revenues must be at least $50,000 U.S. dollars (U.S.D) or $75,000 Canadian dollars (CD); 2003 operating revenues must be at least $1 million U.S.D and CD; be in business a minimum of five years; and be headquartered within North America.

http://www.public.deloitte.com/fast500

Data on location of Inc. 500 companies located in Massachusetts and the LTS are from *Inc. Magazine*. To be eligible for the Inc. 500 list, a company must meet six basic criteria, which include: company is independent and privately held (not a subsidiary or a division); company had sales of at least $200,000 in 2000 (or $200,000 in 1999 for repeat companies); company has a four-year sales history that includes an increase in 2003 sales over 2002 sales—sales in 2000 must be for a full 12 months; if a company has less than 12 months of sales in 2000, it is not eligible for the 2004 Inc. 500; in 2003, a company's net sales were at least $2,000,000; company is not a franchisee, holding company, regulated bank, or utility; and company is based in the United States.

http://www.inc.com/inc500/

Technology Development

9. Small Business Innovation Research (SBIR) Awards

Data on SBIR awards are provided by the Small Business Administration (SBA) and U.S. Department of Commerce. 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 proposal 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 Small Business Association, Tech-Net. The Small Business Technology Transfer Program fact sheet describes the STTR 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, DOE national laboratories), universities, nonprofit hospitals, and other nonprofits.

http://tech-net.sba.gov/

10. FDA Approval of Medical Devices and Biotech Drugs

Information about medical device approvals in the U.S. is provided by the U.S. 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.

To view the full report Medical Devices: Supporting Massachusetts Industries, please visit the website for MassMEDIC.

http://www.massmedic.com/

University of Massachusetts Donahue Institute (authors of the report)

http://www.donahue.umassp.edu/

Data regarding FDA approval of new biotech drugs and indications are from the Biotechnology Industry Organization. For this dataset, the Biotechnology Industry Organization selected only biologics developed by biotechnology and pharmaceutical companies, small-molecule products developed by biotechnology companies, and other selected small-molecule or tissue-engineered products. Additional sources indicated by the Biotechnology Industry Organization include the FDA, BioCentury Publications' BioCentury, BioWorld Publishing Group's *BioWorld Today*, Recombinant Capital Inc., The Pink Sheet, and Signalsmag.com.

http://www.bio.org/speeches/pubs/er/approveddrugs.asp

Research

11. Corporate Research & Development Expenditure, Publicly-Traded Companies

Corporate research & development (R&D) expenditure data are from Standard & Poor's COMPUSTAT database. This 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

12. Patents, Invention Disclosures, and Patent Applications

Patents per capita data for Massachusetts and other LTS are provided by the U.S. Patent and Trademark Office (U.S.PTO).

http://www.uspto.gov

Patent distribution by industry sectors are based on analyses developed by Hall, B. H., A. B. Jaffe, and M. Tratjenberg (2001): "The NBER U.S. Patent Citations Data File: Lessons, Insights, and Methodological Tools." These data comprise detailed information on almost 3 million U.S. 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 U.S. stock market). These datasets are described in detail in Jaffe *et al*: "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 Center), Tufts University, and Northeastern University. Massachusetts hospitals/nonprofit research institutions include: Massachusetts General Hospital, Children's Hospital Boston, Brigham and Women's Hospital, Woods Hole Oceanographic Institute, Center for Blood Research, Dana-Farber Cancer Institute, New England Medical Center, Beth Israel-Deaconess Medical Center, St. Elizabeth's Medical Center of Boston, and Schepens Eye Research Institute.

http://www.uspto.gov

http://www.autm.net

13. Technology Licenses and Royalties

Data on licensing agreements involving Massachusetts institutions are from the Association of University Technology Managers. These datasets are derived from the same institutions providing patent and invention disclosure information.

http://www.autm.net

INNOVATION POTENTIAL

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 of the industry classifications and stages of development used in the Money Tree Survey can be found at the PricewaterhouseCoopers LLP website, found at the link below.

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. This data is for all R&D expenditures by the U.S. Department of Health and Human Services; more than 95% of these expenditures are funded by the National Institutes of Health.

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 SAT Reasoning Test in Massachusetts and the LTS are provided by The College Board Online, Profile of College Bound Seniors. The Profile of College-Bound Seniors presents data for high school graduates who participated in the SAT Program during their high school years. 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. University Enrollments and Public Higher Education Spending

Data on public and private college and university enrollments are derived from the National Center for Education Statistics (NCES). This survey, which is sent out to approximately 3,958 schools in the U.S., has been part of NCES survey work since 1966. Degree-granting institutions are defined as postsecondary institutions that are eligible for Title IV federal financial-aid programs and grant an associate's or higher degree. A private school or institution is one that is controlled by an individual or agency other than a state 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. Grapevine 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 higher education are provided by the National Association of State Budget Offices. Total enrollment data are provided by the National Center for Education Statistics.

http://www.nasbo.org/

http://nces.ed.gov/

18. Educational Attainment and Engineering Degrees Granted

Data on percent of adult population with a bachelor's degree or higher for Massachusetts, the LTS, and the U.S., are from the U.S. 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 U.S. are derived from the U.S. Census Bureau. http://www.census.gov/popest/datasets.html

Total foreign and domestic migration data are provided by the U.S. 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 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 Nonfarm Mortgage Loans. Single-family homes are defined in two ways. They can 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 can 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 home ownership rates come from the U.S. Census Bureau.

http://www.census.gov

Data on total number of housing starts by state are provided by the U.S. Census Bureau, Manufacturing, Mining, and Construction Statistics. Population data are for July 2004 and are also provided by the U.S. Census Bureau.

http://www.census.gov/const/www/permitsindex.html

APPENDIX B: INDUSTRY CLUSTER DEFINITIONS

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

Starting in 2003, the Index moved from the four-digit Standard Industrial Classification (SIC) to the North American Industry Classification System (NAICS) to study the key industry clusters. The analysis of key industry clusters within Massachusetts begins with a disaggregation and examination of all Massachusetts state industry activity to the four-digit NAICS code level. (NAICS was developed in cooperation with the U.S. Economic Classification Policy Committee, Statistics Canada, and Mexico's Instituto Nacional de Estadistica, Geografia e Informatica. These codes were last revised in 2002). 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 nine key industry clusters as defined by the Index reflect the changes in employment concentration in the Massachusetts Innovation Economy that has occurred over time.

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, Electromedical, and Control Instruments Manufacturing
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

Innovation Services

5411 Legal Services
5413 Architectural, Engineering, and Related Services
5416 Management, Scientific, and Technical Consulting Services
5417 Scientific Research and Development Services
5418 Advertising and Related Services
5419 Other Professional, Scientific, and Technical Services
5614 Business Support Services

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

Software & Communication 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

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INDEX STAFF

John Adams Innovation Institute Director: **Patrick Larkin**, MTC Deputy Director

Manager: **Zvi Rozen**, John Adams Innovation Institute Deputy Director

Project Manager: **Ellen Gorowitz**, John Adams Innovation Institute Program Manager

Contributors: **Robert Kispert**, John Adams Innovation Institute Program Director; **Thomas Hubbard** and **Jennifer Rocha**

Communications: **Chris Kealey**, MTC Director for Development and Public Affairs

Graphic Design, and Production: **Christine Raisig**, MTC Publications Manager; **Emily Dahl**, MTC Communications Specialist

Research & Analysis Interns: **Adam Woelfel** and **Matthew Tyson**

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