2005

INDEX OF THE MASSACHUSETTS INNOVATION ECONOMY

MASSACHUSETTS TECHNOLOGY COLLABORATIVE
John Adams Innovation Institute

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MASSACHUSETTS TECHNOLOGY COLLABORATIVE
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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.

Table of Contents

EXECUTIVE SUMMARY 2
ABOUT THE 2005 INDEX 6
ANALYSIS OF THE INNOVATION ECONOMY 7

INDEX INDICATORS

Economic Impact

1. Industry Cluster Employment and Wages 16
2. Corporate Sales, Publicly-Traded Companies 17
3. Occupations and Wages 18
4. Median Household Income 19
5. Manufacturing Exports 20

Innovation Process

Business Development

6. New Business Incorporations and Business Incubators 21
7. Initial Public Offerings (IPOs) and Mergers & Acquisitions (M&As) 22
8. Corporate Headquarters, Technology Fast 500 Firms, and Inc. 500 Firms 23

Technology Development

9. Small Business Innovation Research (SBIR) Awards 24
10. FDA Approval of Medical Devices and Biotech Drugs 25

Research

11. Corporate R&D Expenditure, Publicly-Traded Companies 26
12. Patents, Invention Disclosures, and Patent Applications 27
13. Technology Licenses and Royalties 28

Innovation Potential

Resources

14. Investment Capital 29
15. Federal R&D Expenditure and Health R&D Expenditure 30
16. Intended College Major of High School Seniors and High School Dropout Rates 31
17. University Enrollment and Public Higher Education Expenditure 32
18. Educational Attainment and Engineering Degrees Awarded 33
19. Population Growth Rate and Migration 34
20. Median Price of Single-Family Homes, Home Ownership Rates, and Housing Starts 35

APPENDICES 36
APPRECIATION 40

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.

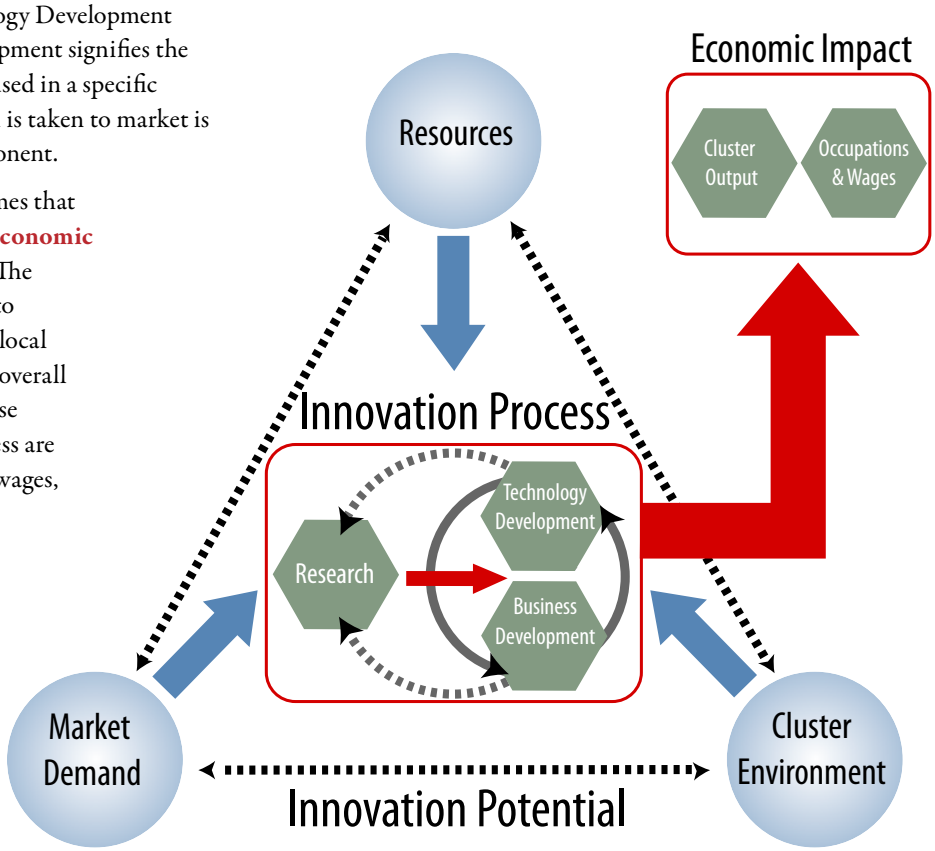
The Framework captures outside factors that have an influence on the overall success of the Innovation Process as well as enablers of the process. These factors include the *Resources* available, the prevailing *Market Demand*, and the *Cluster Environment*, all of which are collectively referred to 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.

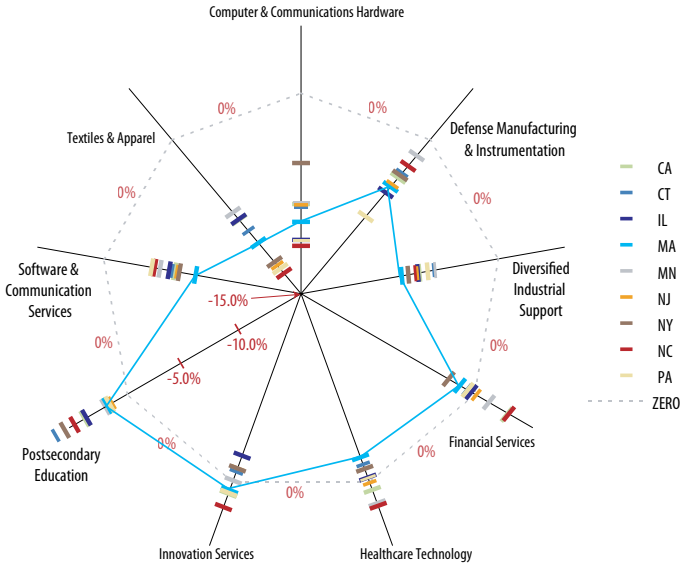
Moreover, while all of the LTS have suffered declines in employment within their key clusters on an aggregate basis, some clusters in some of the LTS have not only fared better than their counterparts in Massachusetts, but have actually grown. (See Figure 1.1)

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

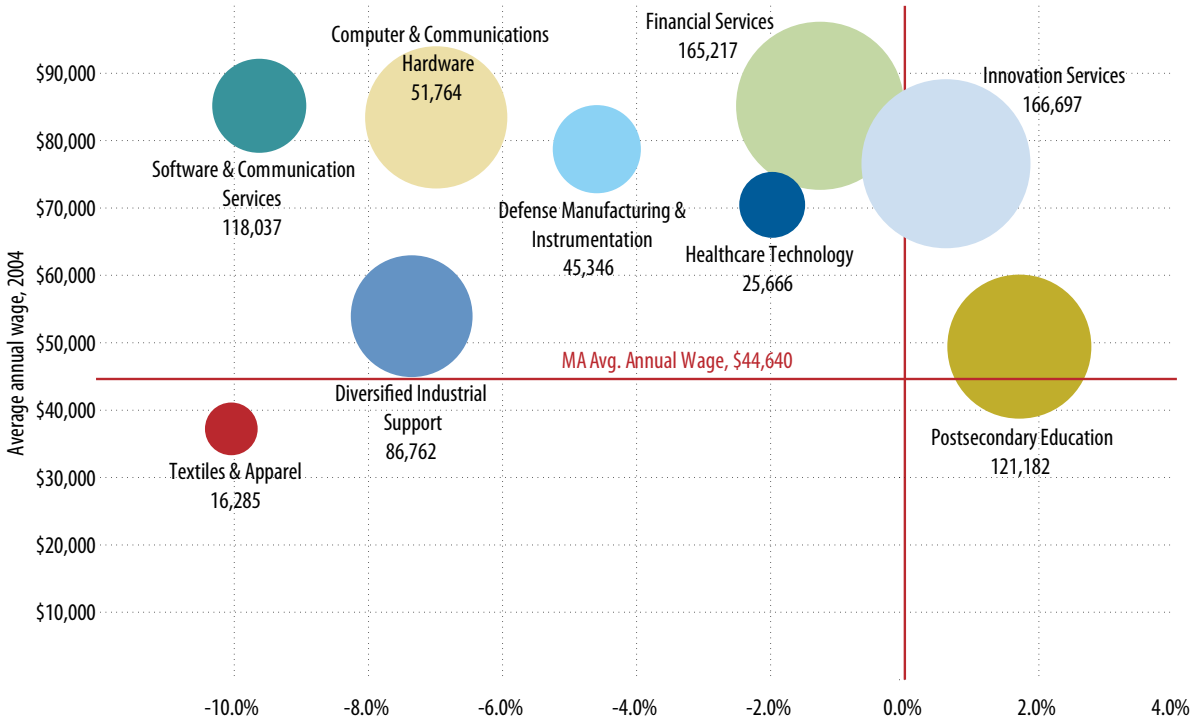
Massachusetts lost over 25,800 jobs in the Computer & Communications Hardware cluster from 2000 to 2004, at an average

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

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%

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.

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*.

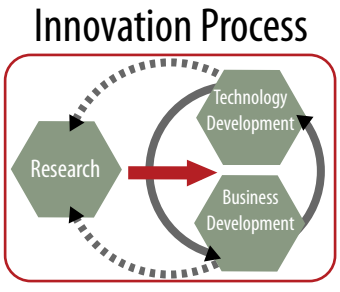


Figure 1.3

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

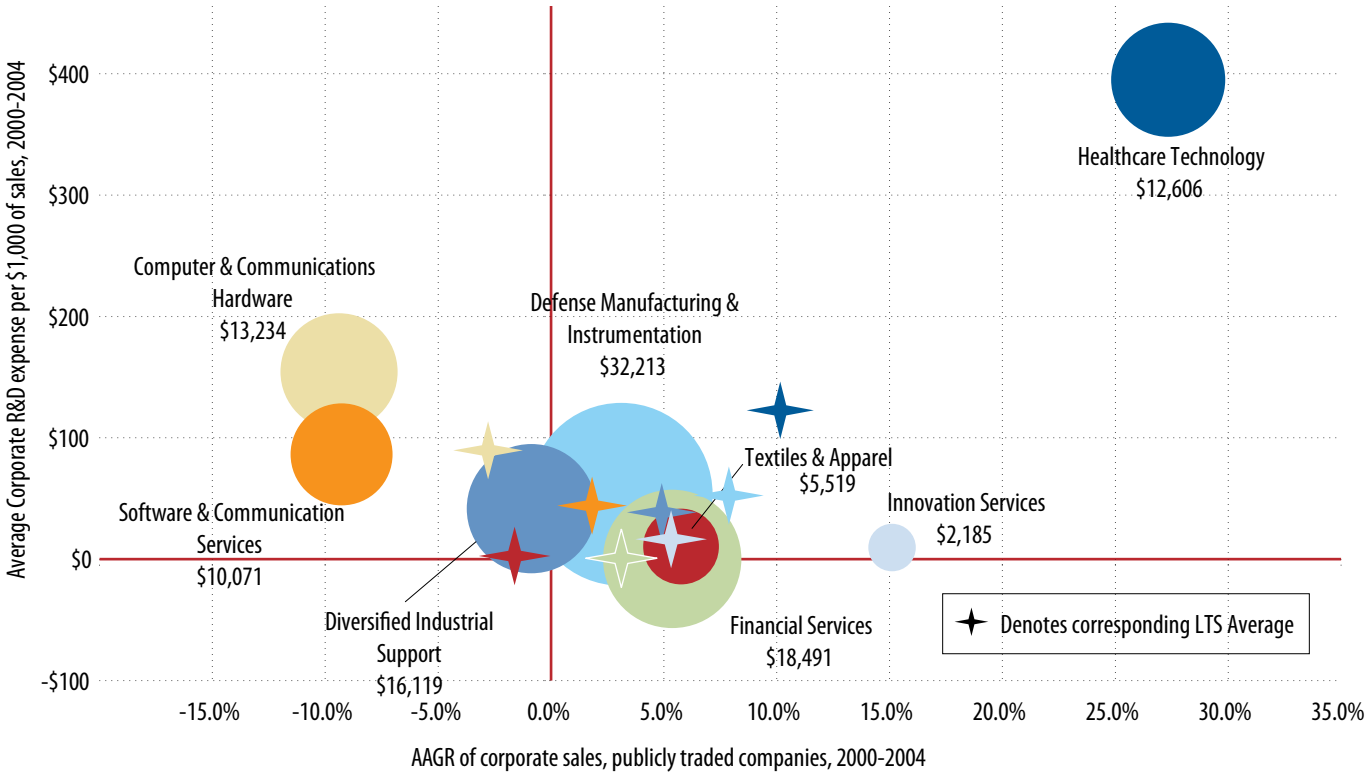
Innovation Process: Research	*2005 Index* Indicators	Significant Trends
Corporate R&D (publicly-traded firms)	Corporate R&D among public companies in Massachusetts holds steady in 2004 at levels twice as high as ten years ago. Massachusetts public firms lead LTS in corporate R&D per $1,000 in sales.	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.

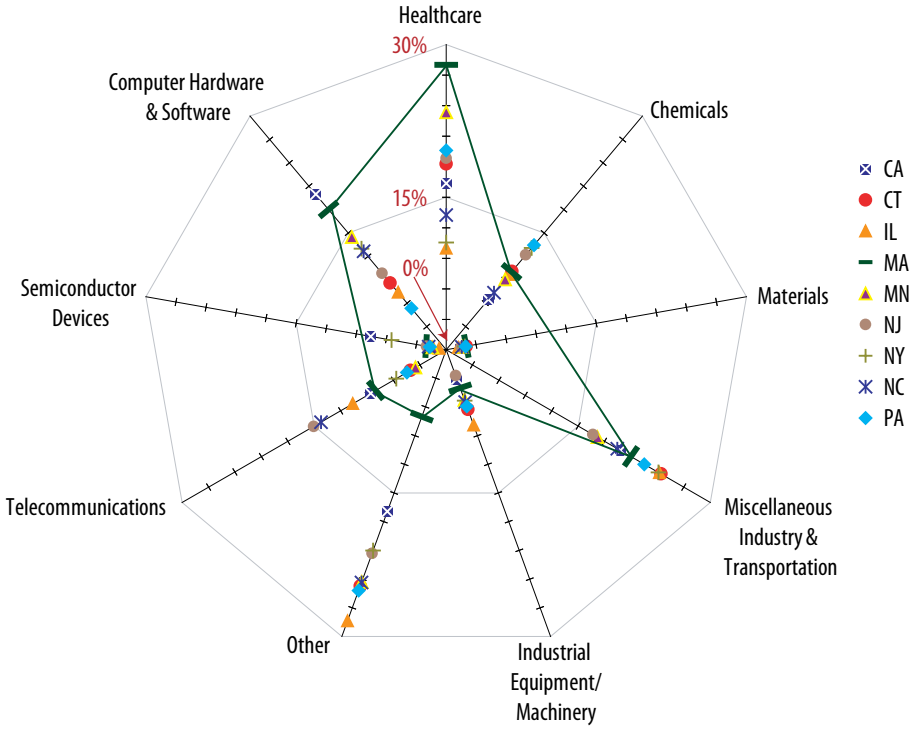
Research and Technology Development: Patents

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.

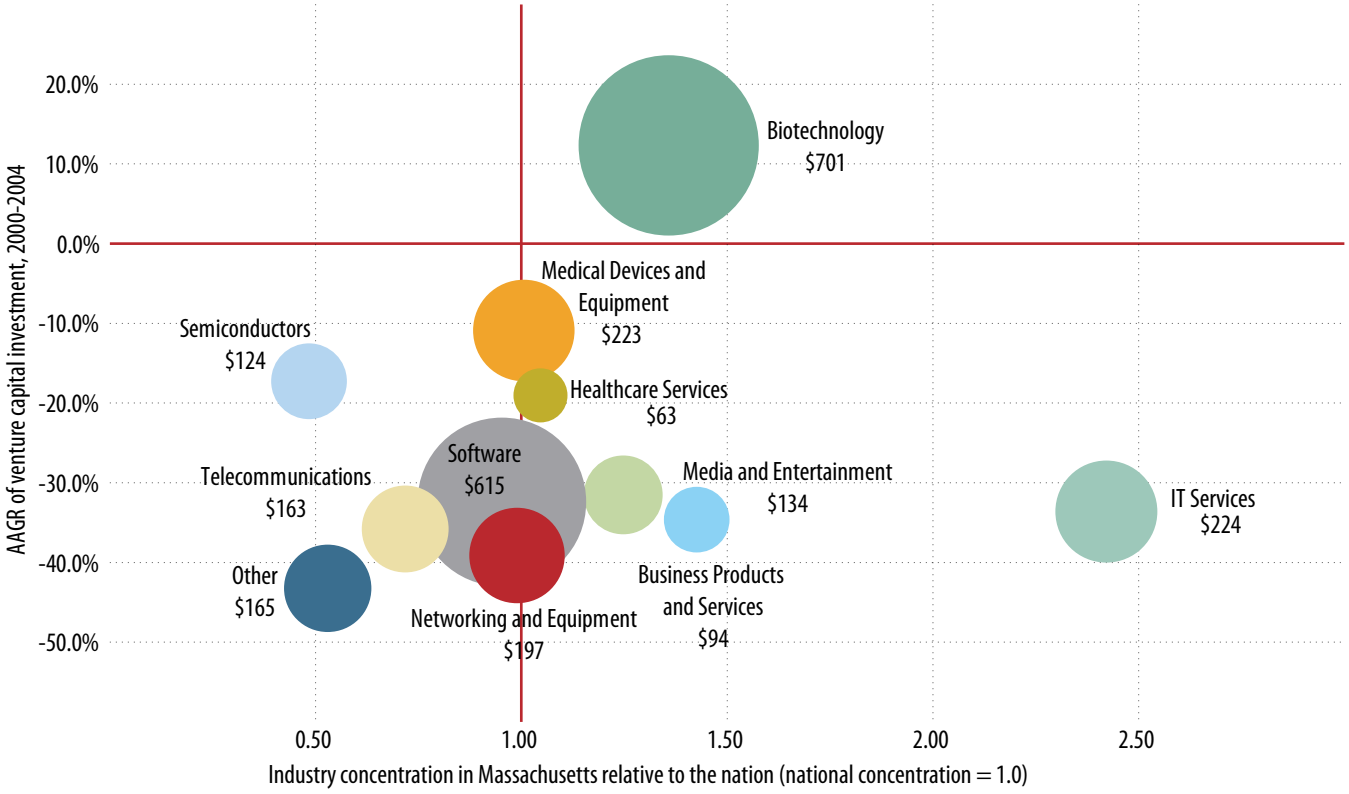
Innovation Potential: Resources

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

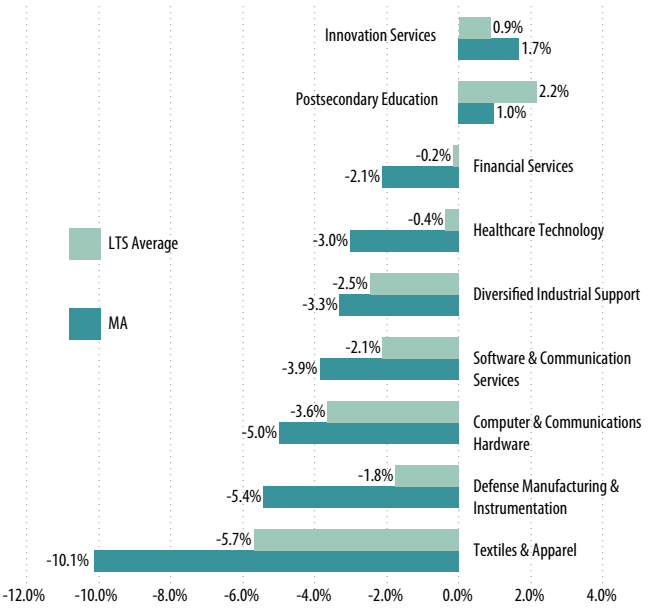
Why Is It Significant?

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?

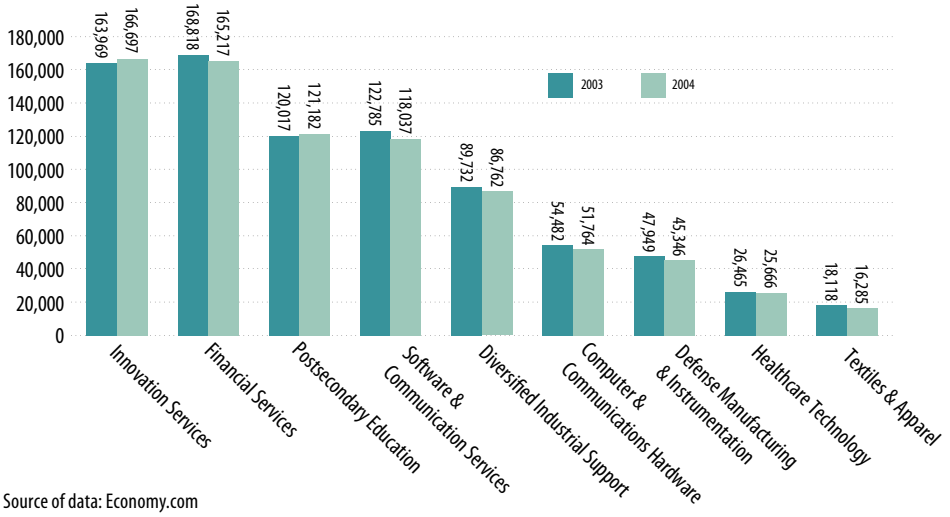
Even though employment in two large clusters, Innovation Services and Postsecondary Education, increased slightly, the majority of Massachusetts' industry clusters continued to lose jobs at a rate greater than the LTS average. Due to the decline in industry cluster employment, the nine key clusters now 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



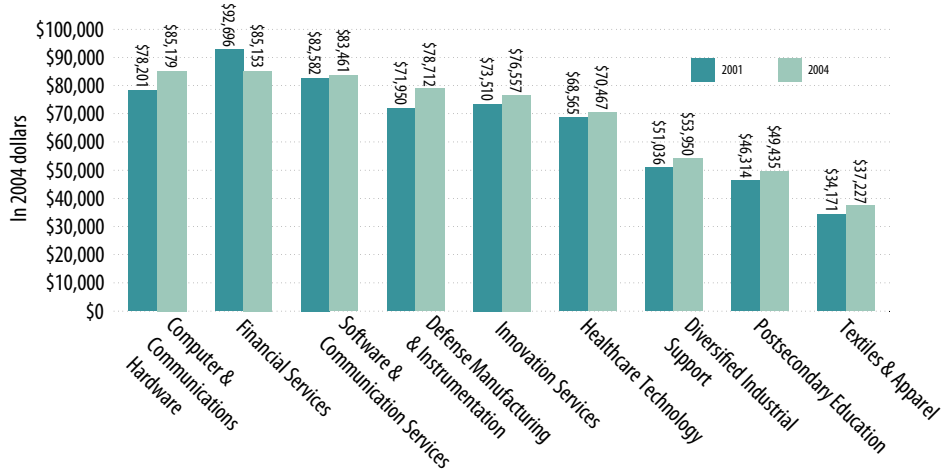
Source of data: Economy.com

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