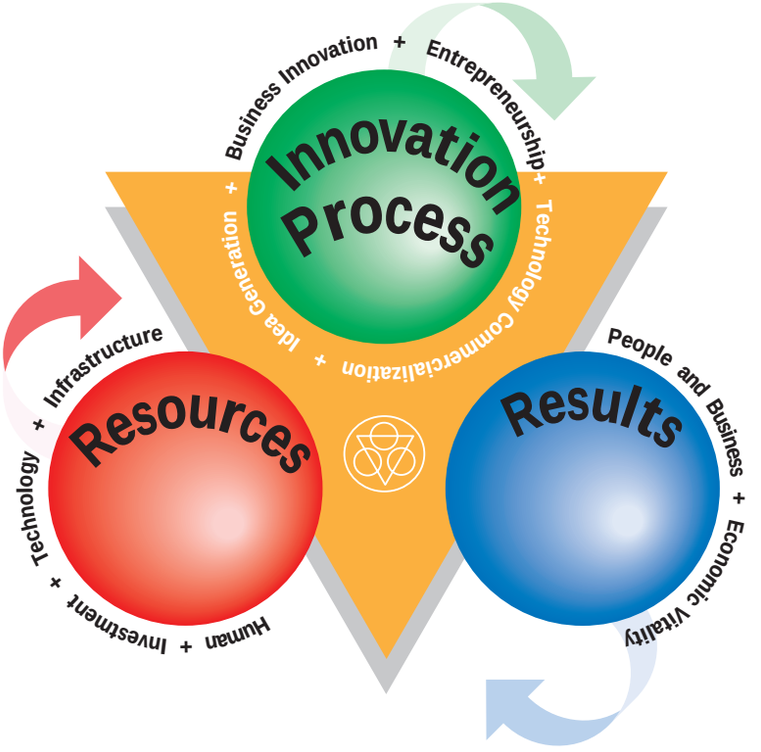
Massachusetts TECHNOLOGY Collaborative

Index
of the Massachusetts Innovation Economy
1999



Prepared by:

Collaborative Economics, *Strategic Advisors to Civic Entrepreneurs*, Palo Alto, California

Massachusetts Technology Collaborative, *Strengthening the Commonwealth's Innovation Economy,* Westborough, Massachusetts

I. RESULTS INDICATORS

Important outcomes of the Innovation Economy are increases in the number of jobs, standard of living, and export sales. They result from ongoing innovation and improvements in productivity that promote competitiveness and rising wages in the global economy. These results are essential to the economic well-being of people and businesses in Massachusetts.

II. INNOVATION PROCESS INDICATORS

The innovation process is reflected in idea generation, technology commercialization, and entrepreneurship, as well as in creativity in established businesses. This dynamic innovation process is an essential component of a competitive economy, because it translates ideas into high-value products and services. Business and people are the beneficiaries. The innovation process has different stages, and strong linkages among them are critical for success.

III. RESOURCE INDICATORS

Critical resources include human resources, technology, investment, and infrastructure. These resources provide the fuel for productivity growth and are the foundation of the Innovation Economy. Private investment decisions and public policies affect the level and nature of available resources.

NINE KEY INDUSTRY CLUSTERS

Computers & Communications Hardware

Defense

Diversified Industrial Support

Financial Services

Healthcare Technology

Innovation Services

Postsecondary Education

Software & Communications Services

Textiles & Apparel

LEADING TECHNOLOGY STATES

Massachusetts

and

California

Colorado

Minnesota

New Jersey

New York

Texas

The 1999 *Index* provides the annual update of emerging trends in the Massachusetts Innovation Economy. It continues to:

- Describe how the Massachusetts Innovation Economy is performing
- Examine how the Innovation Economy works
- Assess the resources that fuel the Innovation Economy

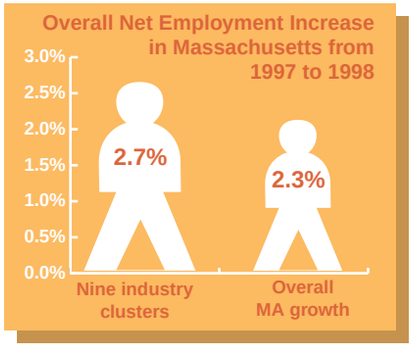
This system-wide view of the Innovation Economy enables stakeholders to look at the performance of the economy and its underlying structure and dynamics. The Innovation Economy indicators tell a story about how well innovation resources are being turned into tangible results for people and business. This approach makes it possible to identify early warning signs of weakness in the innovation process and in the resources that this process translates into high-performance results.

In addition, this year's *Index* includes a special analysis that explores Massachusetts activity in electronic commerce.

MEASURING RESULTS

How is the Massachusetts Innovation Economy performing? What does performance tell us about a rapidly evolving innovation-driven economy? What are the impacts on business and people?

The Massachusetts economy continues to restructure toward innovation-intensive clusters, though overall cluster job growth slows. Leading-edge services sectors continue to grow, while traditional manufacturing jobs decline.



- Overall net employment in the nine industry clusters grew 2.7% from 1997 to 1998, compared to an overall state increase of 2.3%.
- The Software & Communications Services cluster added 6,236 new jobs in 1998. The cluster's growth was the largest absolute and relative employment increase of the nine key industry clusters between 1997 and 1998. However, the annual growth rate for this cluster, 6.0%, was only three-fifths that of the previous year.
- The Financial Services cluster remains the largest cluster, with 130,498 jobs, adding 2,905 jobs between 1997 and 1998. It surpassed Software & Communications Services in average pay per worker between 1997 and 1998. Financial Services is now the second highest-paying cluster of the nine (after Innovation Services), at an average of $67,610 per worker.
- Average pay per worker increased in the Defense and Textiles & Apparel clusters in the state. However, the gap between the average pay in the Defense cluster in Massachusetts ($53,628) and that in the Leading Technology States (LTS) ($64,295) widened. Defense and Textiles & Apparel also lost 429 and 489 jobs, respectively, between 1997 and 1998. These decreases represent the ongoing decline of the traditional manufacturing sector in the state.
- With total employment of nearly 660,000, eight of the nine key industry clusters (all except Postsecondary Education) paid an average annual wage greater than the all-industry Massachusetts average.

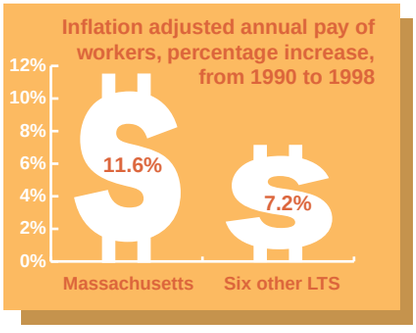
Export orientation is an important sign of a vital economy. While manufacturing exports slowed, services exports continue to grow.

- The value of international manufacturing exports per employee declined (8%). This decrease was similar to that experienced by other LTS, all of which had much greater exposure to troubled Asian markets.
- In software, Massachusetts led in exports per employee compared to the six other Leading Technology States (LTS). At $23,970 per employee, Massachusetts software exports per employee were almost three times the national average per employee. In Innovation Services exports per employee, Massachusetts leapfrogged New Jersey and now ranks third in exports per employee when compared with the other LTS.

This year's Index *suggests overall gains in cluster vitality in terms of job growth. How does this translate into results for people?*

Overall, Massachusetts workers have gained from the Innovation Economy's growth, and the demand continues for highly-skilled workers in an innovation-driven economy.

- Inflation adjusted annual pay of workers in Massachusetts increased



  11.6% between 1990 and 1998. This increase compares favorably with a 7.2% increase in the six other LTS and 3.4% nationally.

- For the first time since 1993, earnings increased for families at the lowest 20% of the earnings distribution.
- According to an MTC skills needs survey, technology-intensive businesses indicated that in May 1999, 8.6% of their skilled production worker positions, 8.4% of their manager positions, and 7.6% of their technician jobs were unfilled.

MEASURING THE INNOVATION PROCESS

The innovation process indicators include idea generation, technology commercialization, and entrepreneurship. Each aspect of the innovation process is vital to overall success.

- Massachusetts continues to lead the LTS in patents per capita. This lead is an important competitive advantage in idea generation—an early phase in the innovation process.
- The number of invention disclosures received by Massachusetts universities, hospitals, and research institutions increased by 20%, marking an active year in the initial registry of inventions with commercial potential.
- The number of new technology licenses issued by Massachusetts institutions between 1996 and 1997 rose by 28%. Technology-licensing values sharply increased in the same period, exceeding $49 million.

Entrepreneurship is an important component of the innovation process. Entrepreneurs take ideas and apply them to products and services, as well as connect them to the marketplace. The Index *suggests some mixed signals for entrepreneurial activity.*

- On a per capita basis, Small Business Innovation Research (SBIR) awards to Massachusetts businesses continue to eclipse awards to California companies by four times.
- New business incorporations in Massachusetts continued to decline in 1998, resulting in a 7% decline since 1995.
- The number of IPOs continued a downward trend, dropping 13% to 14 IPOs in 1998, the lowest number since 1990. The average value of IPOs in Massachusetts has historically trailed that of IPOs in the U.S.; the state lost considerable ground in 1998 as the value of IPOs nationally rose 70% compared to no change in Massachusetts. M&As in Massachusetts grew 7% from 377 to 403 between 1997 and 1998.
- Although the market value of Massachusetts-based NASDAQ companies grew from more than $39.8 billion in 1994 to $89.6 billion in 1999, the average annual growth in market value of these companies trailed the average growth of all NASDAQ firms in the U.S. during the same time period.

Business innovation by established companies is an important measure of increasing prosperity for the residents of Massachusetts. Productivity gains and the location of corporate headquarters are two indications of progress in this area.

- Value-added per employee in Massachusetts has grown almost 20% in inflation adjusted terms since 1990, but continues to trail the six other LTS.
- Massachusetts showed moderate growth in the number of its corporate headquarters within its nine key industry clusters between 1997 and 1998.

MEASURING RESOURCES

Resources essential to the growth of the Innovation Economy include technology, R&D, investment capital, and people. In Massachusetts, these components are strong relative to the six other LTS.

Massachusetts remains the leader in federal R&D spending and is increasingly a front-runner in health-related R&D.

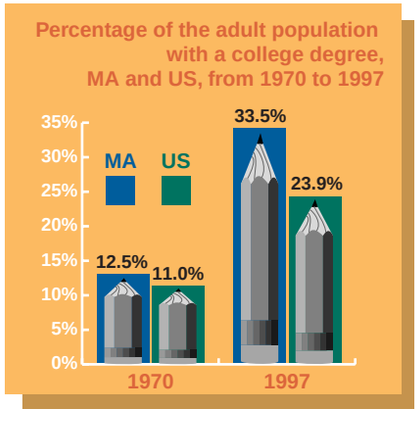
- In 1997, Massachusetts had the highest per capita federally funded R&D expenditures ($288) of the LTS, with the next closest LTS, California, at 64% of the Massachusetts level.
- At $171 per 1,000 people, Massachusetts is far ahead of it nearest competitor in per capita health R&D expenditures. Of the six other LTS, New York ranks second with just one-third of that per capita spending amount.

Investment capital fuels growth of technology-intensive companies, whether they are start-ups, about to issue an IPO, or about to be acquired. Venture investment in Massachusetts continues its upward trend.

- Venture capital investment in Massachusetts reached $1.9 billion in 1998, a 33% increase from 1997. Massachusetts continues to attract 11% of the annual venture capital investment in the United States.
- Computer Software & Services and Communications companies received more than half (54%) of the venture capital investment in Massachusetts in 1998. The state also showed signs of strong venture investment in e-commerce relative to that of the other LTS.

In an innovation-driven economy, people are a critical resource. This fact is true for the current workforce as well as for young people who will enter the workforce a decade hence. An Innovation Economy requires long-term commitment to the cultivation of highly educated and highly skilled workers.

- Since 1970, Massachusetts has nearly tripled the percentage of its residents



  with college degrees; nationwide, the percentage doubled during this period.

- The number of graduates awarded degrees in engineering and computer science increased modestly from 1997 to 1998, reversing a downward trend.
- Out-migration from Massachusetts was positively offset by international immigration in 1997, continuing the trend from 1995. It is noted that in 1998, Massachusetts experienced the smallest amount of out-migration in this decade.

Lessons from the Index

This year's *Index of the Massachusetts Innovation Economy* documents a continuing, historic shift in the Commonwealth towards a knowledge-based economy, the industries and occupations of which rely upon ***scientific research***, ***technical skills***, and ***entrepreneurial initiative.***

In some respects this represents nothing new: the state's economy has been dominated by high skills, high technology, and high finance for a very long time. Yet, while the Massachusetts economy of the sixties, the seventies and the eighties rose and fell on the success of a few key products and companies, today's Innovation Economy is more diverse, more dependent on continuous formation of new enterprises, and in greater demand of higher skills from a broader segment of the state's population.

What Are the Strengths of the Massachusetts Innovation Economy?

JOB GROWTH LED BY KEY INDUSTRY CLUSTERS:

Employment growth in Massachusetts is distributed widely among cluster industries. For the third straight year the *Index* shows that employment in six out of nine key industry clusters in the state has grown, and that employment in these clusters has increased at a rate significantly higher than state employment growth overall (Indicator # 1). The nine key clusters represent industry groups in which Massachusetts has a higher-than-national average concentration; together, they represent over a quarter of all jobs in the Massachusetts economy (Indicator #2).

Once again, employment growth in the key industry clusters is concentrated in three clusters—Software & Communications Services, Financial Services, and Innovation Services (consulting engineers, management consultants, and contract research organizations) (Indicators #1 and #2). Average pay in each of these clusters is at least 67% higher than the state average.

The common themes found in these growing fields are high levels of education and training, and a heavy reliance upon Information Technology (IT) and the use of IT skills. Even within the Financial Services cluster, one out of every four jobs is now considered an IT job.

NEW FIRMS GROW FROM A DIVERSE BASE:

While employment growth is most concentrated in Software & Communications Services, Financial Services, and Innovation Services, fast growing "gazelle" firms (i.e., publicly traded companies whose sales have grown at an annual average compound rate of 20% or more for the last four years) are widely dispersed among the key industry clusters. Healthcare technology firms comprise nearly a quarter of all "gazelle" firms in the state. There are more gazelles among the state's computer and communications hardware firms than software and communications services companies, despite the contracting number of jobs in the computer hardware industry (Indicator #18).

MASSACHUSETTS RESEARCH COMMUNITY STILL LEADS THE NATION:

Industrial diversity is also reflected in the variety and continued growth of the state's R&D base and in the portfolio of firms receiving venture capital funds (Indicators #26, #27, and #29).

The 1999 *Index* documents the continuing leadership of the state in academic research, idea generation, and commercialization of research findings and new technologies. Once again, Massachusetts trails only California in the dollar amount of federally supported research, and leads all states on a per capita basis (Indicator #26). The volume of federally supported biomedical research in Massachusetts continues to increase, and has done so at an accelerated rate in recent years (Indicator #27). The renewed investment in biomedical sciences is illustrated by the continuing increase in biomedical patents generated by Massachusetts residents and institutions (Indicator #10), and ultimately by the growth in the number of healthcare technology "gazelles" in the state (Indicator #18).

R&D DRIVES HIGH RATES OF INNOVATION AND IDEA GENERATION:

Massachusetts continues as the national leader in patent generation per capita. The Commonwealth also receives more federal research seed money for small business than any state in the country on a per capita basis (Indicator #15). In 1998 universities and teaching hospitals in Massachusetts set new records for the issuance of technology licenses that translate new research discoveries from university laboratories into new product development in businesses (Indicator #12).

VENTURE CAPITAL:

Venture capital investment in the state's firms rose dramatically in 1998, (Indicator #29), as it did nationally. In relative terms, Massachusetts held its own, attracting about 11% ($1.9 billion) of the total U.S. venture capital investment. Massachusetts also receives a higher than average share of venture capital money, on a per capita basis, than the other LTS. The distribution of venture capital investments in the state closely reflects the upsurge of investments nationally in Software & Communications Services companies, which totaled 40% of all venture capital investment in Massachusetts in 1998.

Venture capital investment in Internet-related and e-commerce companies has also been increasing in Massachusetts over the past four years. For the first two quarters of 1999, venture capital investment in these Massachusetts firms had reached $819 million. (See E-Commerce Special Analysis that follows.)

TECHNICAL TALENT:

Massachusetts has one of the most highly educated populations in the United States (Indicator #22). The 1999 *Index* suggests that high growth in the state's economy is drawing a greater number of skilled and educated people into key industry clusters.

In 1998, a decade-long decline in the number of college students graduating with engineering or computer science degrees was modestly reversed (Indicator #23). Foreign immigration continues to remain an important resource for Massachusetts growth (Indicator #21). Nearly one-quarter of the foreign immigrants to Massachusetts occupied highly-skilled management, professional and technical positions in 1998. Most telling, in 1998 domestic out-migration from the state decreased to its lowest level in ten years (Indicator #21).

What are the Gaps and Potential Weaknesses in the Massachusetts Innovation Economy?

SLOW LABOR FORCE AND JOB GROWTH:

Growth in the state's labor force reached its lowest level in the 1990s, constraining the pool of workers available. Job growth in the nine key clusters overall slowed in 1998, to 2.7% from 3.5% in 1997. Job growth in the state's economy as a whole slowed even more, to 2.3% from 2.6% growth in 1997.

The state's near-zero workforce growth poses a serious challenge to sustained growth in the Massachusetts Innovation Economy. Slow growth in the state's pool of technically skilled workers may impose an effective limit to growth in the state's key industry clusters. It places pressures on the economy that could drive up business costs. It could also divert the development of innovative products and processes away from the Commonwealth. Importing more people will not, by itself, resolve the state's workforce challenge. The state should intensify its "grow your own" strategy by better equipping its residents with the skills necessary for jobs in the Innovation Economy.

NURTURING HIGH-GROWTH FIRMS:

Throughout the 1990s the state's reputation as a seed-bed of high-growth technology firms has been tested by the sale of Massachusetts-based companies to firms from outside the state. A chronic labor force shortage may test the state's reputation even further.

Yet the evidence of weakness within the state's Innovation Economy is mixed.

Initial Public Offerings (IPOs) among Massachusetts-based companies remained at low levels in 1998 (Indicator #16). The national IPO market also fell in 1998. However, as of fall 1999, the national IPO market had bounced back, and Massachusetts IPOs had bounced back with it. Through the first two quarters of 1999, Massachusetts firms offered as many IPOs (14) as in 1998.

Merger and acquisition (M&A) activity climbed to record highs in 1998, (Indicator #16) and included several high-profile sales of Massachusetts-based firms to outside interests. However, "convergence" in communications-related industries has generated unprecedented levels of mergers and acquisitions. As the *Index* and its Special Analysis on Electronic Commerce demonstrate, Massachusetts has healthy and growing clusters of firms that operate in the rapidly-changing communications marketplace.

The average annual growth in market value of NASDAQ companies in Massachusetts trailed the average growth of all NASDAQ firms in the United States between 1994 and 1999 (Indicator #17). Value-added per employee within several key industry clusters continues to lag behind that of comparable clusters in the LTS (Indicator #20).

Whether the evidence is a serious cause for concern or not, policymakers should be cautious about public policies that might have a direct or unique impact on high-growth firms in the state. For example, two of the most dynamic industry clusters, Healthcare Technology and Software & Communications Services, operate in marketplaces that are both heavily regulated and are also the subject of intense national debate regarding reform and deregulation.

CORPORATE RESEARCH & DEVELOPMENT (R&D):

In 1998, Massachusetts publicly traded firms spent an average of $15,640 per employee on R&D, an increase of 6% from 1997. This amount, however, is less than the 1996 level of $16,216 per employee. For the state to prosper, in the face of negligible workforce growth and the increase in acquisitions of Massachusetts entrepreneurial firms by out-of-state companies, it needs to ensure the acceleration of new ideas from its research community into new products and services for the state's Innovation Economy. To accomplish this, both the public and private sectors must continue to actively support the Massachusetts academic research and development base.

The 1999 *Index* illustrates the importance of science, technological skills, and entrepreneurship to the Massachusetts Innovation Economy. Although Massachusetts continues to be strong in many areas, the challenge is to build on its innovative strengths, while also addressing those gaps in the innovation process which might impede sustainable economic prosperity.

Implications for Action

The health of the Massachusetts Innovation Economy depends on many of the same building blocks that underlie the entire state economy—a favorable business climate, a competitive cost structure, and clarity and fairness in regulation. The *Index* affirms that there are other, more specific, policy issues that are of particular importance to innovative firms and the innovation process in the Commonwealth. These fall into three broad categories: **workforce, entrepreneurship, and research and development (R&D).**

Political leaders, public policymakers, and private decision-makers must focus on the following goals:

- Growing and retraining our own skilled workforce
- Growing our own companies
- Growing our R&D base

GROWING AND RETRAINING OUR OWN SKILLED WORKFORCE

Massachusetts faces a long-term threat to its leadership as an Innovation Economy, because the primary ingredient for its future growth—a skilled workforce—is not expanding fast enough to meet rising demands. This critical nexus between the growth of the Innovation Economy and the continual training of the workforce must be fully considered in state policy discussions.

In light of persistent shortages of technically skilled workers, Massachusetts ought to intensify efforts that will draw more residents into the Innovation Economy, and equip them with the skills necessary to succeed. This will be no easy task, given the historically low rate of growth in the workforce, and a record high labor participation rate. Among the key goals:

- **Costs of living**: One of the causes of out-migration has been the high costs of living in the state. Renewed efforts by lawmakers to promote policies that will expand housing availability and affordability and to restrain high costs of living will contribute to continued economic viability for the state.
- **Career awareness**: Efforts to heighten awareness of technical careers, and the educational prerequisites for these careers, have become increasingly important. Studies consistently find that U.S. high school students have a limited understanding of the opportunities available in technical fields and of the educational requirements for them. Moreover, there is a trend nationwide of college students shifting away from technical fields of study, including computer science, mathematics, and engineering, that support the growth of high-tech industries. Massachusetts corporate leaders should be strongly encouraged to expand their participation in the state's network of school-to-work partnerships. Massachusetts state government and local Regional Employment Boards need to take full advantage of new flexibility with federal funding offered through the 1997 Workforce Investment Act. Public and private investments are needed to support the work of organizations like the Engineering in Massachusetts Collaborative (EiMC), so that they are positioned to provide a high-profile clearinghouse for educators and corporate leaders eager to employ best practices in math and science enrichment, and in career awareness.
- **Adult education:** Adult education must be a high priority for our system of lifelong learning. The skills of many adults are becoming obsolete as a result of rapid change in the new information age economy at a time when the growth of the student population is insufficient to meet growing demand. The skills of the adult workforce must be retooled through utilizing a variety of existing institutions, including community colleges and technical schools. Opportunities under the federal Workforce Investment Act should be leveraged to ensure that adults can get the requisite training for skills needed in the Innovation Economy.
- **University-corporate partnerships**: Massachusetts must encourage the creation and expansion of successful partnerships among the state's colleges, universities and its technology companies. The pipeline between the state's science and engineering schools and high-growth technology industries should be expanded and strengthened.
- **The special mission of higher education in Massachusetts**: A highly skilled workforce has long been at the heart of Massachusetts competitive advantage. Post-industrialization has seen a movement from an industrial base towards a knowledge-based economy. This transformation has led to even greater demand for highly skilled workers. Higher education plays a pivotal role in the Innovation Economy, for it can provide Massachusetts residents with lifelong learning opportunities and various skills sets across the full range of academic institutions.

- **K-12 education reform and improvement**: Systemic reform of math and science education, and an improvement in student levels of math and science competence are key investments in the Massachusetts Innovation Economy. The continuing, successful implementation of the state's 1993 Education Reform Act must be a high priority if Massachusetts residents are to be the beneficiaries of the new economy.

GROWING OUR OWN COMPANIES

Each of the critical issues surrounding workforce availability noted above is of importance to entrepreneurship and new enterprise formation in the Commonwealth. The 1999 *Index* suggests that Massachusetts is stronger at starting early stage companies than growing them into successful businesses over the long term. Many small companies are being sold or acquired rather than growing and generating large numbers of jobs or value-added at leading technology firms. There are many reasons for this. Several Massachusetts clusters, such as Healthcare Technology and Biotechnology, have a strong R&D advantage, but find it difficult to get financing for later stage development. In the Information and Communications Technology clusters, steps can be taken to enhance the information infrastructure and regulatory environment essential for business expansion in e-commerce.

The public and Massachusetts policymakers need to take steps to:

- **Support healthcare reforms that promote healthcare innovation:** The Healthcare Technology cluster has become increasingly important in the Massachusetts economy, as seen in the indicators for both venture capital investment and "gazelle" companies. Massachusetts has been a seedbed for innovation in medical practice and healthcare technology for several decades. The Healthcare Technology cluster has the potential to become more important in the years ahead, if the national investment in biomedical research increases (Indicator #27).

  As a result, Massachusetts has a large stake in the ongoing national debate over healthcare funding, particularly in the debate over Medicare reform. Medicare is not only the largest single payer for new medical technology, it is also the principal funding source for medical education in the U.S., and a major source of funding for clinical research. Medicare restrictions mandated under the 1997 Balanced Budget Act have already created serious financial problems for the state's world-class academic health centers (teaching hospitals and medical schools).

- **Raise public awareness of the competitive issues in communications, and support competitive policies that accelerate the introduction of advanced services:** IT is transforming business practices across the board, and the Massachusetts Innovation Economy has become critically dependent upon IT infrastructure. As the Internet continues to explode in size and usability, it has become more imperative that the state build a telecommunications infrastructure second to none, providing high-speed, competitive web and data access to all parts of the state.

  The rapid pace of change in the telecommunications industry means that there are numerous regulatory and policy issues that must be decided in Massachusetts that will affect investment and the rollout of new services. (As of this writing, one such issue – "open cable access"– may be the subject of a statewide referendum vote in November 2000.) Policymakers in the state should collaborate to develop an easy-to-understand assessment of the key telecommunications issues in order to inform public discussion.

- **Encourage the growth of electronic commerce:** The emergence of electronic commerce has had a great impact on the Innovation Economy. Massachusetts is positioning itself to be a prominent e-commerce player through its attraction of venture capital investment to Internet-related and e-commerce companies, and through its growing cluster of e-commerce companies. The results of Massachusetts e-commerce investments are evidenced in the increasing number of jobs created and the amount of revenues generated by these businesses.

  Business must collaborate with the state to create an environment where e-commerce can thrive. This will secure an important role for the state and its businesses in the global e-commerce marketplace of the 21st century. To fully realize the potential of e-commerce, the state should focus its attention on creating favorable policies on Internet taxation, privacy, security, and the telecommunications infrastructure.

  In addition, state government should become an active user of e-commerce, conducting as much state business as possible online, such as transactions at the Massachusetts Registry of Motor Vehicles.

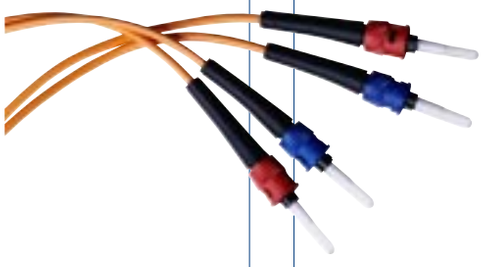
GROWING OUR R&D BASE

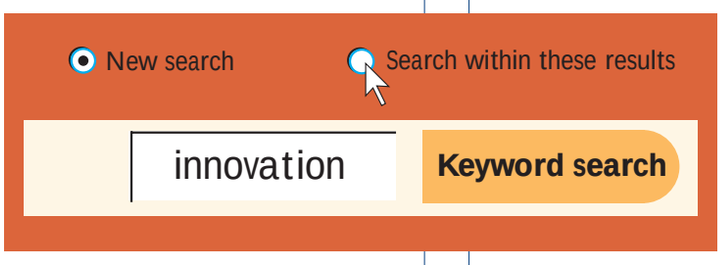
- **Grow our research and development (R&D base); continue advocacy for federal science policy:** Scientific research and technology development remain the jewel in the crown of the Massachusetts Innovation Economy, and the state's leadership in developing a world-class R&D base remains the foundation of future prosperity. This leadership is threatened as Congress considers ways to reduce federal R&D spending in this and future budgets in order to stay within the limits of the Balanced Budget Act. While the state's performance remains strong, Massachusetts needs to be proactive in supporting and enhancing its research community. In the past, universities and teaching hospitals were voices crying in the wilderness for increased R&D funding. Today, however, the interrelationship of R&D funding and growth of the Innovation Economy calls for joint efforts of political, business, and academic leadership. The active involvement of groups such as the Greater Boston Chamber of Commerce and the New England Council is very encouraging.

- **Lead in healthcare policy**: As described above, Massachusetts has a large stake in the outcome of the continuing debate over healthcare and health finance in the U.S., particularly in the debate over Medicare reform. The state's extensive academic healthcare community (teaching hospitals and medical schools) is a major industry in its own right, and is the foundation of key industries, such as the state's rapidly-growing medical device industry. Massachusetts policymakers must assess the impact of competing healthcare reform plans on the state's healthcare delivery, and research and technology development, and take strong positions in support of those which strengthen this critical cluster.

- **Consider an active state role in support of innovation**: Massachusetts state government has not, as a rule, invested directly in scientific research. The most recent statistics from the National Science Foundation show that Massachusetts ranks 37 among the 50 states in terms of state "own-source" revenue appropriated for research. There is often considerable disagreement among experts as to the efficacy of state-supported R&D; however, Massachusetts policymakers need to be aware that state support of research has become a serious economic development tool for other states. Massachusetts should monitor this competition from other states, assess the efficacy of such policies, and discuss whether such strategies may now be appropriate for sustaining the strength of Massachusetts world-class research community.

E-Commerce in Massachusetts





"One of the dominant questions coming out of global companies today is 'How do we become an e-business *now*?' Leading executives realize breakthrough e-competitors will emerge in virtually every industry, and they don't want to be left behind."

Frank Doyle
Global Leader
Technology, Info-Comm & Entertainment
PricewaterhouseCoopers, LLP

The emergence of electronic commerce over the past decade has had a profound impact on the Innovation Economy. E-commerce refers to any business process conducted over the Internet or similar non-proprietary networks. Enabled by the rise of the World Wide Web and related information technologies, Forrester Research predicts that e-business in the United States will reach $1.3 trillion by 2003, and that e-tail in the U.S. will reach $184 billion by 2004.

The Internet is changing the way organizations do business. Delivering products and services electronically increases the speed and efficiency with which organizations can interact with clients, partners, and employees. By utilizing Internet tools such as electronic mail (e-mail) and file transfer, streaming audio and video, online databases, and Web pages, e-commerce business practices have the potential to help companies reduce costs, enhance customer service, enter new markets, and develop additional revenue streams. E-commerce is being embraced by business and industry and the public sector, and is responsible for sizable growth in information technologies (IT) and telecommunications industries.

The e-commerce field is still emerging for this special analysis. We have classified e-commerce businesses and activities into the following five major categories:

E-Business

E-business is the conducting of business-to-business (b-to-b) processes online. These processes include purchasing and sales, Internet-based EDI (Electronic Data Interchange), information services, electronic publishing, and extranets (internal communication systems extended to contractors and business partners). In order to be competitive, companies are developing e-business plans that align IT solutions with their corporate strategies. E-business allows companies to streamline the production of goods and services while simultaneously enhancing collaboration and communication among suppliers, wholesalers, retailers, and customers.

E-Tail

E-tail is primarily focused on businesses selling goods and services to consumers (b-to-c) over the World Wide Web. Both established retailers and new online retailers or ".com" companies are rapidly shifting their efforts to online sales, marketing, and customer service. Banking and financial services are examples of industries that have begun to establish a strong online presence resulting in decreased costs and increased revenues.

E-Intranet

E-intranet services are shifting human resource management and internal communications to the Web. E-mail, Internet-based ERP (Enterprise Resource Planning), the electronic distribution of materials and software, and knowledge sharing could not only reduce management costs, but also increase the possibility of innovative solutions to business challenges.

E-Tech

E-tech companies provide software, consulting, and business services for e-commerce. The emerging cluster of e-tech companies centered around various e-commerce activities is responsible for a significant portion of e-commerce revenues and employment.

E-Commerce Services

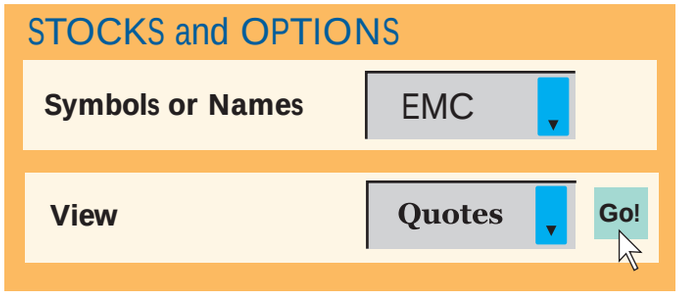
E-commerce services, like traditional business services, have become important to companies expanding into new e-commerce markets. The majority of e-commerce services provides consulting for online marketing, e-commerce strategies, and Web design.

E-commerce is rapidly becoming an integral part of business innovation. How does Massachusetts stack up in the nation's e-commerce markets? Using the *Index's* framework, which organizes thinking around resources, innovation processes, and results, the following special analysis explores:

- The emergence of e-commerce companies in Massachusetts
- The extent to which established Massachusetts companies are employing innovative e-business practices
- The impact these innovation processes are having on business and people
- The implications for public and private sector investment in e-commerce

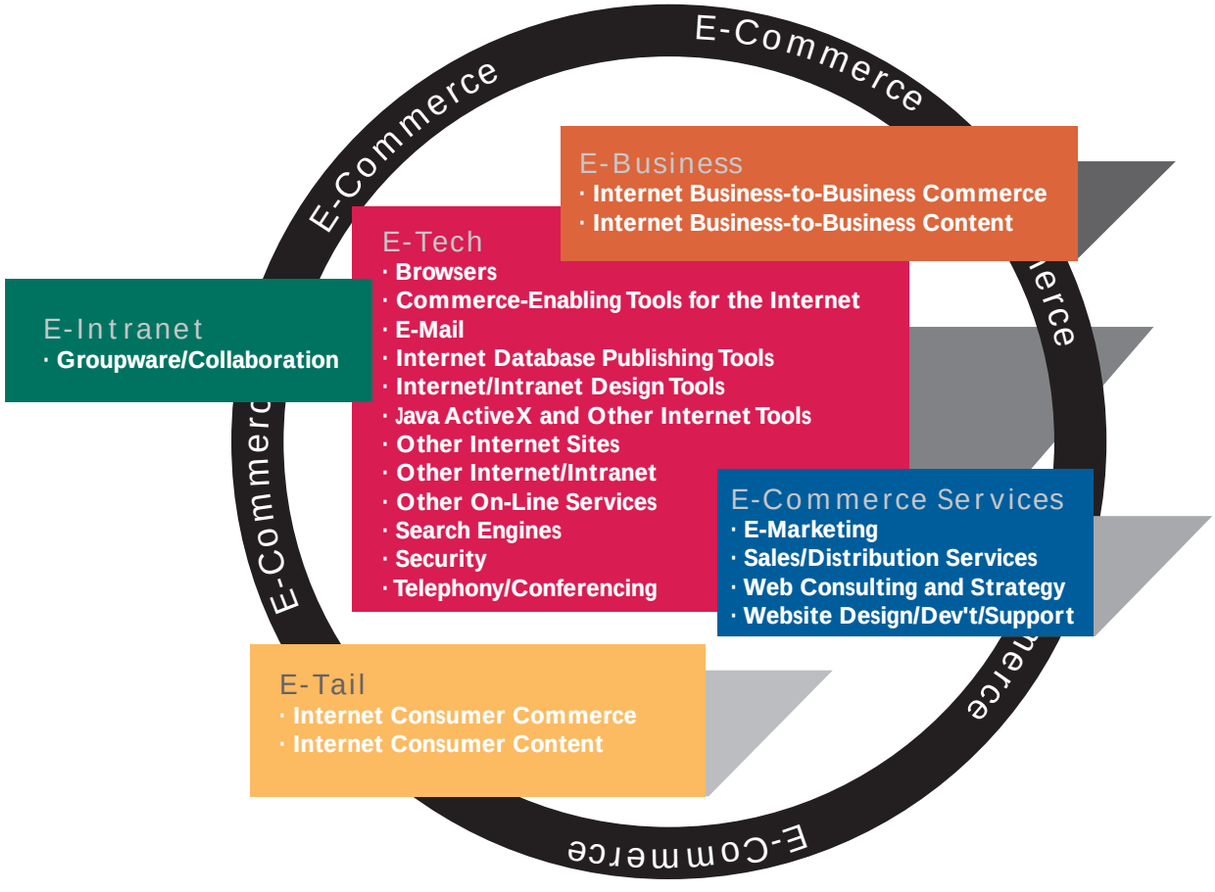
Although e-commerce activity has grown in Massachusetts, the state must establish as a priority the creation of a business environment in which e-commerce can thrive if it is to be a leader in the global e-commerce marketplace of the 21st century.

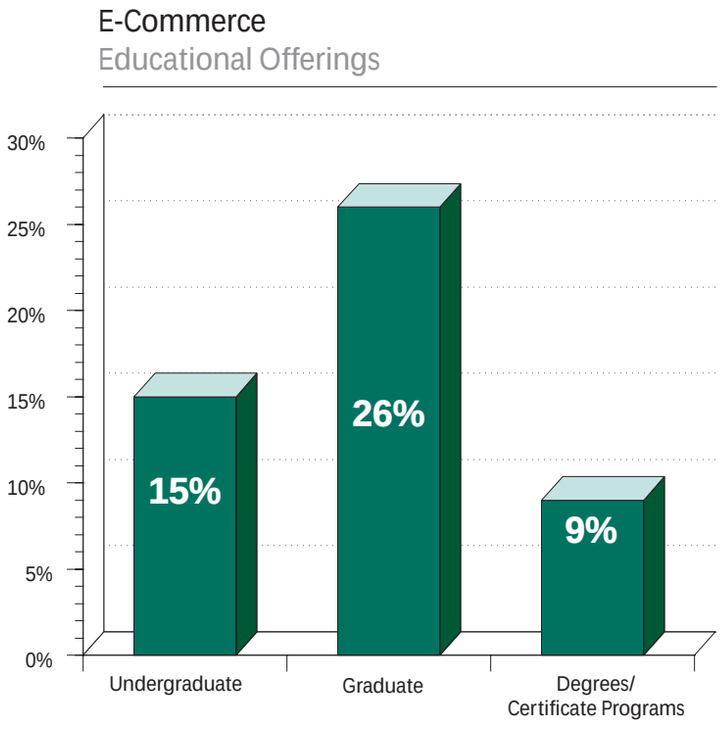
This analysis draws heavily from survey work completed by Computer Economics, Inc., *The 1998 Massachusetts Directory of High Technology Companies* published by Mass High Tech, and data provided by PricewaterhouseCoopers.



"Online trading is running at 37% of all retail trades; it's expected to hit about 50% by the end of next year."
U.S. Bancorp, Piper Jaffray
BusinessWeek,
October 4, 1999

E-Commerce
Categories Defined





Percentage of Massachusetts academic institutions with e-commerce offerings, 1999

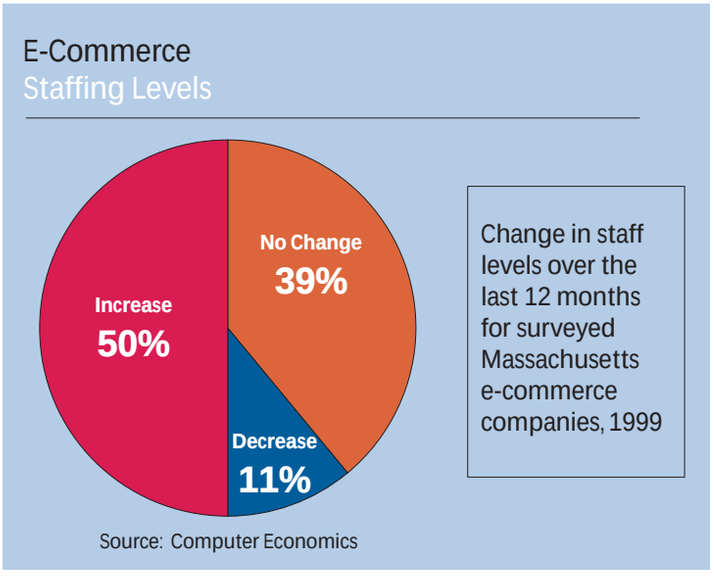
Source: Massachusetts Technology Collaborative E-Commerce Survey

E-Commerce Assets

A region's ability to support e-commerce begins with its assets. E-commerce requires a highly skilled workforce that can address the challenges and strategies involved in developing and maintaining electronic commerce. According to a 1999 Massachusetts Technology Collaborative survey, major academic institutions in Massachusetts have been steadily increasing their number of e-commerce related courses and programs. Of the 31 colleges and universities surveyed, 15% offered undergraduate coursework, 26% offered graduate coursework, and 9% offered degrees or certificate programs in e-commerce.

Staffing trends are important because information systems are the nerve center of most e-commerce operations. A broad survey of industries conducted by Computer Economics shows that from February 1998 to February 1999, 50% of Massachusetts companies increased staffing levels in information systems, compared to 44% nationwide. Another 39% of surveyed Massachusetts companies maintained steady employment in this area. (A complete list of company categories surveyed by Computer Economics is included in Appendix A.)

Corresponding to an increase in staffing, a Computer Economics survey reports that Massachusetts companies spent, on average, nearly $13,800 per employee on information systems as compared to $12,500 per employee nationwide in early 1999.



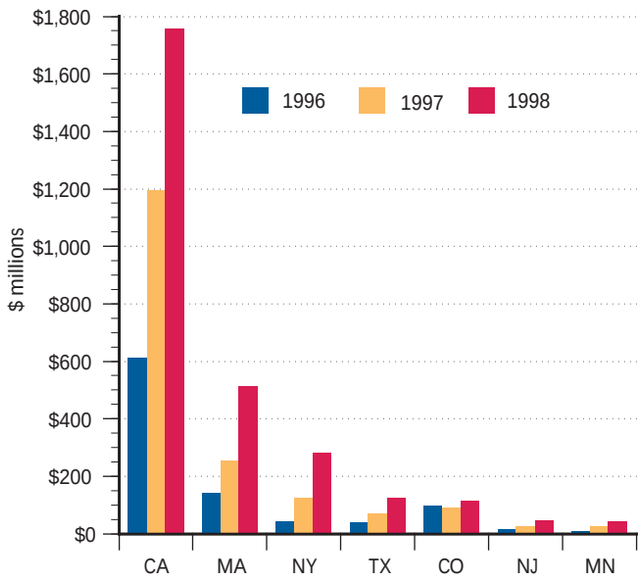
Change in staff levels over the last 12 months for surveyed Massachusetts e-commerce companies, 1999

Source: Computer Economics

Venture capital investment in Internet-related and e-commerce companies is an important indicator of this sector's future job and revenue growth. PricewaterhouseCoopers (PwC) classifies Internet-related and e-commerce companies into four categories based on a company's primary line of business. E-commerce companies fall under the PwC category of services, which includes electronic retailing, electronic commerce, and online entertainment. (A complete list of PwC Internet-related and e-commerce categories is located in Appendix A.)

According to PwC, venture capital investment in this sector first became significant in 1995, when $36.3 million was invested. By 1998, this figure for Massachusetts had reached $514 million, representing 15% of the total U.S. venture investment in Internet-related and e-commerce businesses. At the time of this report, PwC data for the first two quarters of 1999 show that venture capital investment in Massachusetts firms has reached $819 million.

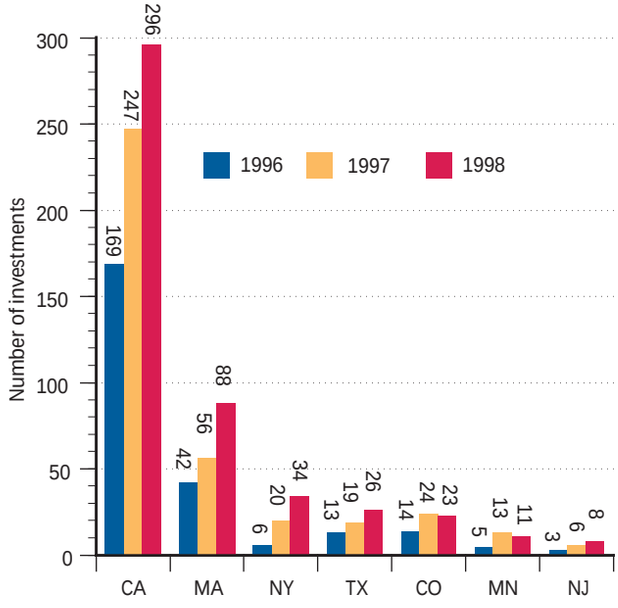
E-Commerce
Value of Venture Capital Investments



E-commerce venture capital investments made in Massachusetts and other LTS, 1996–1998

Source: PricewaterhouseCoopers

E-Commerce
Number of Venture Capital Investments



Number of e-commerce venture capital investments, Massachusetts and other LTS, 1996–1998

Source: PricewaterhouseCoopers

When compared to the other Leading Technology States (LTS), PwC data reveal that in 1998, Massachusetts was second only to California in the number of Internet-related venture capital investments. California leads the LTS with 296 venture capital investments, followed by Massachusetts (88), New York (34), and Texas (26).

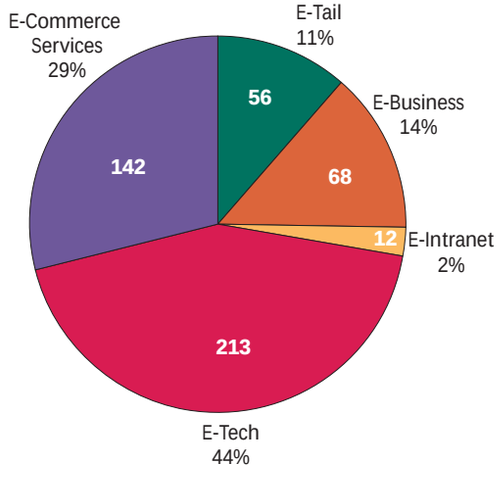
E-commerce is being integrated into the operations of existing and conventional businesses. Fidelity Investments and Staples are two prominent examples of traditional companies that have entered the online marketplace. The success of emerging e-commerce companies has posed a unique challenge to other companies to become increasingly involved in e-commerce.

Innovation Processes

Clustering effects, management, and technology are strongly influenced by e-commerce innovation processes and yield positive results for business and people.

A critical mass of e-commerce companies is important for maximizing supplier-producer relationships and a shared infrastructure. This cluster effect also develops a competitive position for the state in the e-commerce marketplace. According to *The 1998 Massachusetts Directory of High Technology Companies*, published by Mass High Tech, 491 companies identified themselves as e-commerce companies.

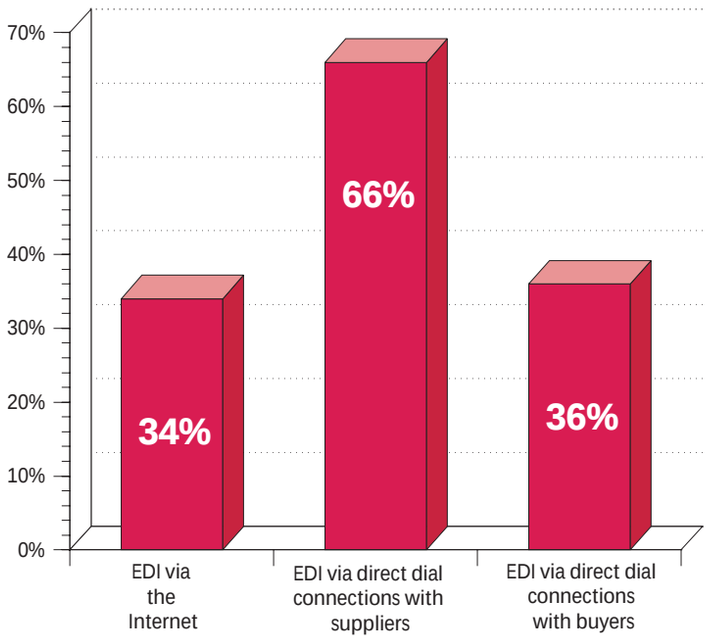
E-Commerce
Companies



Distribution and number of e-commerce companies, Massachusetts, 1998

Source: Mass High Tech

E-Commerce
Electronic Data Interchange



Massachusetts e-commerce companies that utilize various e-commerce capabilities, 1999

Source: Computer Economics

Online transactions are an important indicator of applied innovation. Of the Massachusetts companies surveyed by Computer Economics, 38% engage in Web-based business-to-business (b-to-b) transactions, while 37% are conducting Web-based business-to-consumer (b-to-c) transactions. These figures closely resemble national e-commerce transaction activity.

Electronic data interchange (EDI), a technology used since the 1970s, allows companies to communicate design specifications, technical documentation, and operations management across organizational boundaries. Originally used on proprietary networks, which limited the ability of smaller suppliers to participate in bidding processes with larger producers, EDI is now being used over the Internet. According to a Computer Economics survey, slightly over one-third of Massachusetts companies use EDI via the Internet. Sixty-six percent use EDI via direct dial-up connection with suppliers, and 36% use direct dial-up connections with buyers.

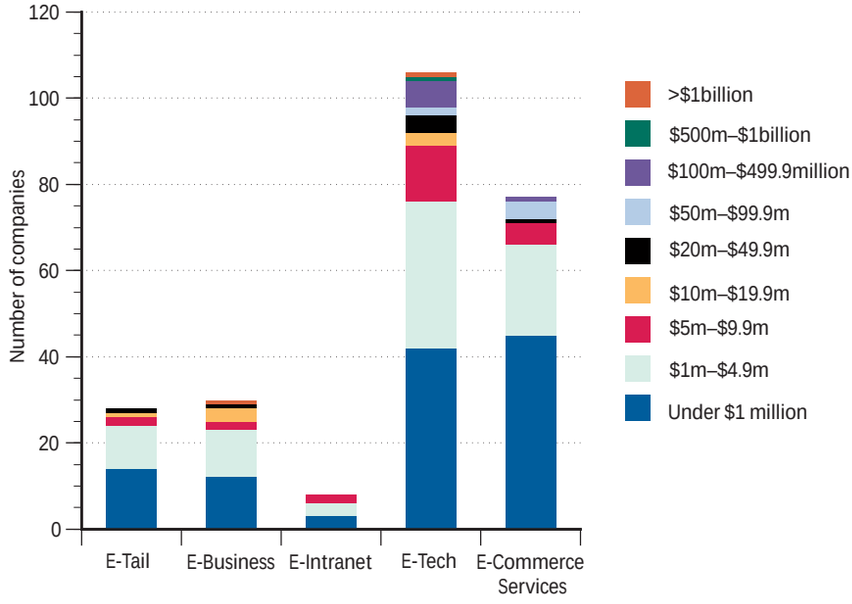
E-commerce technologies can create additional value for businesses by reducing their transaction costs and increasing their efficiency. As an example, according to Arthur D. Little, Federal Express has reduced its customer care expenses by 65 to 70 percent.

Results

The results of e-commerce innovation can be seen in the numbers of jobs created and the amount of revenues associated with e-commerce companies.

The 491 e-commerce companies listed in *The 1998 Massachusetts Directory of High Technology Companies* employed a total of 18,567 people in 1998. Over two-thirds of these people were employed by e-tech companies. The reported total annual revenue of e-commerce companies to *The Directory* shows that e-tech and e-commerce services generate the largest shares of e-commerce revenue in Massachusetts.

E-Commerce
Company Revenues



Revenue distribution of e-commerce companies, Massachusetts, 1998

Source: Mass High Tech

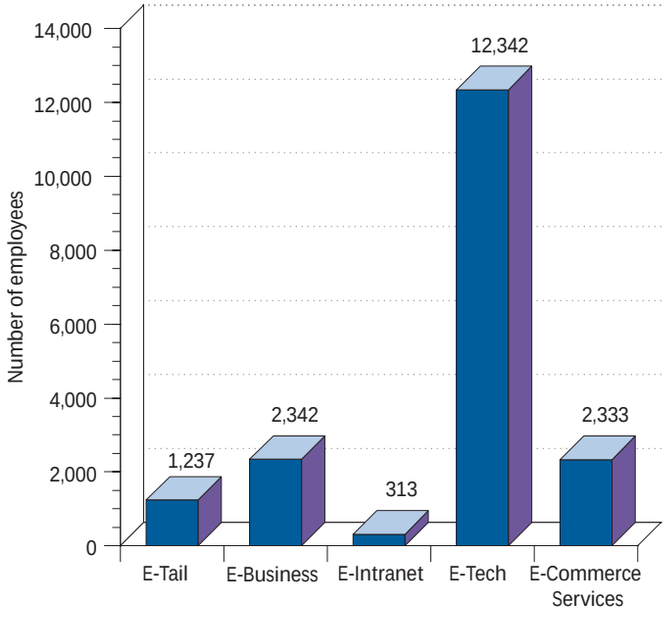
Implications

Massachusetts is well positioned to expand its e-commerce sector. The state has already made considerable investments in e-commerce assets and technologies and has a sizable number of e-commerce companies in addition to traditional businesses entering the online marketplace.

As e-commerce becomes increasingly important to the Massachusetts Innovation Economy, the state should nurture an environment that supports the evolving infrastructure needs and the new business models and relationships required for competition in the electronic marketplace. In order to realize the full potential of e-commerce in Massachusetts, collaborative partnerships among industry, government, and academia are necessary. For instance:

- Given the rapidly changing nature of e-commerce related technologies, industry and academia should create ongoing, substantive partnerships to design relevant curricula to meet the evolving workforce needs of e-commerce.
- State and local government agencies should embrace e-commerce strategies for public service delivery and civic engagement. Government should be an active e-business user itself and conduct as much of its business online as possible, eliminating unnecessary paperwork and procedures.
- Government should also work to ensure that public access to the Internet is available to all state residents.
- The state needs to develop a policy framework on Internet taxation, privacy, security, and telecommunications infrastructure that supports and encourages the growth of e-commerce in Massachusetts.
- Measures for tracking the growth and characteristics of e-commerce in Massachusetts need to be improved so that public and private investment and policy decisions in this dynamic area can be made on the basis of the best possible information.

E-Commerce
Employment



Number of employees, e-commerce companies, Massachusetts, 1998

Source: Mass High Tech

THE FRAMEWORK FOR INNOVATION

The *Index* measures progress of three key components of the Massachusetts Innovation Economy. It is based on a dynamic conceptual framework that links **resources** to economic **results** through an **innovation process**. The framework measures Massachusetts progress in leveraging its resources through innovation to create higher levels of economic performance. In a vital cycle, high economic performance supports ongoing investment and reinvestment in the key resources required to sustain the Innovation Economy.

The Massachusetts Innovation Economy has three interrelated and interactive components:

- **Results**: Outcomes for people and business—job growth, rising average wages, and export sales
- **Innovation process**: Dynamic interactions that translate resources into results—idea generation, commercialization, entrepreneurship, and business innovation
- **Resources**: Critical public and private inputs to the Innovation Economy—human, technology, and investment resources, plus infrastructure

The format of this document reflects the relationship among these components. The *Index* begins by presenting the economic **results** of the Massachusetts Innovation Economy and follows with measures of the state's **innovation process**. It concludes by highlighting key **resources** of the Massachusetts Innovation Economy.

SELECTING INDICATORS

Indicators are quantitative measures that tell us how well we are doing: whether we are going forward or backward; getting better, worse, or staying the same.

A rigorous set of criteria was applied to all potential indicators. All of the selected indicators:

- Are derived from objective and reliable data sources
- Are statistically measurable on an ongoing basis
- Are bellwethers that reflect the fundamentals of economic vitality
- Can be understood and accepted by the community
- Measure conditions in which there is an active public interest

BENCHMARK COMPARISONS: LEADING TECHNOLOGY STATES

Massachusetts should be able to track the Innovation Economy over time, monitoring and 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, in some cases, the Massachusetts indicator is compared with the national average or with a composite measure of six other competitive Leading Technology States (LTS). The six other LTS chosen for comparison throughout the 1999 *Index* are the same as those used in the 1998 *Index*: California, Colorado, Minnesota, New Jersey, New York, and Texas. Although Massachusetts is a Leading Technology State, all references and comparisons to the LTS refer to the six other states; Massachusetts is not included in the calculation of the LTS composite measures. Appendix B describes the methodology for selecting the LTS.

Leading Technology States

NINE KEY INDUSTRY CLUSTERS

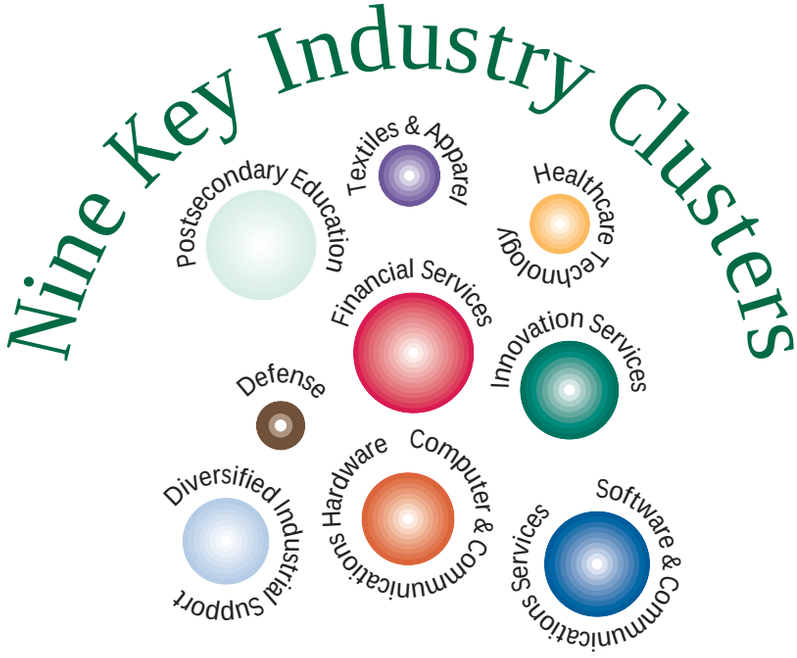
The *Index* monitors the impact of innovation through the nine key industry clusters identified as critical to Massachusetts' economic future and which are linked uniquely to the Innovation Economy. These clusters range from the traditional such as Postsecondary Education, Defense, and Textiles & Apparel industries to the emerging such as Software & Communications Services, and Innovation Services (a combination of highly technical and professional fields such as engineering services and management consulting). Appendix C provides a detailed definition for each of the nine clusters.

Together, these nine clusters account for 24% of nongovernment employment in Massachusetts and 35% of total private sector payroll for 1998. At $56,131, the average wage of the nine key industry clusters is 46% higher than that of the rest of the Massachusetts economy. In the prior one year period, the clusters also accounted for 24% of nongovernment employment and 35% of total private sector payroll. The average wage paid by the clusters was $48,600 in 1997.

DATA AVAILABILITY

For the 1999 *Index*, most indicators are developed from existing secondary sources. The exceptions are primary data gathered by Massachusetts Technology Collaborative on the retention of engineering graduates within the state (Indicator #23), an occupational needs survey developed by MTC and distributed by Massachusetts industry councils to their members (Indicator #6), a survey of universities and research institutions on technology commercialization (Indicator #11), and a survey of academic institutions on e-commerce course work and degree programs (see Special Analysis on E-Commerce). In most cases, indicators from secondary sources required the reconfiguration of existing datasets. These groupings of data are derived from a wide range of sources; consequently, there are some unavoidable variations in the time frames used and in the specific variables that define the indicators being measured. Appendix B provides notes on data sources for each indicator.

In some key areas, data are simply not available or are cost-prohibitive. In such instances, proxies for unavailable data are used.



1. Industry Clusters

Overall Cluster Job Growth Slows; Shift Toward Knowledge-Intensive Services Continues

WHY IS IT SIGNIFICANT?

Nine key industry clusters, defined as geographic concentrations of interdependent industries, account for 24% of all nongovernment jobs in Massachusetts. These clusters are more highly concentrated in Massachusetts than in the nation overall and are potential sources of competitive advantage for the state's economy.

HOW DOES MASSACHUSETTS PERFORM?

More than 660,000 people are employed within the nine key Massachusetts industry clusters, a 2.7% net increase since 1997 (see Appendix C for definitions of the nine key industry clusters). This increase compares to a 2.3% increase in total jobs statewide. Financial Services continues to be the largest employer, with 130,498 people; Defense remains the smallest at almost 22,000 workers.

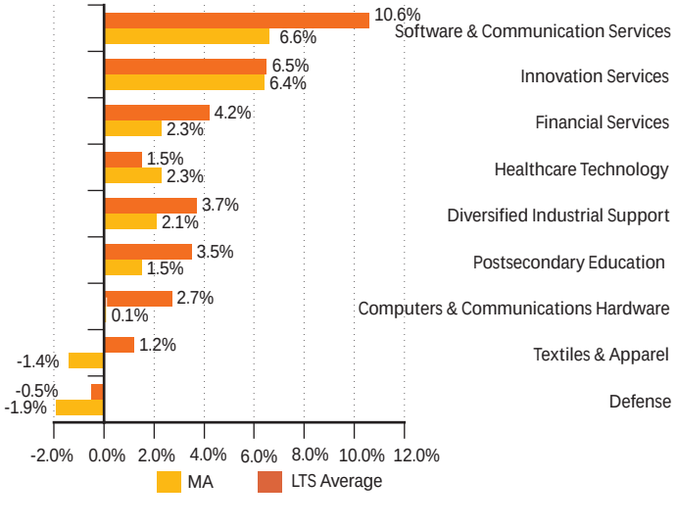
Overall, knowledge-intensive services clusters continued to add jobs, but more slowly between 1997 and 1998. Software & Communications Services registered the largest increase in jobs since 1997: 6,236 new jobs (6.6% increase). This cluster added nearly 10,000 jobs between 1996 and 1997. Other strong gainers were Innovation Services, up 6.4%, with 5,201 new jobs, and Financial Services, up 2.3%, creating nearly 3,000 new jobs. Computers & Communications Hardware gained 96 jobs in 1998 after having added 1,405 jobs during 1997. Employment in traditional manufacturing posted moderate job losses, continuing the negative trend from the previous year. The Defense cluster continued to contract by an average annual rate of 1.9%, shedding 429 jobs between 1997 and 1998. The Textiles & Apparel cluster also contracted, shedding 489 jobs between the same period.

WHAT DOES THIS TREND MEAN FOR MASSACHUSETTS?

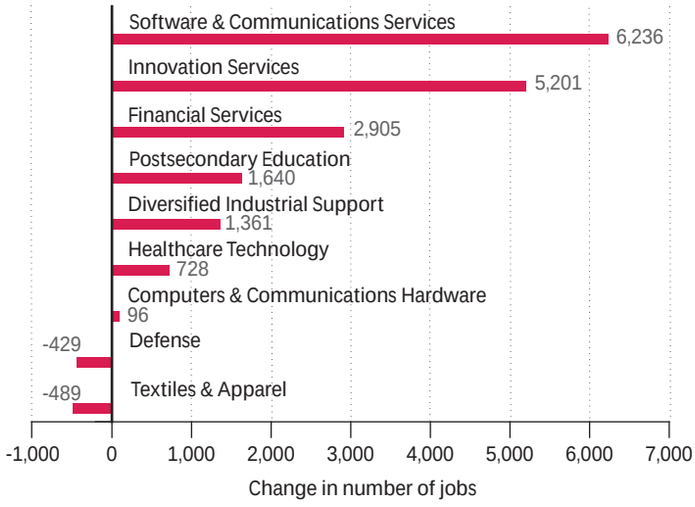
Although job growth was not as dramatic between 1997 and 1998 as in the previous one-year period, restructuring toward a knowledge-intensive economy continued. The 1998 employment figures bear witness to this economic restructuring. In 1992, there were 47,643 jobs in Defense, more than double the 1998 figure. Moreover, Computers & Communications Hardware predominated in 1992 with 91,154 jobs; in 1998, Financial Services, Postsecondary Education, Software & Communications Services, and Innovation Services each employed more people than the Computers & Communications Hardware cluster.

To support this new economy growth, Massachusetts needs a flexible and highly skilled workforce. A dynamic education and training system provides skills-based mobility, allowing people to adapt at different phases of their careers to a continually changing economy.

Percent change in cluster employment for Massachusetts and other LTS, 1997–1998



Net employment change, nine key industry clusters, Massachusetts, 1997–1998



Source for all indicator 1 data: Regional Financial Associates, Collaborative Economics

Total employment, nine key industry clusters, Massachusetts, 1998

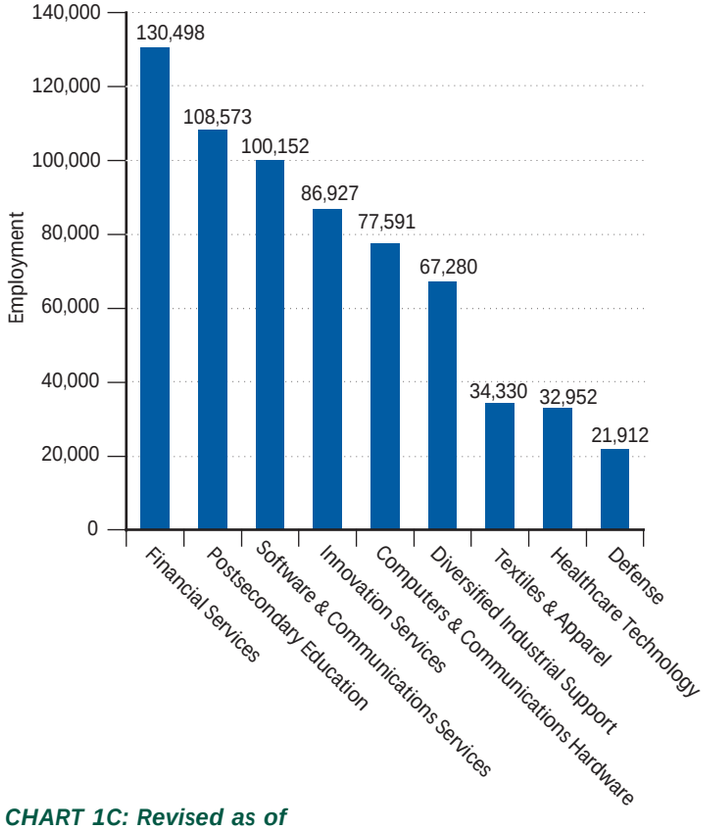


CHART 1C: Revised as of January 1, 2000

2. Employment Diversification

Diverse Cluster Portfolio Shows Resilience in Jobs Despite Signs of Overall Slowing

WHY IS IT SIGNIFICANT?

Successful economies consist of specialized industry clusters that display relatively high employment concentrations, yet they do not rely on just one or two of these clusters. Over-reliance on a particular cluster can leave a state vulnerable to economic shifts and reduce its resilience. Areas characterized by long-term economic growth tend to have a diverse portfolio of industry clusters and have innovative cross-cluster fertilization resulting from interaction among these different clusters.

HOW DOES MASSACHUSETTS PERFORM?

The industry clusters that are most concentrated in Massachusetts relative to the nation are Postsecondary Education (3.0 times as concentrated), Textiles & Apparel (2.2 times), and Computers & Communications Hardware (2.1 times). Of these industry clusters, only Postsecondary Education experienced an increase in employment relative to the nation between 1993 and 1998.

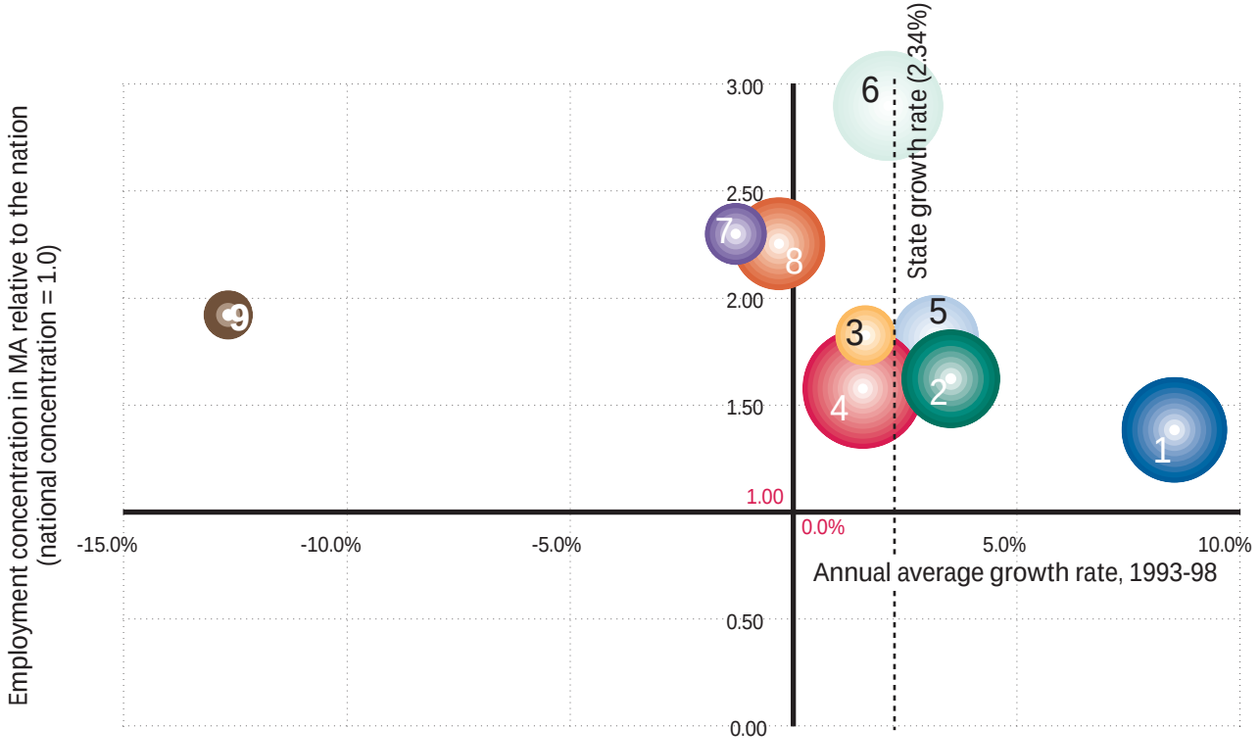
The growth rate of Software & Communications (9.3%) was more than three times the state's overall growth rate from 1993 to 1998. Innovation Services grew at 4.0%; Diversified Industrial Support expanded at 2.9% during that period.

Of the nine key industry clusters, Financial Services is the largest, with 20% of total cluster employment. The Postsecondary Education, Software & Communications Services, and Innovation Services clusters have 16%, 15%, and 13% of the total cluster employment, respectively. The Defense cluster has the smallest at 3%. (The size of each sphere on the chart reflects the relative size of employment in Massachusetts.)

WHAT DOES THIS TREND MEAN FOR MASSACHUSETTS?

Unlike ten years ago when the state's economy was highly dependent on Defense and Computer Hardware, now the Massachusetts portfolio of specialized clusters is more diverse. This change provides a broader base of employment and an economy better able to weather a variety of economic and structural changes. The cluster portfolio also increases the potential for cross-cluster synergies that can lead to the emergence of new industry clusters in Massachusetts. Healthy collaboration and networks stimulate cross-industry relationships. An example of the state's role in facilitating cluster development is the Massachusetts Technology Collaborative's Cluster Program, one initiative of which was its work with the medical device industry and creation of MassMEDIC.

Portfolio of nine key industry clusters by employment concentration and growth, Massachusetts, 1993–1998



1. Software & Communications Services
2. Innovation Services
3. Healthcare Technology
4. Financial Services
5. Diversified Industrial Support
6. Postsecondary Education
7. Textiles & Apparel
8. Computers & Communications Hardware
9. Defense

Source: Regional Financial Associates, Collaborative Economics

3. Average Pay

Knowledge-Intensive Services Continue To Lead in Wages and Wage Growth

WHY IS IT SIGNIFICANT?

Key industry clusters generate wealth through national and international sales of their innovative processes, products, and services. The strong demand for their innovative offerings allows these cluster firms to afford higher pay for their knowledge-based workers.

HOW DOES MASSACHUSETTS PERFORM?

Workers in the fast-growing, knowledge-intensive services clusters tend to earn the highest wages. The Innovation Services cluster had the highest average pay, at $71,009 per year in 1998, a 2% increase from 1997. In a reversal from 1997, Financial Services now ranks second, at $67,610 per year, closely followed by now third-ranked Software & Communications Services at $64,197. The average annual change in pay for the nine key clusters was a little more than 3% between 1997 and 1998, as compared to 4% in the previous year.

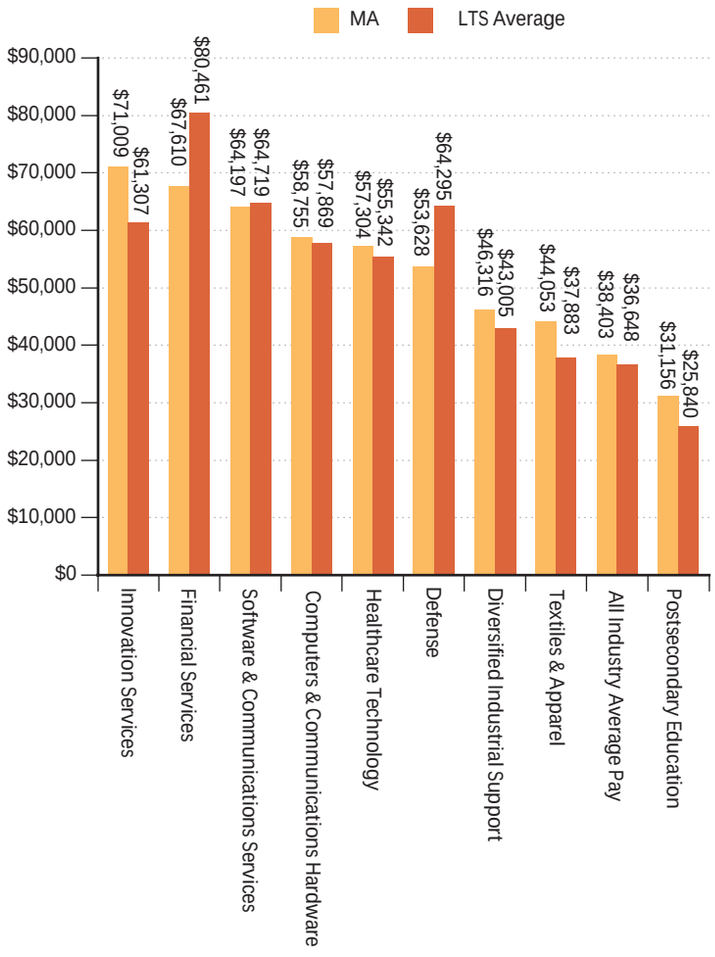
The average wage in eight of the state's nine key clusters (all but Postsecondary Education) is higher than the average annual pay per worker of $38,403 in the state as a whole. Compared to clusters in the other six Leading Technology States (LTS), six of the Massachusetts industry clusters have higher average wages. The salary gap between Massachusetts and its competitors narrowed in Financial Services, while widening in Defense.

From 1994 to 1998, wages in the Financial Services cluster in Massachusetts have increased sharply at nearly 26% in inflation adjusted terms. Average pay in Financial Services in Massachusetts remains considerably below the average for the other LTS. Real wages in Innovation and in Software & Communications Services both grew, on average, by 14%; those in Textiles & Apparel rose by nearly 12%. The average real wage growth rates for Diversified Industrial Support (5.3%), Postsecondary Education (3.7%), and Defense (2.8%) were well below the Massachusetts average (9.5%).

WHAT DOES THIS TREND MEAN FOR MASSACHUSETTS?

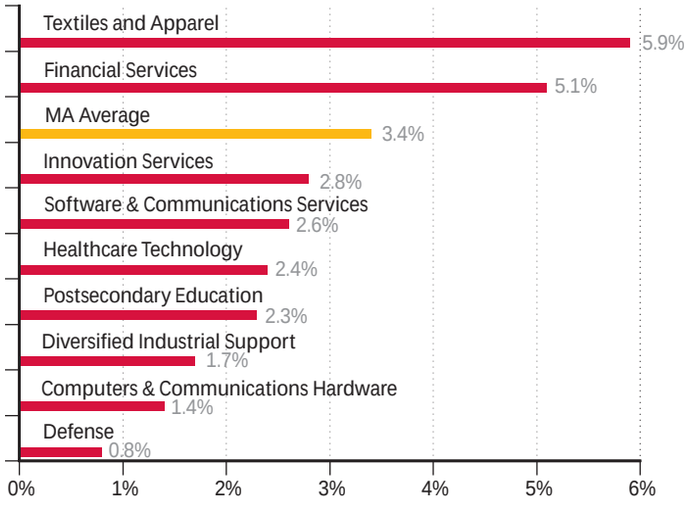
Massachusetts job growth is concentrated in relatively well-paying industries. This concentration helps to raise the average standard of living of Massachusetts residents. The near-term challenge is to provide the necessary supply of well-qualified workers for these industry clusters. The longer-term challenge is to bolster productivity levels that support growth in real wages.

Average pay per worker, nine key industry clusters, Massachusetts and other LTS average, 1998



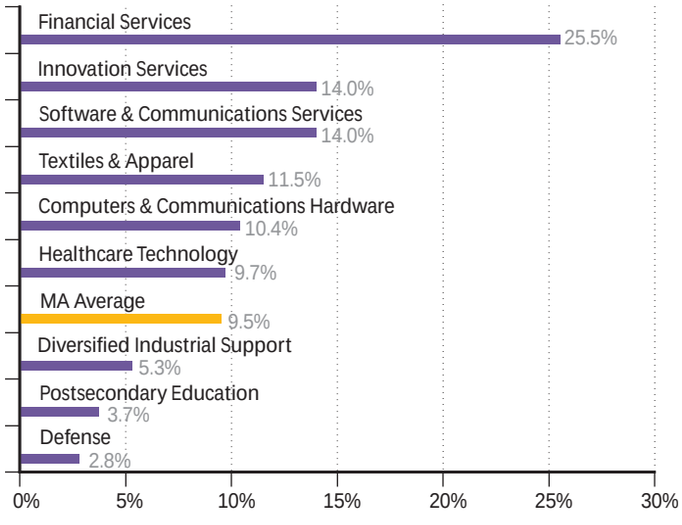
Source: Regional Financial Associates, Collaborative Economics

Cluster industry wage growth rate, Massachusetts, 1997–1998 (inflation adjusted)



Source: Regional Financial Associates, Collaborative Economics

Cluster industry wage growth rate, Massachusetts, 1994–1998 (inflation adjusted)

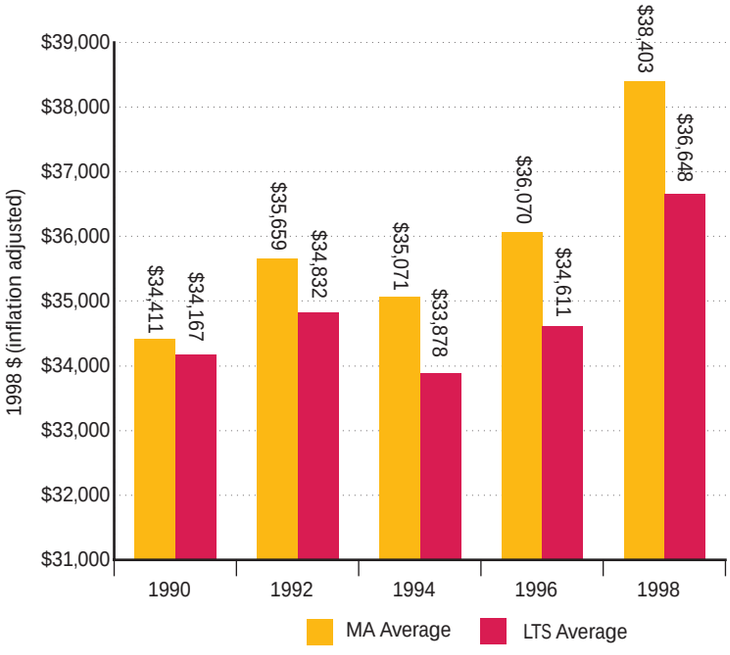


Source: Regional Financial Associates, Collaborative Economics

4. Pay per Worker

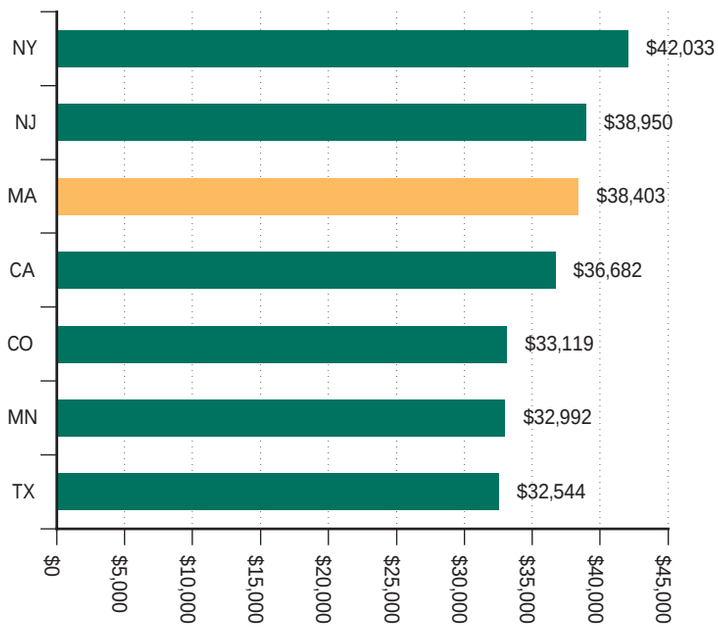
Average Pay Remains Relatively High and Outpaces Inflation

Average annual pay per worker, Massachusetts and other LTS average, 1990–1998 (inflation adjusted)



Source: Bureau of Labor Statistics

Average annual pay per worker, Massachusetts and other LTS, 1998



Source: Bureau of Labor Statistics

WHY IS IT SIGNIFICANT?

Growth in pay per worker, adjusted for inflation, is a measure of job quality and a key determinant of standard of living. It can reflect rising levels of education and productivity. It can also result from employers increasing wages to attract and retain workers in short supply.

HOW DOES MASSACHUSETTS PERFORM

In 1998, the average annual pay in Massachusetts was $38,403 compared to an LTS average of $36,648. From 1997 to 1998, average annual pay per worker increased 3.0% in inflation adjusted terms in Massachusetts, slightly below the 3.1% average increase in the six other LTS.

Between 1990 and 1998, average annual pay of Massachusetts workers increased 11.6% in inflation adjusted terms, compared with 7.2% in the six other Leading Technology States (LTS). Of the six other LTS, Massachusetts consistently reported the third-highest average annual pay per worker, behind New York and New Jersey and just ahead of California.

WHAT DOES THIS TREND MEAN FOR MASSACHUSETTS?

Rising pay per worker, adjusted for inflation, indicates that on average Massachusetts workers are benefiting from the economic growth occurring in the state. It also reflects tight labor markets due to slow labor force growth. To sustain competitiveness over time, Massachusetts industries need to increase productivity faster than wage growth. Since 1990, Massachusetts productivity has increased 19.8% in inflation adjusted terms, as compared to 5.7% for the U.S.

5. Earnings Distribution

Earnings of Bottom 20% of Families Increase for First Time since 1993

WHY IS IT SIGNIFICANT?

Successful economies create opportunity for all families to move ahead. They promote a rising standard of living for the lowest group and a stable or narrowing gap between the highest and lowest groups.

This indicator compares the annual earnings of families at the top, middle, and bottom of the earnings distribution. Over time, individuals and families move both up and down the distribution of earnings. Good data on earnings mobility in Massachusetts are not currently available, suggesting an important area for future work.

HOW DOES MASSACHUSETTS PERFORM?

In 1998, the median earnings for the top 20% of families continued to rise from the previous year by 2.1%; median earnings for the middle 20% declined by 1.5%. Earnings for the bottom 20% of families rose by 31.3% from $7,921 in 1997 to $10,400 in 1998. This last change represents the first increase since 1993. The gap between the top 20% and the bottom 20% improved from a ratio of 13 to 1 to a ratio of 10 to 1. This differential is the lowest since 1991.

The Massachusetts pattern follows a national trend where average hourly wages for the lowest earners increased in 1998.

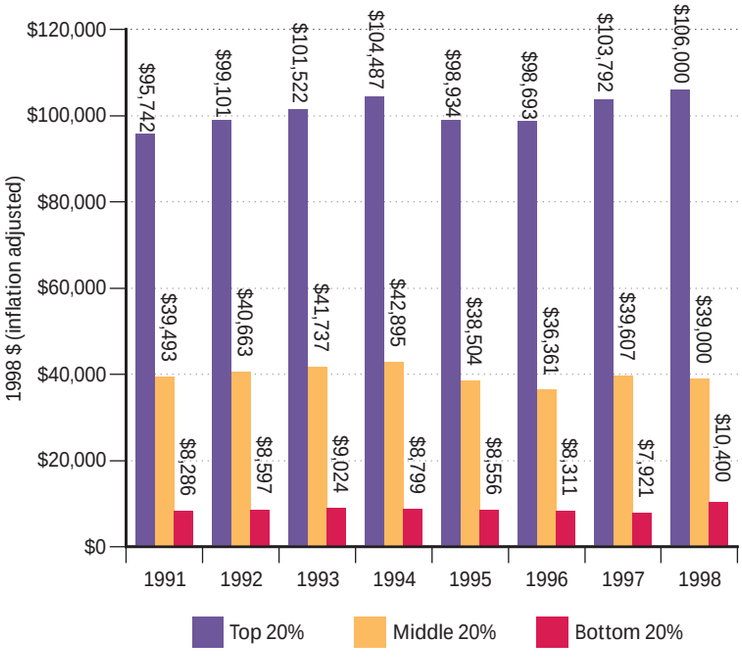
Historically, changes in median earnings of the middle 20% have tended to parallel the earnings of the top 20%, although in 1998 the gap between the two grew slightly. The ratio of the median family earnings for the top 20% to the middle 20% increased from 2.6 to 2.7.

Many factors are associated with earnings inequality, including changing family structure, the growing wage premium paid for a college education, and economic cycles.

WHAT DOES THIS TREND MEAN FOR MASSACHUSETTS?

The growing economy only recently translated into gains for the bottom 20% of working families. This change is due in part to record levels of employment and to the increase in the minimum wage. In a tightening economy, however, the gap is likely to re-expand, and differences in education and skills levels would reemerge more prominently as a critical differentiator for career opportunities. Massachusetts should address issues of basic skills development, retraining, and other barriers to upward mobility so that individuals in the state can develop the necessary skills which will enable them to better weather economic cycles.

Earnings of the top, middle, and bottom 20% of Massachusetts working families, 1991–1998

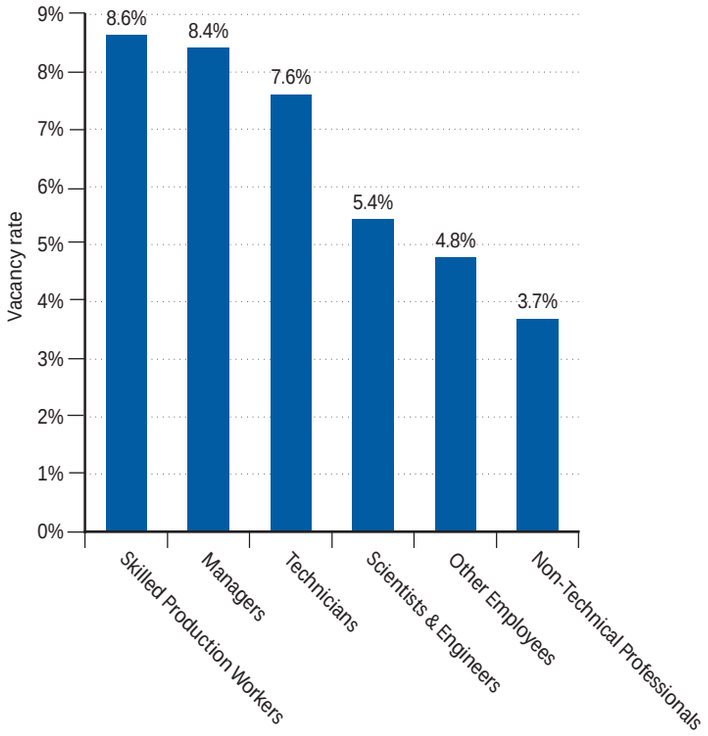


Source: Current Population Survey, U.S. Census Bureau

6. Skills Needs

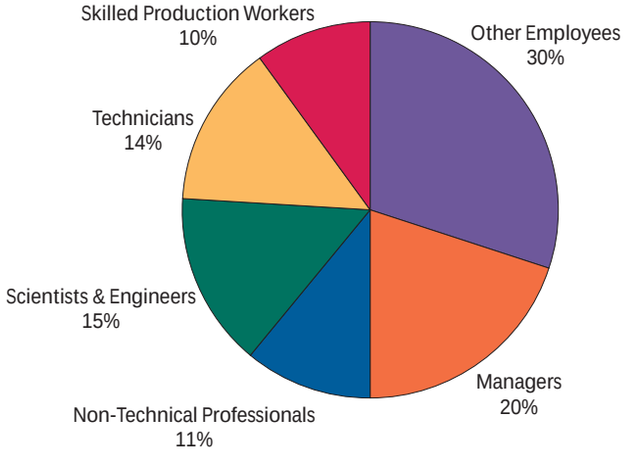
Technical Jobs Go Unfilled in Technology-Intensive Companies

Vacancy rate by occupation within technology-intensive companies surveyed, Massachusetts, 1999



Source: Massachusetts Technology Collaborative Workforce Needs Survey

Distribution of current occupations within technology-intensive companies, Massachusetts, 1999



Source: Massachusetts Technology Collaborative Workforce Needs Survey

WHY IS IT SIGNIFICANT?

The occupational structure of Massachusetts technology-based industries contains a significant concentration of technical and professional talent. Massachusetts corporations cite the limited availability of these skilled workers as an impediment to continued success.

HOW DOES MASSACHUSETTS PERFORM?

In May 1999, the Massachusetts Technology Collaborative surveyed companies in a range of industries important to the Innovation Economy. This "point-in-time" survey was similar to the one used for the 1998 *Index*. The memberships of the Massachusetts Biotechnology Council, the Massachusetts High Technology Council, the Massachusetts Medical Device Industry Council, and the Massachusetts Software Council participated in the survey.

Nearly two-thirds of the survey respondents' employees had professional, technical, or skilled production jobs. Of the contract/temporary employee pool at the companies surveyed, 43% worked as engineers & scientists, technicians, or production workers.

The occupational vacancy rates for those companies surveyed indicated that their greatest need was for skilled production workers, for whom the rate of unfilled jobs was nearly 9%. This need was followed by a vacancy rate for managers and technicians of about 8%. The vacancy rate for scientists and engineers was more than 5%. In contrast, a year ago, scientists and engineers had the highest vacancy rate. These vacancy rates reflect the importance of and increased demand for higher skills at all levels of employment in technology-intensive companies in the state.

WHAT DOES THIS TREND MEAN FOR MASSACHUSETTS?

The shortage of skilled workers can slow the growth of the Massachusetts economy and exert upward pressure on labor costs. A continued shortage can undermine company hiring and growth strategies and discourage expansion within the state and the relocation of companies from other areas. The vacancy rate for scientists and engineers has fallen since last year; however, technology-intensive companies continue to feel the impacts of relatively tight labor markets. A Dun & Bradstreet Corporation survey of small companies (100 employees or less) conducted in February 1999 found that 29% anticipate adding employees this year, down from 35% in 1998.

Massachusetts must focus on the long term and make a priority of programs that retrain existing workers, allow for the foreign in-migration of skilled talent, and develop an educational system that enables and encourages lifelong learning. An emphasis on all segments of the talent pipeline is a prerequisite for the continued prosperity of workers, companies, and communities in the Massachusetts Innovation Economy.

7. High-Tech CEO Rating of Massachusetts

Tech-Based Business Leaders Continue to Hail the State's Business Climate

WHY IS IT SIGNIFICANT?

Confidence in a region not only reflects current conditions but also influences its future. Positive or negative perceptions of a state affect investment patterns. The perception by high-tech business leaders of how Massachusetts rates as a place in which to create, operate, or expand businesses is a bottom-line indicator of the overall climate for innovation and technology-based industry in the state.

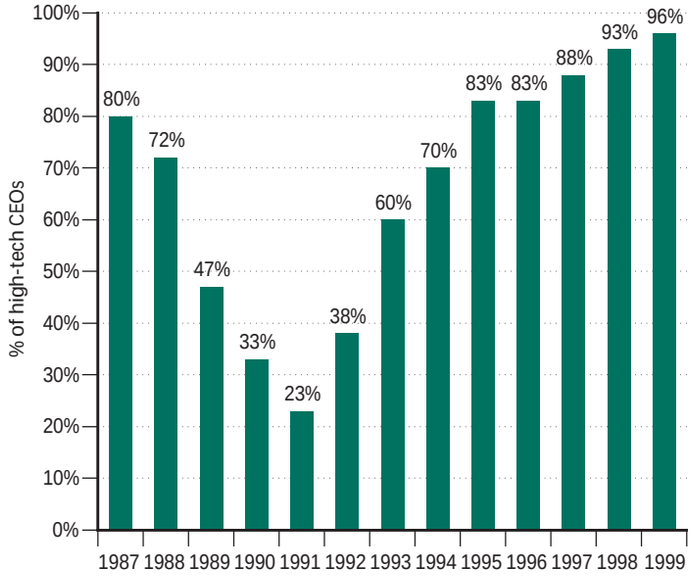
HOW DOES MASSACHUSETTS PERFORM?

The attractiveness of Massachusetts to technology-based business continued its upward climb in the past year. In 1999, 96% of the CEOs responding to the Massachusetts High Technology Council annual survey rated the Massachusetts business climate as "good" or "outstanding," even more than at the height of the 1980s boom. In contrast, in 1991, only 23% of these high-tech CEOs rated Massachusetts favorably.

WHAT DOES THIS TREND MEAN FOR MASSACHUSETTS?

A positive business climate bolsters the attraction, expansion, and retention of firms and jobs in the state. Although perceptions of the business climate fluctuate significantly with economic and political conditions, the core components of a healthy business climate, such as the regulatory environment and the fiscal strength of the state, require sustained attention and strategic planning. Massachusetts must remain vigilant in maintaining a business climate supportive of innovation and risk taking.

Percentage of high-tech CEOs rating Massachusetts "good" or "outstanding" as a place to create, operate, expand high-tech businesses, 1987–1999

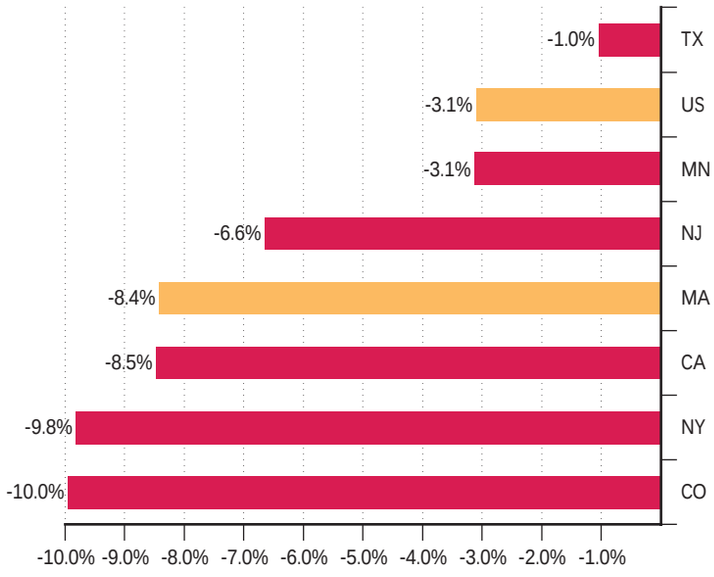


Source: Massachusetts High Technology Council

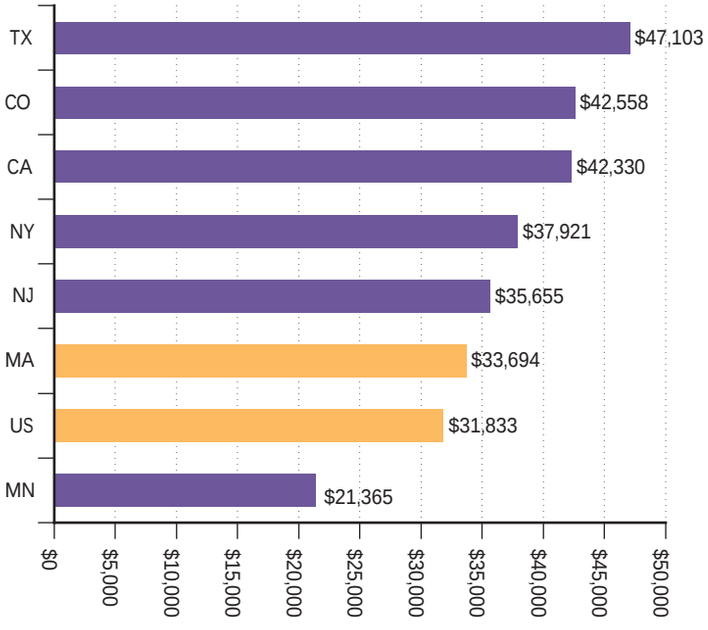
8. Manufacturing Exports

Value of Manufacturing Exports Slows

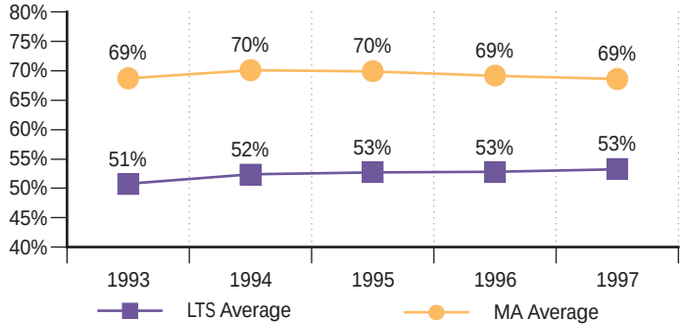
Change in value of manufacturing exports per employee, Massachusetts and six other LTS, 1997–1998 (inflation adjusted)



Value of manufacturing exports per employee, Massachusetts and six other LTS, 1998



High-tech exports as a percentage of manufactured exports, Massachusetts and other LTS average, 1993–1997



WHY IS IT SIGNIFICANT?

Exports are an important indicator of global competitiveness. Serving growing global markets can bolster growth in employment, sales, and market share at innovation-based companies. Also, diversity of markets creates a countercyclical hedge against downturns in any single market. Measures of services exports should be used to complement manufacturing figures when assessing performance of the Innovation Economy. Exports also measure the competitive posture of Massachusetts products relative to the rest of the world, and this either leads to growth or contraction of companies.

HOW DOES MASSACHUSETTS PERFORM?

Massachusetts and each of the other six Leading Technology States (LTS) experienced decreases in the value of their manufacturing merchandise exports between 1997 and 1998. The value of Massachusetts exports per employee shrunk by nearly 8% in inflation adjusted terms during that period as compared to the U.S. value, which fell by about 3%. The value of Massachusetts manufacturing exports per employee has increased by 28% since 1992.

Per employee, Massachusetts manufacturing exports ($33,694) remain low compared to the six other LTS, although they rank just above the national average ($31,833). Within manufacturing, technology-based industries in Massachusetts account for approximately 70% of all exports from 1993 to 1997; this compares with just more than half in the LTS.

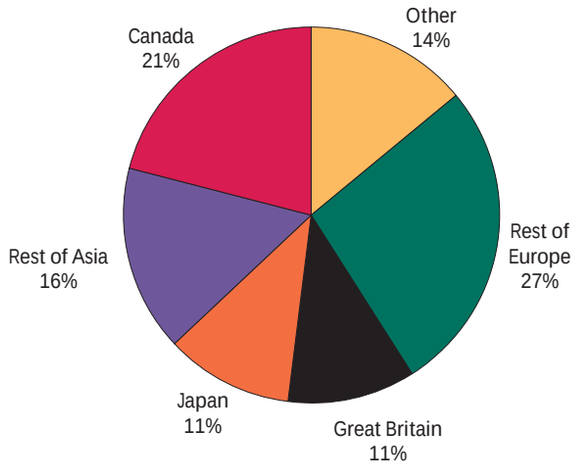
The destination of Massachusetts manufacturing exports remained steady between 1997 and 1998, with the largest percentage going to Europe, excluding Great Britain, (27%); followed by Canada (21%); then Asia, excluding Japan, at (16%). Japan and Great Britain each received 11% of Massachusetts exports.

WHAT DOES THIS TREND MEAN FOR MASSACHUSETTS?

An important issue for Massachusetts is why the value of its manufacturing exports declined at a rate similar to that of other state economies that had significantly greater exposure to Asia. Although the state is less dependent upon exports to Asia than other states, it is unclear how other factors explain its one-year 8% decline. At least part of this decline is likely to reflect the continuing structural change in the state's economy toward services.

Source for all indicator 8 charts: Office of Trade and Economic Analysis, International Trade Administration, U.S. Department of Commerce

Destination of Massachusetts exports, 1998



9. Service Exports

Software Export Revenues Continue to Be Highest among the LTS

WHY IS IT SIGNIFICANT?

Service sectors have been growing in economic importance, particularly export-oriented services that are knowledge-based and innovation-driven such as software. Nationally, approximately 28% of U.S. exports are in the service sectors. From 1990 to 1998, the percentage of total services employment jumped from 24% to 28% of total national employment and from 30% to 35% of total Massachusetts employment.

Although U.S. service exports, particularly in information technology (IT), have continued to grow dramatically, economists have not yet been able to establish standard methodologies for tracking and valuing such exports. This indicator estimates the growth in value of service exports.

HOW DOES MASSACHUSETTS PERFORM?

In software exports, Massachusetts ranked above the other six Leading Technology States (LTS) in terms of export revenue per employee. Its export revenue of $23,970 per employee was almost three times the national average. California was the next closest LTS at $23,629 per employee. In 1998, the software establishments in the state received an estimated $679 million from international sales of their software products.

Compared to the other six LTS, Massachusetts ranked third in 1998 at $4,005 in Innovation Services export revenue per employee, with New York in first place ($4,774 per employee) and California in second place ($4,450 per employee). The national average of export revenue per employee in Innovation Services is estimated at $2,771 in that year.

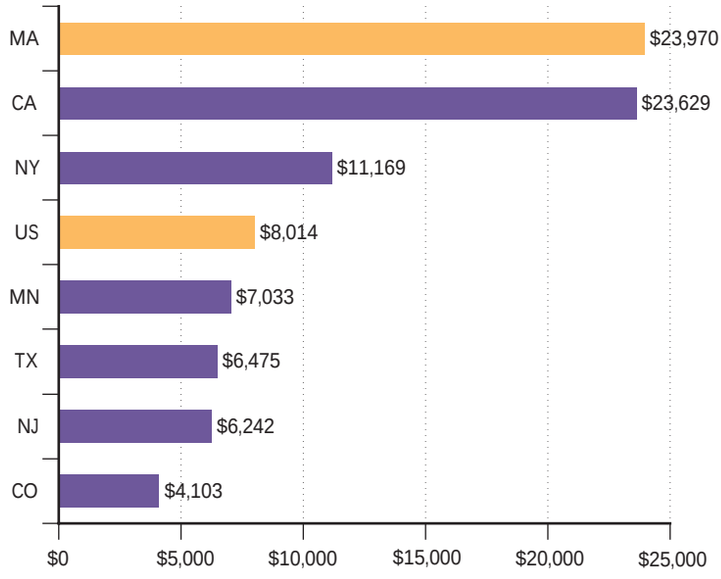
In 1998, exports in Software Services and Innovation Services continued to grow from the previous year, despite the tumult in Asian economies.

WHAT DOES THIS TREND MEAN FOR MASSACHUSETTS?

The state's growing proportion of employment in services highlights the importance of this sector to the Massachusetts economy.

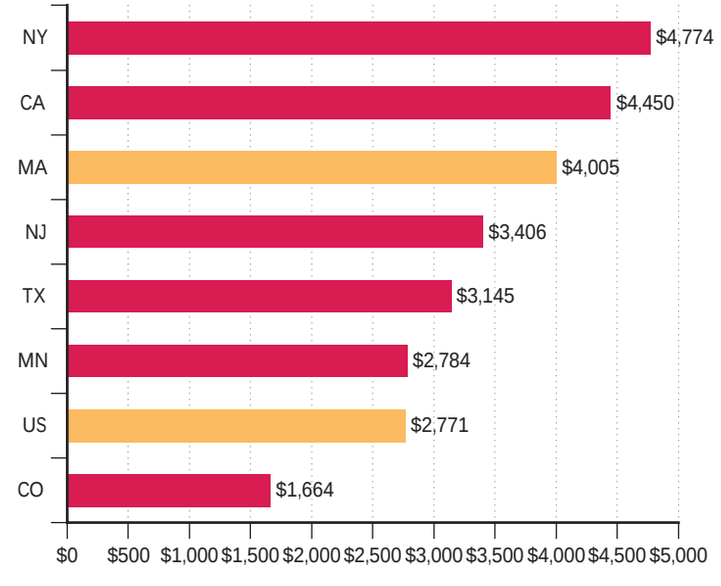
As the Massachusetts economy becomes more services-intensive, the importance of tracking services exports rises. Tracking services as well as manufacturing exports provides a better understanding of the state's global competitiveness. New data sources are needed to help further document the role and impact of the global marketplace on the state's economy.

Export revenue per employee for Software & Communication Services industry cluster, Massachusetts and other LTS, 1998



Source: International Trade Administration, U.S. Department of Commerce

Export revenue per employee for Innovation Services industry cluster, Massachusetts and other LTS, 1998



Source: International Trade Administration, U.S. Department of Commerce

10. Patents per Capita

State Continues to Lead in Patents per Capita with Patent Activity in a Diversity of Areas

WHY IS IT SIGNIFICANT?

Patents reflect the initial discovery and registry of innovative ideas. Strong patent activity usually reflects significant R&D taking place. A key motivator to get patent protection is the potential relevance to a marketable product or process. Patent activity can trigger high-impact discoveries that lead to new innovations downstream.

HOW DOES MASSACHUSETTS PERFORM?

Massachusetts continues to rank above all of the six other Leading Technology States (LTS) in patents per capita. In 1998, innovators in Massachusetts were granted 56 patents per 100,000 residents. This rate is slightly higher than the next closest states of Minnesota (52) and California (48).

The absolute number of patents in Massachusetts has increased sharply from 2,445 in 1992 to 3,413 in 1998, a 40% increase. Of those patents granted, 719 were received by individual inventors in 1998, a 25% increase from 1997.

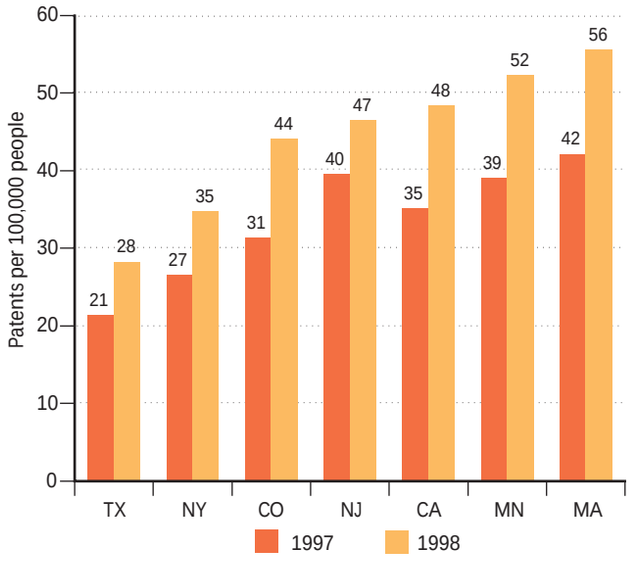
From 1997 to 1998, Colorado (41%), California (38%), and Minnesota (34%) led the LTS in terms of growth in patent activity on a per capita basis. Massachusetts maintained a significant per capita patent growth rate of 32%.

Patents in Massachusetts cross a wide range of sectors. From 1994 to 1998, Healthcare Technology was the most active area, with 22% of all patents, as compared to only 13% between 1988 and 1993. Industrial Equipment/Machinery was second most active in the 1994–1998 period, with 15% of all patents, followed by Computers (11%), Semiconductors & Components (9%), and Chemicals (9%).

WHAT DOES THIS TREND MEAN FOR MASSACHUSETTS?

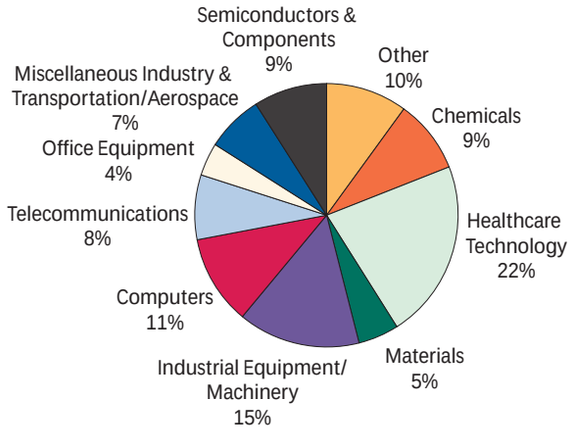
Massachusetts relies on R&D that results in new products and services to sustain its innovation advantage. Idea generation, as captured by strong patent activity, is a crucial element in downstream breakthrough product development and process improvements. Corporations and research institutions in the state should reaffirm their commitment to sustained investment in this aspect of the innovation process. If it is to remain a leader in patent generation, Massachusetts must not become complacent about the need to fund innovative research. As other states focus on becoming more research intensive, it is particularly important for Massachusetts to retain its innovation edge in an increasingly competitive knowledge-based economy.

Number of patents issued to state residents, per capita, Massachusetts and other LTS, 1997 and 1998



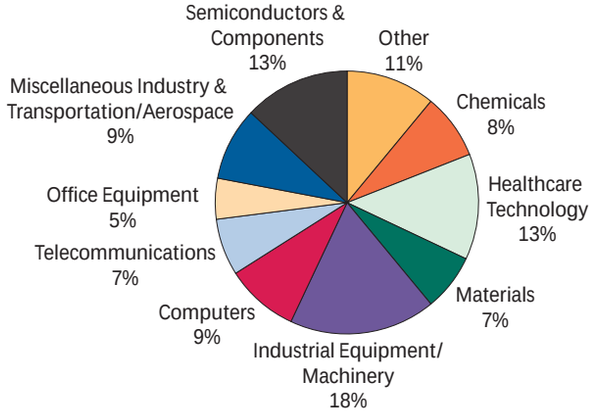
Source: U.S. Patent and Trademark Office, U.S. Census Bureau

Distribution of patents issued, Massachusetts, 1994–1998



Source of pie charts: CHI Research

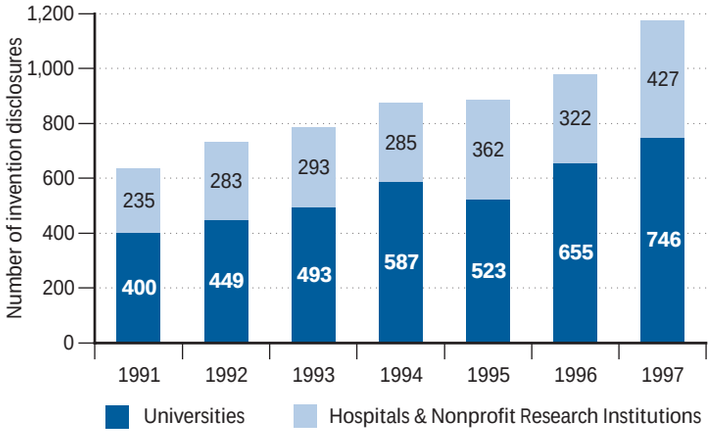
Distribution of patents issued, Massachusetts, 1988–1993



11. Invention and Patent Applications

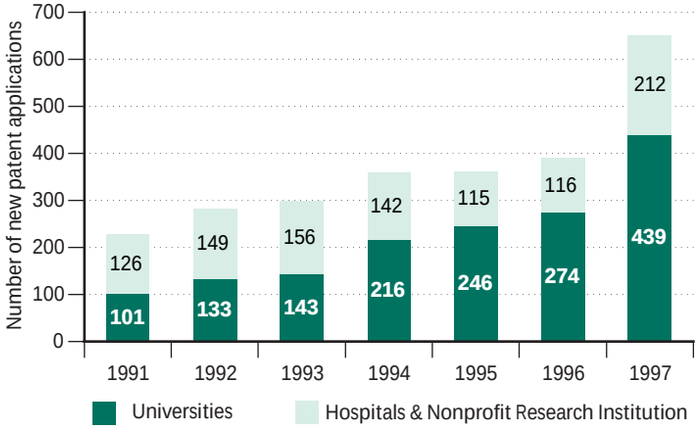
Patent Applications and Invention Disclosures Rise, with Applications Increasing Sharply

Number of invention disclosures received by major universities, hospitals, and nonprofit research institutions, Massachusetts, 1991–1997



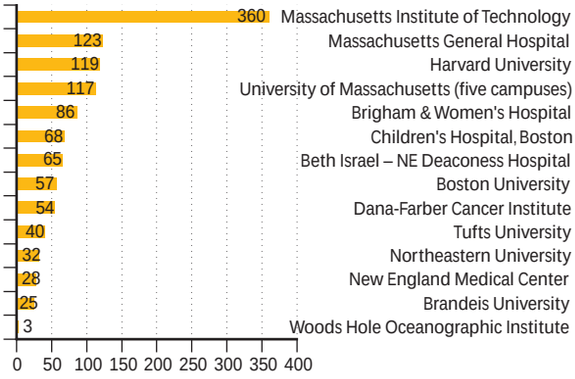
Source: Association of University Technology Managers, Massachusetts Technology Collaborative

Number of new patent applications filed each year by major universities, hospitals, and nonprofit research institutions, Massachusetts, 1991–1997



Source: Association of University Technology Managers, Massachusetts Technology Collaborative

Invention disclosures by institution, Massachusetts, 1997



Source: Association of University Technology Managers, Massachusetts Technology Collaborative

WHY IS IT SIGNIFICANT?

Massachusetts universities, hospitals, and other nonprofit research institutions are important sources of innovative ideas. Individual inventors formally disclose innovations to their sponsoring institutions to initiate the complex process toward patent protection. The next major step following disclosure is formal patent application to the U.S. Patent and Trademark Office. The levels of invention disclosures and formal patent applications reflect the initial registry of innovative ideas or inventions with commercial potential.

Research conducted by major universities, hospitals, and research institutions has a twofold "spillover" effect in the state's economy. First, institutional research induces private investment to capitalize on innovations. Later, the new companies, goods, and services created downstream spur economic vitality.

HOW DOES MASSACHUSETTS PERFORM?

The number of invention disclosures received annually by Massachusetts nonprofit institutions increased 20% from 977 in 1996 to 1,173 in 1997. Since 1991, an average of 64% of invention disclosures was received by universities, with the remainder based in hospitals and research institutions. In 1997, the total number of invention disclosures to major U.S. nonprofit universities, hospital, and research institutions was 10,038.

Of the hospitals and research institutions, Massachusetts General Hospital (MGH) accounted for the most invention disclosures (29%). Significant growth occurred at Brigham and Women's Hospital, Children's Hospital, and New England Medical Center over this period, as well. Among the universities, the Massachusetts Institute of Technology (MIT) alone was responsible for more than half of all the inventions disclosed between 1996 and 1997. Furthermore, the five campus University of Massachusetts system, led by its Medical Center, showed aggressive growth in its invention disclosures, increasing 113% between 1996 and 1997.

New patent applications in Massachusetts rose by nearly 60% between 1996 and 1997 from 390 to 651. The average annual increase from 1991 to 1996 was 11%. The unprecedented growth in patent applications between 1996 and 1997 may be due to the mandatory conversion of provisional patent applications to regular patent applications after a 12-month period. It may also be indicative of a recent change in the examination guidelines for computer-related inventions, which makes software and business methods patentable.

WHAT DOES THIS TREND MEAN FOR MASSACHUSETTS?

Massachusetts demonstrates significant capacity in the early phases of the innovation process, as indicated by the levels of invention disclosures and new patent applications. To realize the full potential of this idea-generation activity, it must be closely linked to commercialization efforts. Innovation network linkages, which connect idea generation to commercial outcomes, must be actively forged and facilitated. Networks between key industry clusters and research institutions are pivotal mechanisms for generating innovations.

12. Technology Licenses and Royalties

Number of New Licenses Sets Record and Reverses Downward Trend; Royalties Continue to Grow

WHY IS IT SIGNIFICANT?

Once a university, hospital, or research institution has a patent, it can enter into a licensing agreement with a company and receive a negotiated fee. This agreement is a step toward commercializing the new idea as a marketable product. The time lag between receipt of a patent and execution of a licensing agreement may, however, be significant.

Licensing revenues are affected by the fields in which research is undertaken and by the degree to which university and other institutional research is focused in areas that can lead to marketable products and profitability rather than other considerations. For example, strategic industry/academic relationships that can strengthen the basic research infrastructure over the longer term can temper short-term gains by the nonprofit institution. The number of new technology licenses and gross royalties derived are indicators of the success of technology-transfer efforts by universities, hospitals, and research institutions.

HOW DOES MASSACHUSETTS PERFORM?

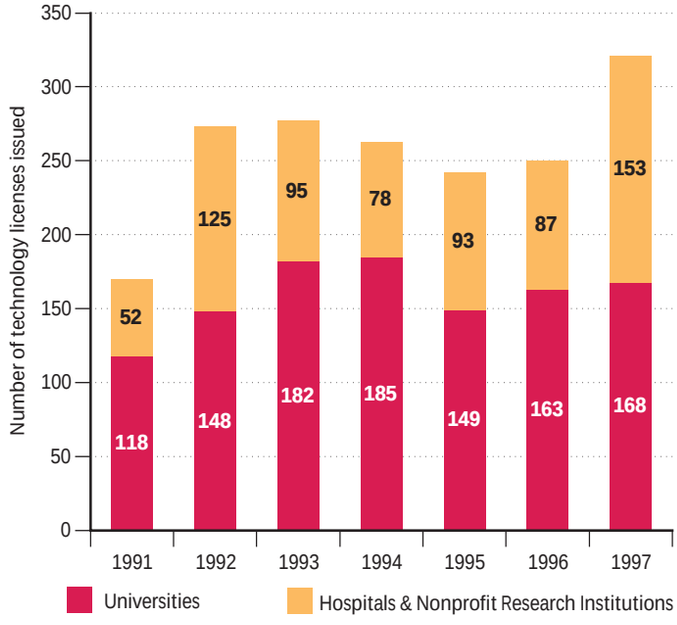
New technology licenses issued by major nonprofit universities, hospitals, and research institutions in Massachusetts rose 28% (to 321) between 1996 and 1997 compared to a 23% increase nationwide. The Massachusetts Institute of Technology (MIT) and Harvard University together generated 85% of the technology licenses in 1997. Since creation of the MIT licensing office a little more than a decade ago, 44% of MIT's licensing agreements can be tracked to local Massachusetts licensees.

Gross royalties received from licensing in Massachusetts increased from $12.3 million in 1991 to $50 million in 1997, with the single sharpest increase (72%) occurring between 1996 and 1997. Nationwide, gross royalties to nonprofit universities, hospital, and research institutions rose 22% from 1996 to 1997. In 1997, the four institutions in Massachusetts receiving the highest amount of royalties were, in descending order, MIT, Harvard, Dana-Farber Cancer Institute, and Brigham & Women's Hospital.

WHAT DOES THIS TREND MEAN FOR MASSACHUSETTS?

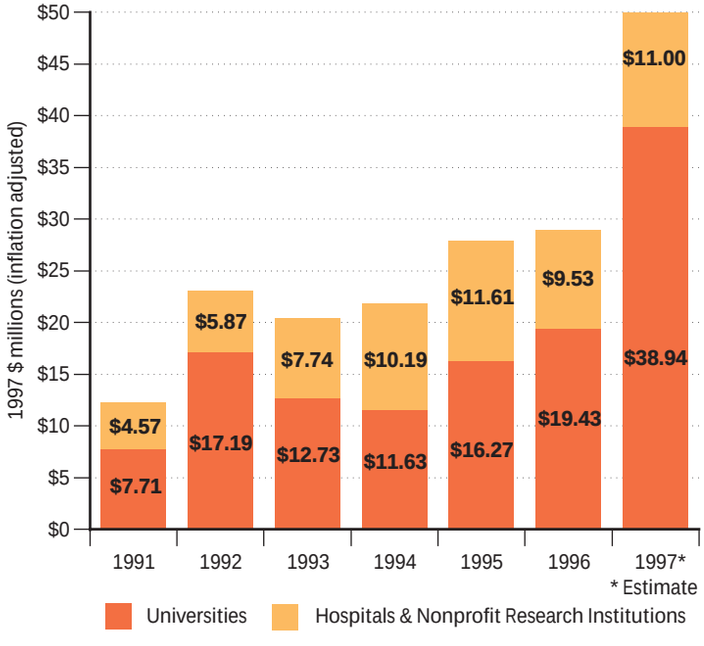
In 1997, major nonprofit universities, hospitals, and research institutions executed a record number of new technology licenses, surpassing the 1992 number of new technology licenses. Growth in the value of licensing has been significant, with a dramatic increase between 1996 and 1997. These positive trends reflect dynamism in the commercialization of applied research. This activity level suggests that this aspect of the innovation process, which depends upon connections between the research and business communities, is strong. Continued strengthening of linkages between these research institutions and businesses is important for maintaining and accelerating technology-transfer efforts.

Number of technology licenses issued by major universities, hospitals, and nonprofit research institutions, Massachusetts, 1991–1997



Source: Association of University Technology Managers

Value of technology licenses outstanding, Massachusetts, 1991–1997

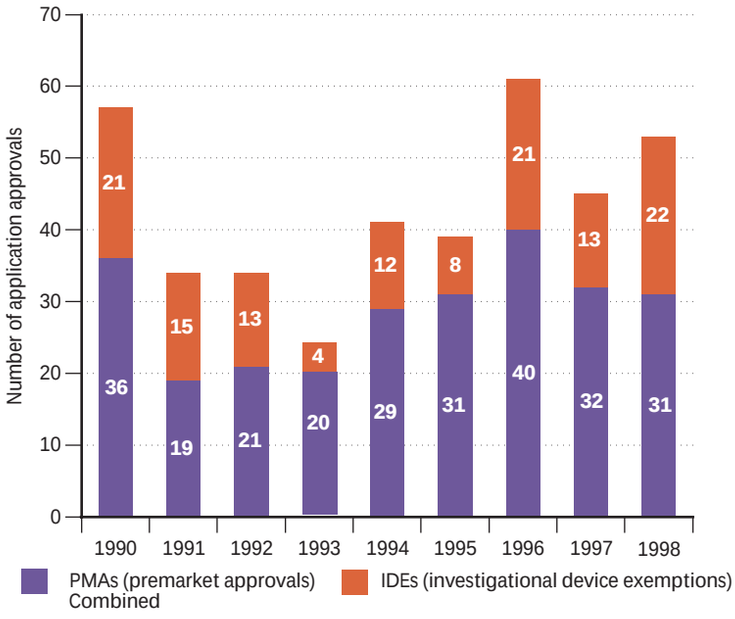


Source: Association of University Technology Managers

13. FDA Approval

Medical Device Applications Show Strong FDA Approval Rate

Number of FDA application approvals for advanced medical devices, Massachusetts, 1990–1998



Source: MassMEDIC, U.S. Food and Drug Administration

WHY IS IT SIGNIFICANT?

The U.S. Food and Drug Administration (FDA) approval process uses three application categories to classify medical devices: investigational device exemptions (IDEs), premarket approvals (PMAs), and 510(k)s for less sophisticated instruments or product improvements. The most complex, the highest-risk, and the newest technologies tend to be classified as IDEs or PMAs. Approval rates reflect innovation in medical device manufacturing and important linkages to the teaching hospitals, where many of these instruments undergo clinical investigation.

HOW DOES MASSACHUSETTS PERFORM?

Massachusetts has consistently ranked among the top states in the nation for approval of IDEs. After a significant decline from 1990 to 1993, IDE approvals in the state nearly tripled from 8 in 1995 to 22 in 1998. IDEs rose by 69% from 1997 to 1998.

The number of PMAs in Massachusetts reflects the concentration of the latest developments in medical device manufacturing. PMAs in Massachusetts dropped slightly between 1997 and 1998. With 31 approvals, Massachusetts ranks third among the Leading Technology States (LTS) behind California and Minnesota, with 116 and 102 approvals respectively.

According to MassMEDIC, the association of medical device manufacturers in the state, more than 230 medical device companies are based in Massachusetts. These firms account for nearly 5% of the state's total manufacturing base and employ more than 23,000 people.

WHAT DOES THIS TREND MEAN FOR MASSACHUSETTS?

FDA approval for advanced medical devices is a critical step in moving from innovative ideas to commercial products in the healthcare field. Timely approval of medical devices enhances the state's competitiveness; it requires cooperation between the federal government and business. While the government should facilitate a timely process, businesses can improve vital communication throughout this review by implementing knowledge management procedures that help to prioritize the flow of information between the FDA and the organization seeking approval for a medical device.

14. New Business Incorporations

New Business Incorporations Decline

WHY IS IT SIGNIFICANT?

The formation of new companies reflects entrepreneurial spirit and innovative thinking in Massachusetts. Increasing numbers of new business ventures are an indicator of an economic environment that encourages innovation and risk taking. New businesses not only provide new jobs but also new products, services, and ideas. A recent ten-country study led by Babson College and the London Business School found that "variation in rates in entrepreneurship may account for as much as one-third of the variation in economic growth."

HOW DOES MASSACHUSETTS PERFORM?

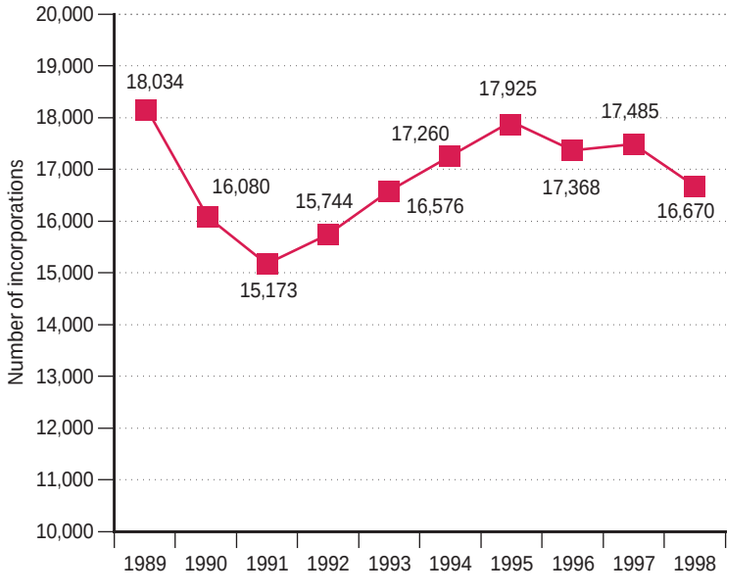
In 1998, 16,670 new business incorporations were registered with the Secretary of State—an approximately 5% decrease from 1997. On a per capita basis, 27 new business ventures were started for every 10,000 residents. Although this rate is up 10% from 1991, it is down 7% from 1995.

For the Massachusetts key industry clusters, the increase in the number of business establishments is concentrated in two areas: Innovation Services and Software & Communications Services. Since 1997, these two clusters added 390 and 369 establishments, respectively. From 1994 to 1998, the number of establishments of these two clusters rose 23% and 50%, respectively. [Establishments can include multiple locations of the same corporation in addition to a new business start.]

WHAT DOES THIS TREND MEAN FOR MASSACHUSETTS?

It is important to determine the causes of the decrease in the number of new business incorporations since 1995. Is it the case that during times of economic growth, new business ventures tend to decrease, because of robust levels of employment in already established companies? While this apparent paradox requires further exploration, it is critical to foster environments throughout the state where new enterprises can incubate and grow, particularly given their demonstrated importance to economic growth. New businesses must have timely access to a supportive network of advisers, financiers, researchers, and employees regardless of economic cycles.

Number of total new business incorporations, Massachusetts, 1989–1998

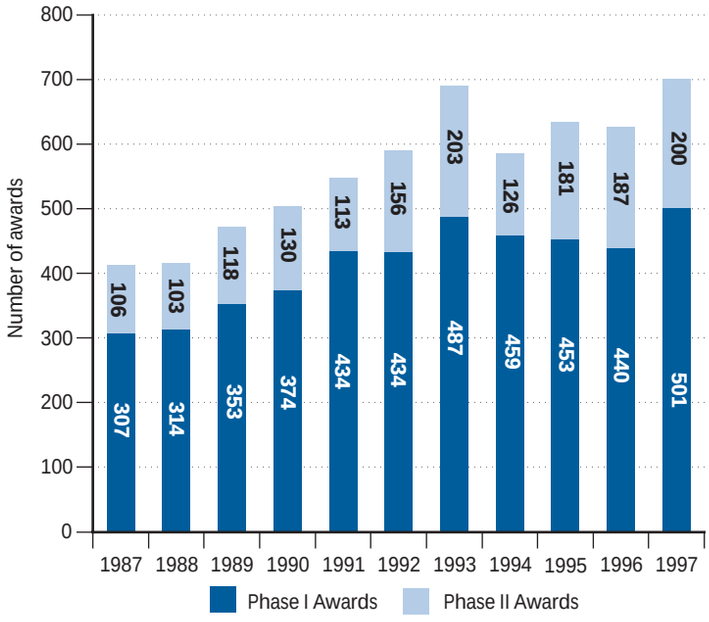


Source: Secretary of the Commonwealth

15. SBIR Awards

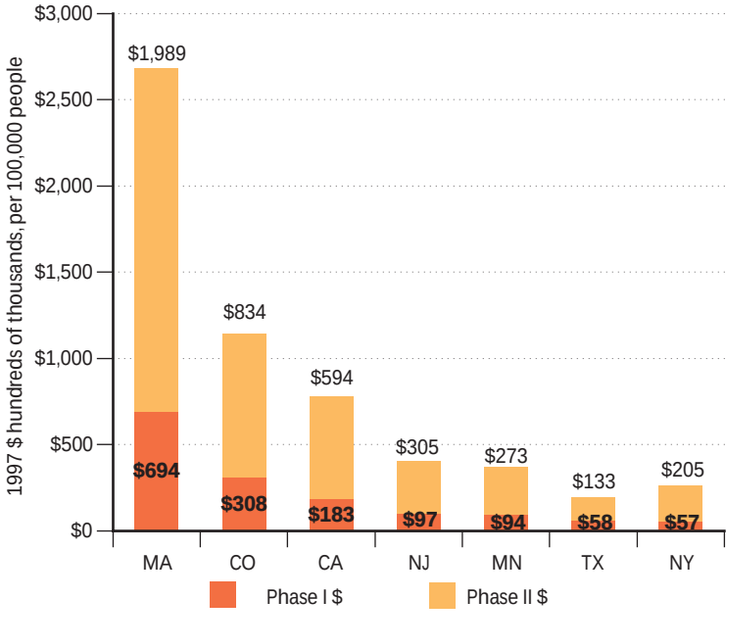
Small Business Innovation Research Awards Increase in Number and Value

Number of SBIR awards to Massachusetts companies by phase, 1987–1997



Source: Small Business Administration

Dollar value of SBIR awards for Massachusetts and LTS, per 100,000 people, 1997



Source: Small Business Administration

WHY IS IT SIGNIFICANT?

The Small Business Innovation Research (SBIR) Program provides competitive grants to entrepreneurs seeking to do "Phase I" proof-of-concept research to establish the technical merit and feasibility of their ideas, and "Phase II" development to build on these findings and further advance their ideas toward commercialization. Nationally, companies that receive funding from Phase II of the SBIR program significantly outperform similar companies that do not receive support. Success in the SBIR program also attracts outside capital investment.

HOW DOES MASSACHUSETTS PERFORM?

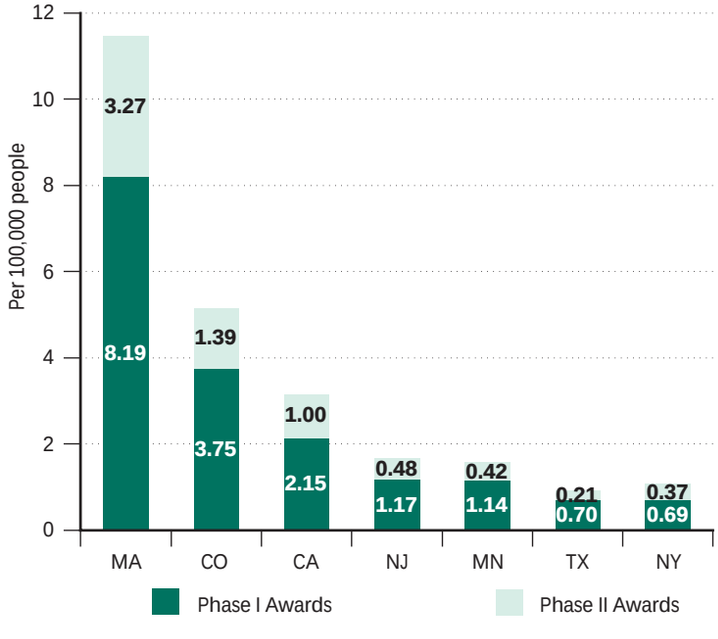
Massachusetts experienced a 12% increase in the total number of SBIR awards received (701) in 1997. Receipt of Phase I awards grew by nearly 14% in this period; Phase II awards rose by approximately 6%. Since the inception of the program in 1983, Massachusetts has consistently ranked second in the total number of SBIR awards received behind California, which had a total of 1,016 awards in 1997. On a per capita basis, SBIR awards to Massachusetts remain four times higher than those to California, and two times higher than those to Colorado.

In 1997, the total dollar value of SBIR awards to Massachusetts companies was $164 million—a record level. Phase II awards are significantly larger in dollar value than Phase I awards and constitute about 75% of all SBIR funding in the state.

WHAT DOES THIS TREND MEAN FOR MASSACHUSETTS?

The success of Massachusetts in this program is an indicator of entrepreneurship and of state and federal support of the R&D intensive entrepreneurial activity in the state. By maintaining its strong support for the SBIR program, Massachusetts sets the stage for continued growth of emerging companies.

Number of SBIR awards to Massachusetts and other LTS companies by phase per capita, 1997



Source: Small Business Administration

16. Mergers & Acquisitions and Initial Public Offerings

IPOs Remain at Record Low Levels in 1998, Signs Point to Increase in 1999; M&As Climb to Record Highs

WHY IS IT SIGNIFICANT?

The number of initial public offerings (IPOs) is an indicator of future high-growth companies. "Going public" raises significant capital to invest and stimulate growth in a company to its next level. A successful IPO reflects confidence by investors that the company can generate increases in value and can sustain growth.

Mergers and acquisitions (M&As) are another important route to liquidity for entrepreneurs and investors in rapidly growing companies. Founders of innovation-based companies may significantly benefit by selling the company to another firm that can develop the technologies and products to the next level. The financial assets and entrepreneurial talent freed through the sale can be aligned with new entrepreneurial ventures.

HOW DOES MASSACHUSETTS PERFORM?

Massachusetts IPO activity continued to decline in 1998 (–13%), although to a much lesser extent than in 1997 (–70%). In Massachusetts, there were only 14 IPOs in 1998, the lowest number since 1990. These IPOs were primarily in Software & Communications Services. California led the Leading Technology States (LTS) in IPO activity in 1998 with 66 IPOs, followed by Texas with 34, and New York with 24. Nationally, there were 310 IPOs in 1998.

In the first half of 1999, the number of IPOs in Massachusetts is equal to the total number of IPOs for all of 1998. Nationally, there have been 219 during the same period.

The gap has widened significantly between the average dollar value of Massachusetts IPOs and those of the nation. In 1998, Massachusetts IPOs generated on average only 43% ($44 million) of the national figure ($103.5 million). The average value of IPOs in Massachusetts has historically trailed that of the U.S.; however, the state lost considerable ground as the value of IPOs nationally rose 70% compared to no change in Massachusetts.

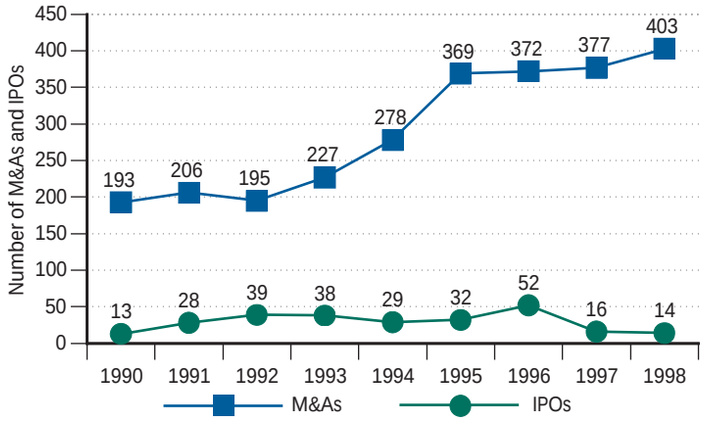
While IPO activity as well as average IPO value continued to fall relative to the nation, M&As in Massachusetts continued to climb steadily to 403 in 1998. This change is a 7% increase from 1997. In 1998, the ratio of M&As to IPOs was 29 to 1 for Massachusetts and 39 to 1 for the U.S.

WHAT DOES THIS TREND MEAN FOR MASSACHUSETTS?

Although volatility in the securities market affects IPO levels, the severe and sustained two-year downturn in Massachusetts is cause for concern. Fewer IPOs can lead to fewer fast-growth companies in the state.

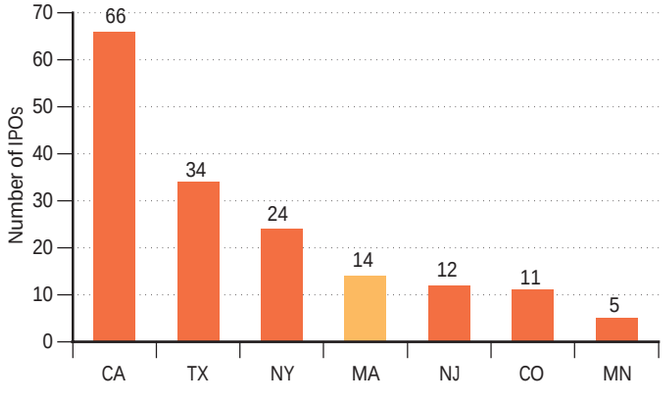
It is not clear how the continued increase in M&As will affect regional economic growth. The local capture of talent and investment following a merger or acquisition is largely a function of the rationale for the change, as well as the location of the headquarters of the acquiring firm.

Number of mergers and acquisitions (M&As) and initial public offerings (IPOs), Massachusetts 1990–1998



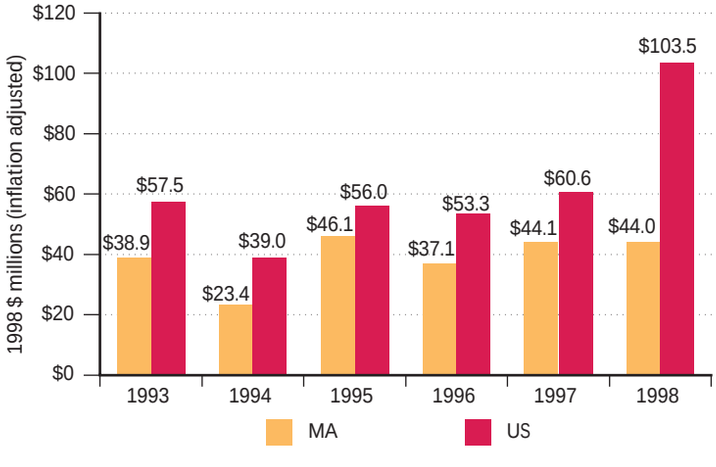
Source: Securities Data Company, Hale and Dorr, LLP

Number of IPOs for Massachusetts and the other LTS, 1998



Source: Hale and Dorr, LLP

Average dollar value of IPOs, Massachusetts and U.S., 1993–1998

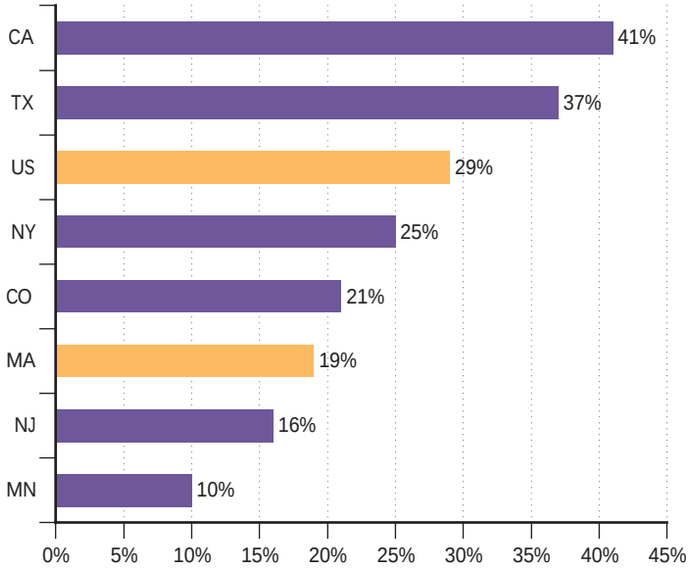


Source: Hale and Dorr, LLP

17. NASDAQ Firms' Market Value

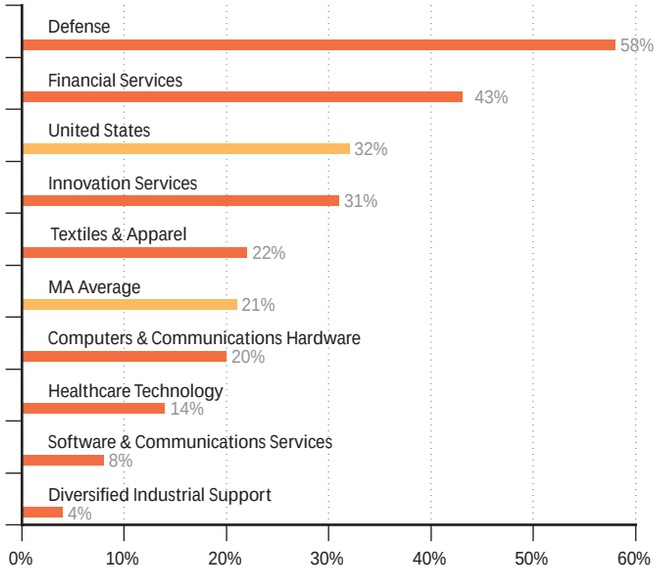
NASDAQ Firms Continue to Have Below-Average Growth in Market Value

Annual average growth rate of total market capitalization for the U.S., Massachusetts, and the other LTS, 1994–1999



Source: NASDAQ, Collaborative Economics

Annual average growth of NASDAQ companies' market value by clusters, Massachusetts, 1994–1999 (inflation adjusted)



Source: NASDAQ, Collaborative Economics

WHY IS IT SIGNIFICANT?

The National Association of Securities Dealers' stock exchange, NASDAQ, is known for its innovative, emerging growth companies. Seventy percent of its listed companies are small, with market capitalization of less than $100 million. NASDAQ is home to some of the nation's fastest-growing technology-based companies.

HOW DOES MASSACHUSETTS PERFORM?

The market value of Massachusetts-based NASDAQ companies grew from more than $39.8 billion in 1994 to $89.6 billion in 1999, when adjusted for inflation. With an annualized growth rate of 21% in this period, Massachusetts trailed the 32% annual growth of all NASDAQ firms in the U.S.

The average annual growth rate of Massachusetts NASDAQ companies between 1994 and 1998 was strongest in Defense (58%), followed by Financial Services (43%) and Innovation Services (31%).

WHAT DOES THIS TREND MEAN FOR MASSACHUSETTS?

Massachusetts small-capitalized firms continue to have below-average market value. Does this performance reflect entrepreneurial capabilities of managers or the industrial mix of emerging firms in Massachusetts? This indicator, in combination with a downturn in business starts and a continued drop in the number of IPOs, signals a need to further assess linkages in the technology commercialization process among research institutions, venture capitalists, and businesses. What collaborative efforts among concerned players might improve the market attractiveness of these Massachusetts firms? The entrepreneurial dynamic in a region is important for jobs and revenue creation; it is a fundamental element in a vital Innovation Economy.

18. Gazelle Companies

Number of Fast-Growth "Gazelle" Companies Continues to Grow

WHY IS IT SIGNIFICANT?

As the United States transitions toward a knowledge-based economy, a new generation of growth-oriented companies is emerging. One benchmark of such growth is the number and distribution of "gazelles"—i.e., publicly traded companies whose sales have grown at an annual average compound rate of 20% or more for the last four years. By generating substantial increases in output and jobs, gazelles stimulate growth of other businesses and personal spending. (David Birch of Cognetics, Inc., in Cambridge, coined the term "gazelle.")

HOW DOES MASSACHUSETTS PERFORM?

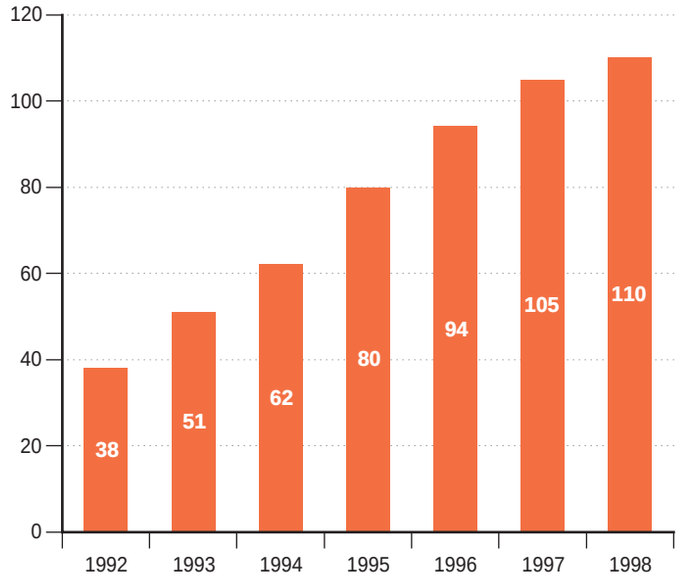
The number of gazelle companies has nearly tripled in Massachusetts since 1992. With 110 gazelles in 1998, Massachusetts continues to cultivate fast-growth businesses among its publicly traded companies. Twenty-seven percent of the state's publicly traded firms are gazelles.

Gazelle companies are well distributed across the Massachusetts key industry clusters. The cluster with the greatest percentage of the total is Healthcare Technology (24%), followed by Computers & Communications Hardware (16%), and Software & Communications Services (14%). Twenty-one percent of the gazelles fall into the "other" category, which spans retail, restaurants, waste management, healthcare, and other diverse services and products.

WHAT DOES THIS TREND MEAN FOR MASSACHUSETTS?

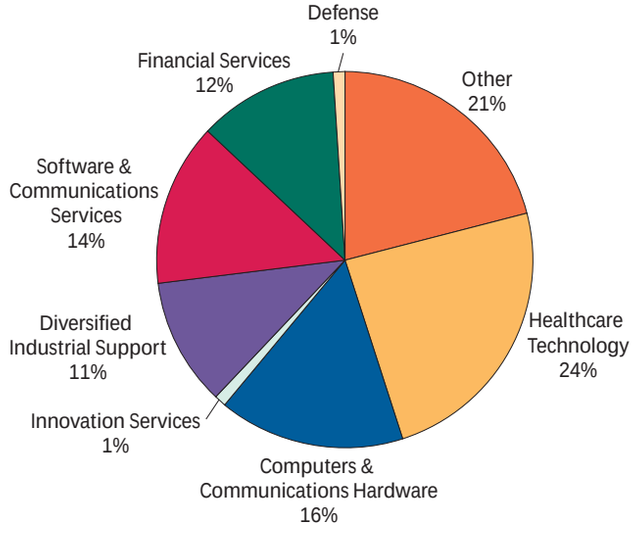
Healthy gazelle growth in publicly traded companies is an important indicator of entrepreneurial and innovative activity in larger-scale businesses. Their aggressive competitive strategies generate employment and revenue growth. By creating jobs in dynamic environments, they also provide relevant career experiences for workers in a rapidly changing Innovation Economy.

Number of publicly traded "gazelle" companies, Massachusetts, 1992–1998



Source: Compustat, Collaborative Economics

Distribution of publicly traded "gazelle" companies, Massachusetts, 1998

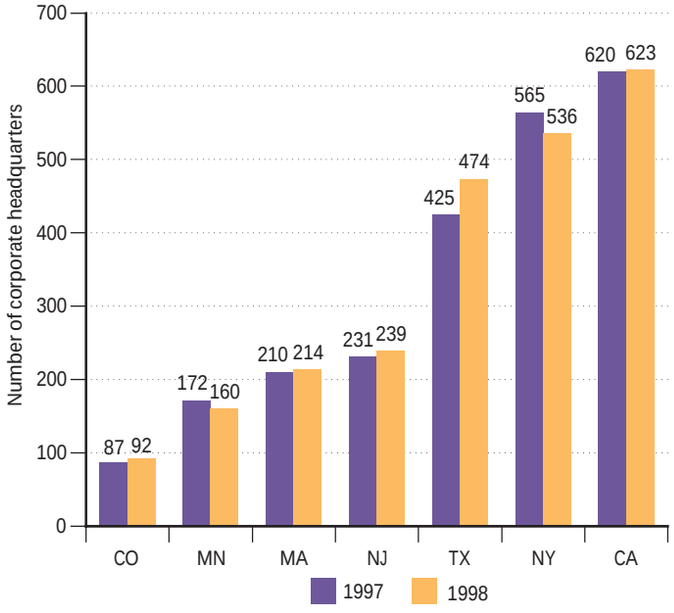


Note: Portions may not sum to 100% due to rounding
Source: Compustat, Collaborative Economics

19. Corporate Headquarters

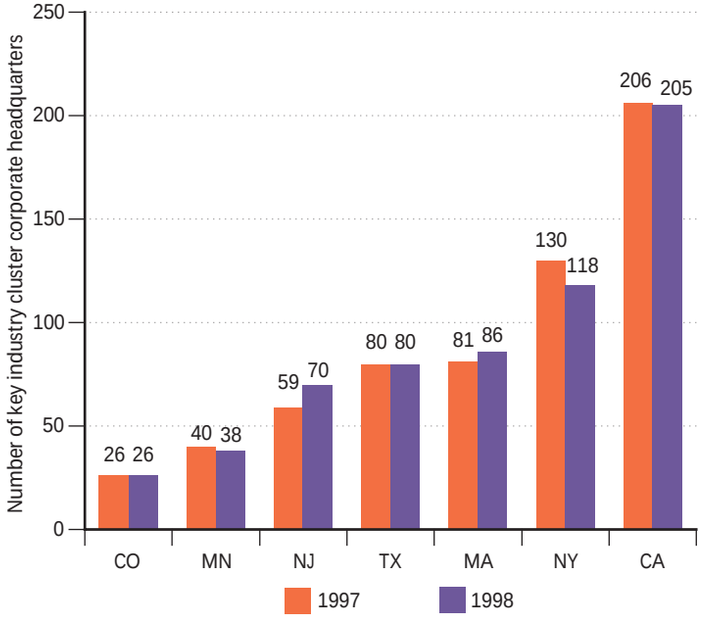
Corporate Headquarters Increase

Number of corporate headquarters located in Massachusetts and the other LTS, corporations with more than 500 employees, 1997 and 1998



Source: American Business Information

Total number of key industry cluster corporate headquarters located within Massachusetts and other LTS, 1997 and 1998



Source: American Business Information

WHY IS IT SIGNIFICANT?

Corporate headquarters are important "anchors" of industry clusters. They spawn new businesses and corporations and typically keep key strategists and development-related activities located close by. Corporate headquarters tend to have greater community ties, including philanthropic support, than do branch plants.

HOW DOES MASSACHUSETTS PERFORM?

In 1998, Massachusetts was home to the corporate headquarters of 214 firms with more than 500 people, an increase of 2% since 1997. Of the other six Leading Technology States (LTS), Texas (12%) experienced the most growth in corporate headquarters, with more than 500 employees during this period. In California, corporate headquarters grew by less than 1%.

Jumping from 81 to 86, Massachusetts showed moderate growth (6%) in the number of corporate headquarters in its key industry clusters between 1997 and 1998. Of the other six LTS, only New Jersey (19%) surpassed the growth of Massachusetts; all the others either stayed the same or lost headquarters.

WHAT DOES THIS TREND MEAN FOR MASSACHUSETTS?

Although some large corporate headquarters have been lost in Massachusetts through mergers and acquisitions, in recent years the number of significantly sized companies headquartered in Massachusetts is growing. With its excellent business climate and highly skilled professional and technical workers, Massachusetts is an attractive site for corporate headquarters, which are often the primary location for the firm's research and entrepreneurial activities. The spillover benefits to the larger community are also valuable. Massachusetts should actively seek to retain the headquarters of newly emerging firms as well as promote itself to other R&D and headquarter facilities located outside the state.

20. Value-Added per Employee

Value-Added per Employee Trails LTS Average

WHY IS IT SIGNIFICANT?

High and increasing value-added per employee in companies fosters high and increasing incomes for workers. Value-added—derived by subtracting the costs of a company's materials, inputs, and contracted services from the final revenue of its outputs—indicates how much economic value is created by the company. (See Appendix B for a more detailed definition.) Increased innovation—the development of more high-value goods and services or of more efficient processes that reduce production costs—is an important factor driving increases in value-added.

HOW DOES MASSACHUSETTS PERFORM?

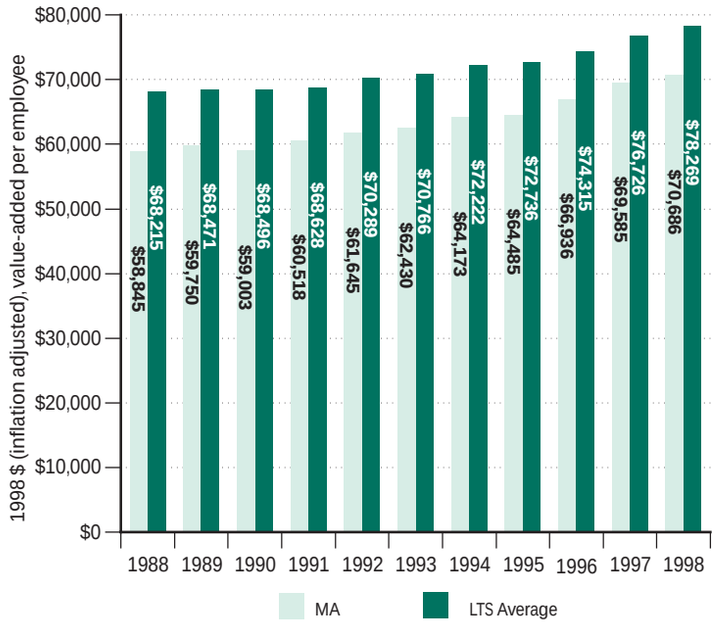
Value-added per employee in Massachusetts has grown almost 20% in inflation adjusted terms since 1990. Value-added in Massachusetts continues to trail the Leading Technology States (LTS) average. The gap between the two has narrowed since 1990, although in 1998 Massachusetts lost some ground.

Massachusetts value-added trails that of the LTS in five industry clusters—Computers & Communications Hardware, Financial Services, Software & Communications Services, Diversified Industrial Support, and Healthcare Technology.

WHAT DOES THIS TREND MEAN FOR MASSACHUSETTS?

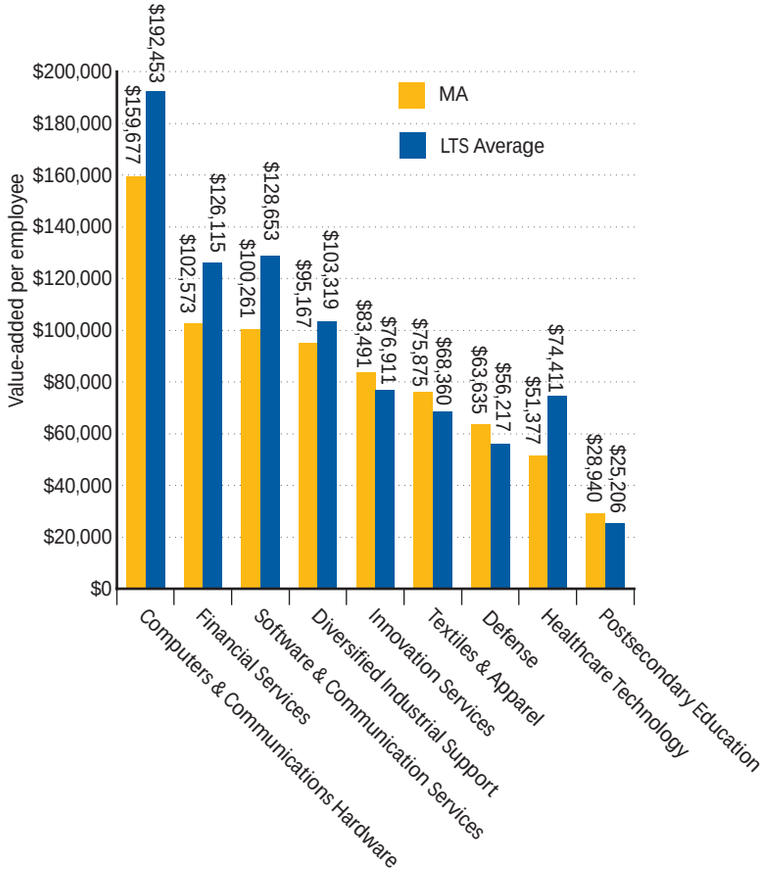
As a broad indicator, the upward trend in value-added in Massachusetts is positive. The lingering question, however, is why Massachusetts value-added is consistently below the average for the other LTS. One possible contributor to this trend is that upward pressures on wages due to shortages of skilled workers can decrease value-added per employee.

Historic growth of overall value-added per employee, Massachusetts and other LTS, 1988–1998



Source: Regional Financial Associates, Collaborative Economics

Value-added per employee, nine key industry clusters, Massachusetts and other LTS average, 1998



Source: Regional Financial Associates, Collaborative Economics

21. Migration

Foreign Talent Aids Innovation Churn as It Increases Labor Force

WHY IS IT SIGNIFICANT?

Labor force expansion can help to sustain the economic growth of a region as employers have a larger pool of workers from which to hire. Alternatively, labor shortfalls, particularly in areas of high demand, can constrain economic growth as employers experience staffing shortages, higher wages, or both. The in-migration of talent is an important source of innovation churn, as foreign-trained talent introduces new perspectives and methods.

HOW DOES MASSACHUSETTS PERFORM?

Immigration has an important role in the growth of the Massachusetts population and the dynamism of the state's Innovation Economy. Each year from 1991 to 1998, Massachusetts experienced domestic out-migration. In 1998, more than 8,000 people moved from Massachusetts to other states; this is the smallest amount of out-migration in this decade.

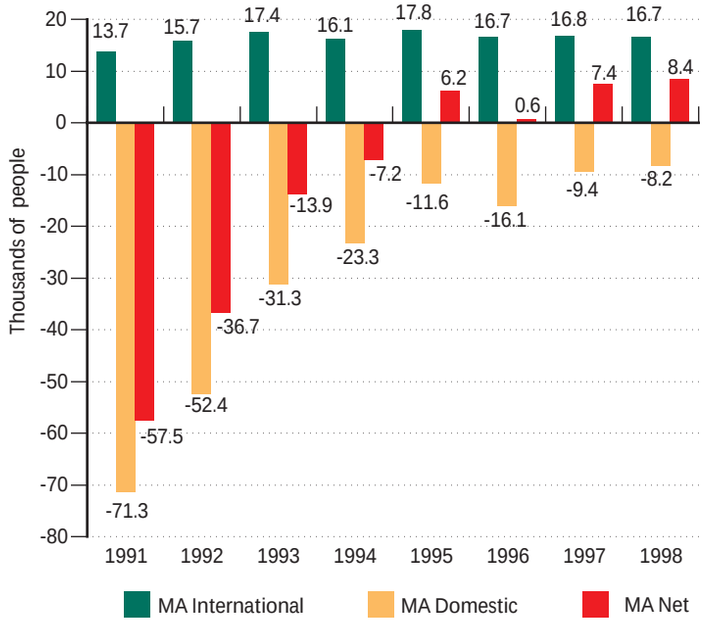
International immigration supplements the skilled workforce needed to drive a range of innovation needs from basic research at university and teaching hospitals to successful product development in businesses.

Nearly one-quarter of the foreign immigrants to Massachusetts occupied highly skilled management, professional, and technical positions in 1998, down from one-third in 1996. This 1998 number compares with 51% of foreign immigrants to Minnesota employed in highly skilled positions, 40% in New Jersey, 21% in California, 14% in Colorado, 11% in New York, and 5% in Texas.

WHAT DOES THIS TREND MEAN FOR MASSACHUSETTS?

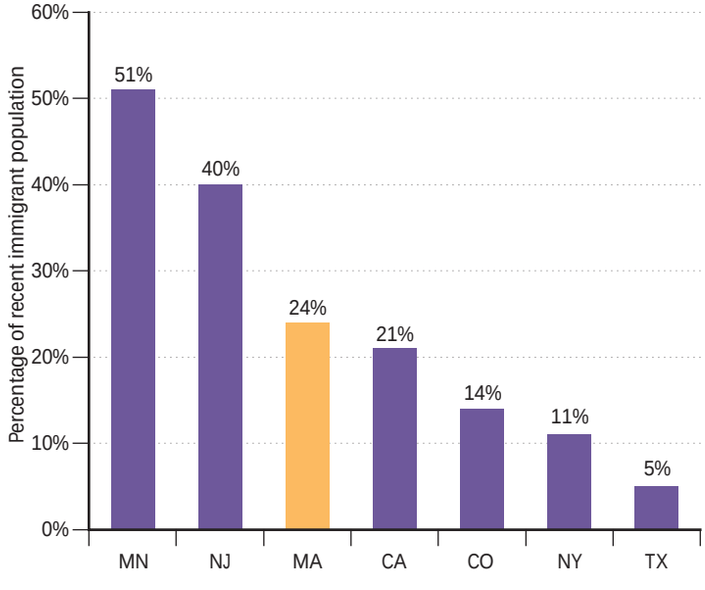
Immigration of skilled workers continues to be an important ingredient for the economic success of Massachusetts. Given the slow growth of the local workforce and the importance of providing a catalyst for innovation through the infusion of new perspectives and approaches, Massachusetts continues to look toward the in-migration of talented workers from other states and countries. The state faces a dual challenge involving educating and retraining the local workforce and encouraging continued in-migration of skilled workers.

International and domestic migration, Massachusetts, 1991–1998



Source: Mass Insight, Regional Financial Associates, U.S. Census Bureau

Percentage of recent foreign immigrant population to Massachusetts and other LTS in highly skilled management, professional, and technical occupations, 1998

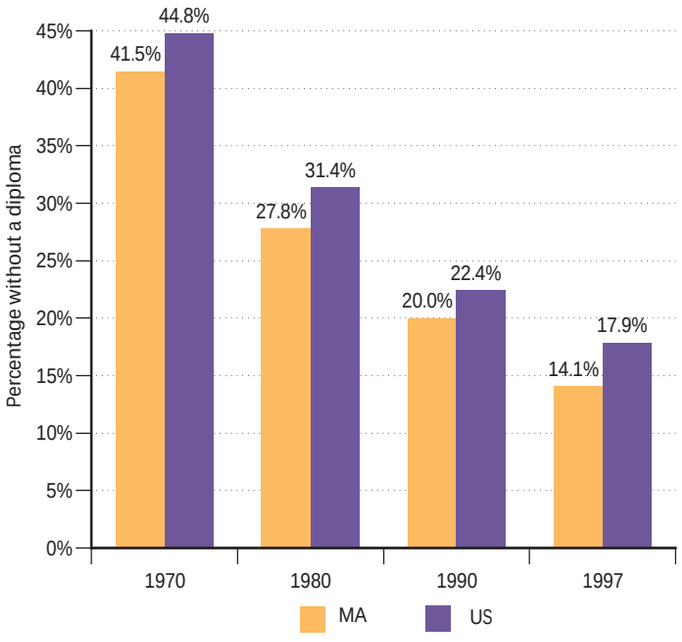


Source: Mass Insight, Northeastern University, U.S. Census Bureau

22. Workforce Education

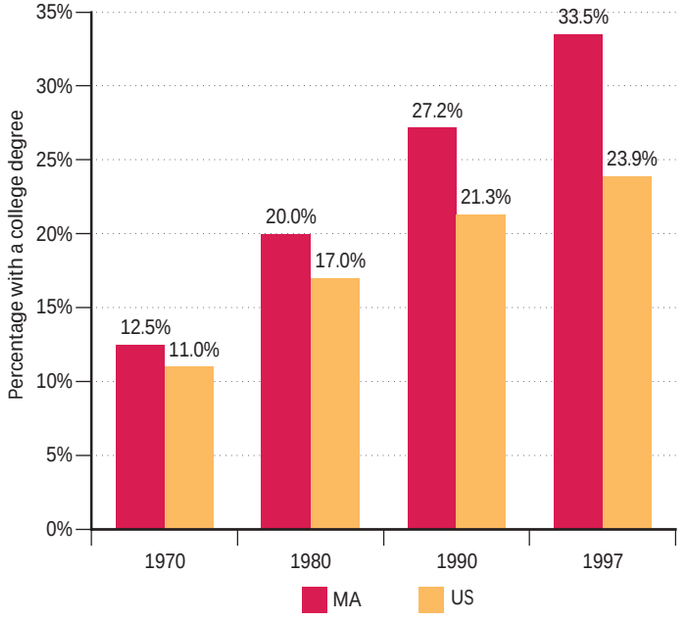
Massachusetts Expands Its Competitive Advantage with a Well-Educated Population

Percentage of the adult population without a high school diploma, Massachusetts and the U.S., 1970–1997



Source: U.S. Census Bureau

Percentage of the adult population with a college degree, Massachusetts and the U.S., 1970–1997



Source: U.S. Census Bureau

WHY IS IT SIGNIFICANT?

The educational attainment levels of the workforce are a fundamental indicator of how well a region can generate and support knowledge-based, innovation-driven economic growth. Education and skills levels reflect labor force quality and are of primary concern to employers. Strong math, scientific, and communications skills are a prerequisite for many occupations, now requiring a minimum of a high school diploma, if not a college degree.

HOW DOES MASSACHUSETTS PERFORM?

In Massachusetts and the nation, the number of people without a high school diploma has fallen considerably. By 1997, 14.1% of the Massachusetts population did not have a high school diploma, compared to 17.9% nationwide. This change represents a 6% decrease in the number of people without secondary school degrees from 1990 for Massachusetts, with a corresponding national decrease of 5%.

Over one-third of the Massachusetts population had a college degree in 1997, compared to a little less than one-quarter nationwide. Between 1990 and 1997, the percentage of Massachusetts residents with a college degree climbed by about 6%. The corresponding national increase was nearly 3%. Since 1970, Massachusetts has nearly tripled the percentage of its residents with college degrees; nationwide, the percentage doubled during this period.

WHAT DOES THIS TREND MEAN FOR MASSACHUSETTS?

A longer-term look at educational attainment levels of the Massachusetts and national adult population highlights the relatively well-educated workforce that Massachusetts has grown over time, compared to that of the nation. These competitive human resources will help fuel Massachusetts leadership role in the new knowledge-based economy. Massachusetts should continue to promote higher education and make it accessible to its residents; it should ensure that students have the prerequisite skills and opportunities to obtain a college degree. The state must also foster a dynamic workplace and social/cultural environment that will encourage well-educated college students to remain in the Commonwealth after graduation. State policies that promote greater housing availability and affordability would also help encourage highly skilled graduates to remain in the state.

23. Engineering and Computer Science Degrees

Engineering Degrees Awarded Show First Sign of Reversing Long-Term Decline

WHY IS IT SIGNIFICANT?

Regions that are well-served by postsecondary engineering and computer science programs have a strong workforce advantage in the creation of new products and ideas. The potential pool of new engineers and computer scientists for technology-related industries is an important indicator of future workforce resources.

HOW DOES MASSACHUSETTS PERFORM?

After a significant and continued decline relative to that of the nation, the total number of engineering degrees awarded in Massachusetts increased from 4,515 in 1997 to 4,578 in 1998.

At the undergraduate level, the number of degrees awarded by Massachusetts schools increased 3.1% from 1996–1997 to 1997–1998 (2,456 versus 2,533). Nationally, undergraduate engineering degrees decreased (–3.0%) during the same period.

At the graduate level, the number of engineering degrees awarded by Massachusetts institutions continued to decline from 1996–1997 to 1997–1998 but at a slower rate than nationwide, –2.5% versus –2.0% respectively. Moreover, where the number of master's degrees awarded fell by almost 3.5%, at the doctoral level, engineering degrees awarded rose by 12.9%.

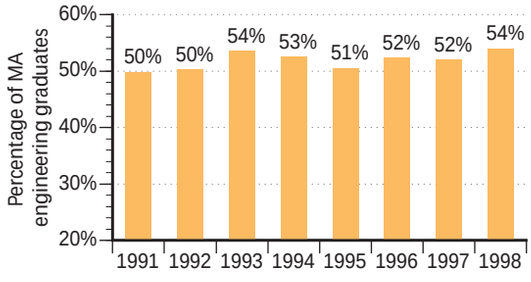
In computer science, the number of undergraduate degrees awarded by Massachusetts institutions increased by 5.1% between 1995 and 1996 (latest data available). At the graduate level, there was a slight increase in doctorates (3.0%) but also a slight decrease in the numbers of master's degrees granted over the same period (–2.2%).

A survey of engineering colleges and universities by the Massachusetts Technology Collaborative found that on average just over half (54%) of the engineering graduates stayed in the state after graduation in 1998. This percentage has been relatively constant over the past five years.

WHAT DOES THIS TREND MEAN FOR MASSACHUSETTS?

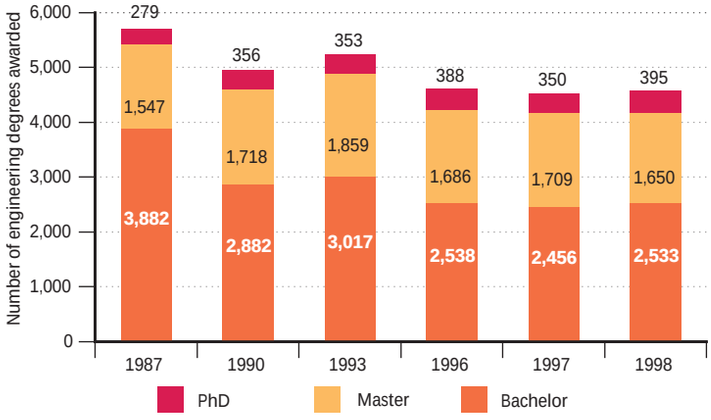
Engineering and technical talent continues to play a critical role in the Massachusetts Innovation Economy. Declining numbers of engineering and computer science graduates can inhibit growth in technology-related sectors. The recent increases in the number of degree recipients at the bachelor's and doctoral degree levels is a welcome change. The total number of technical graduates, however, continues to be well below the figures in the mid-1980s. How can the state encourage and prepare more young women and men to enter and complete engineering and computer science programs? In addition, what steps can the state take to retain a greater percentage of engineering and technology students after graduation? The Engineering in Massachusetts Collaborative (EiMC) is one example of an effort among businesses, schools, and higher education institutions that seeks to increase the number of engineers produced in Massachusetts.

Percentage of Massachusetts engineering graduates still living in Massachusetts, by year of graduation, 1991–1998



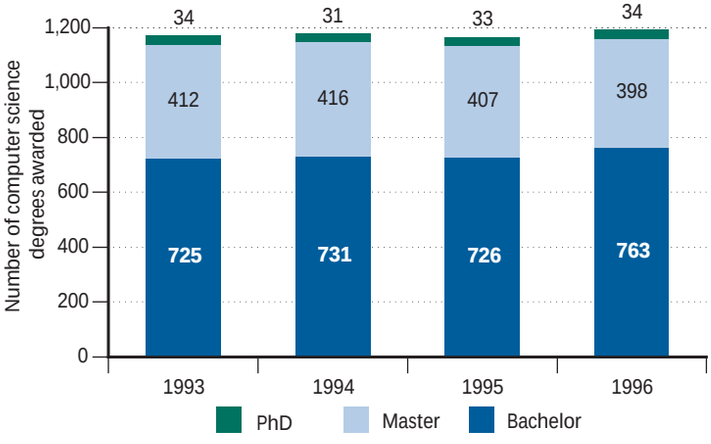
Source: Massachusetts Technology Collaborative Engineering Survey

Number of engineering degrees awarded by Massachusetts schools, by degree level, 1987–1998

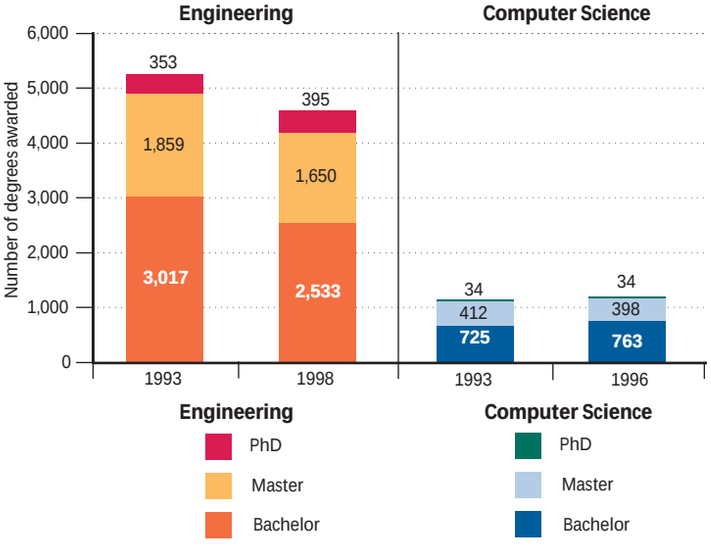


Source: American Association of Engineering Societies, National Science Foundation

Number of computer science degrees awarded by Massachusetts schools, by degree level, 1993–1996



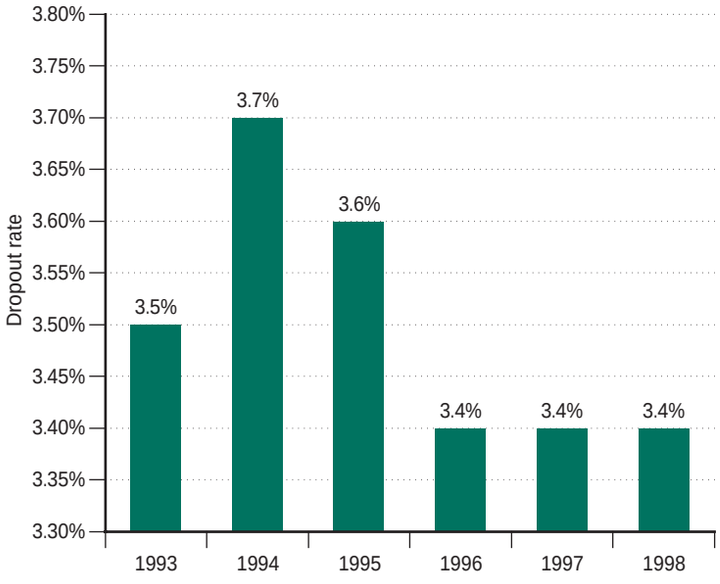
Number of engineering and computer science degrees awarded, by Massachusetts schools, by degree level, 1993, 1998, 1993, 1996



24. Dropout Rates

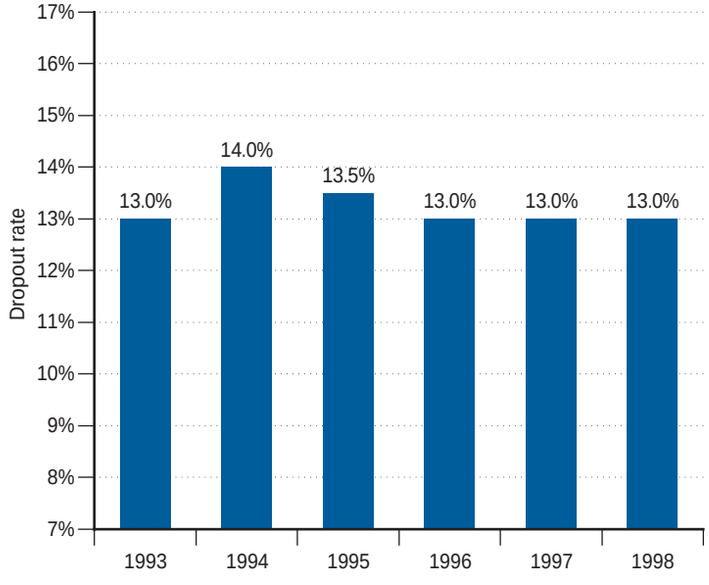
Progress across Race/Ethnicity Is Mixed

Percentage of all high school students who drop out each year, Massachusetts, 1993–1998



Source: Massachusetts Department of Education

Estimated percentage of ninth grade students dropping out before high school completion, Massachusetts, 1993–1998



Source: Massachusetts Department of Education

WHY IS IT SIGNIFICANT?

Most quality jobs require a high school diploma, at a minimum. The high school dropout rate is a risk indicator that warns of lost potential and future societal costs. The need to develop home-grown talent is especially critical in a Massachusetts environment of slow labor force growth.

HOW DOES MASSACHUSETTS PERFORM?

The annual dropout rate was 3.4% for high school students in 1998. Remaining at 3.4% for the past three years, this rate is the lowest in a decade. (This annual rate means that 3.4% of the ninth to twelfth graders enrolled in the state's public schools in the fall of 1997 did not return in 1998 for reasons other than transfer.)

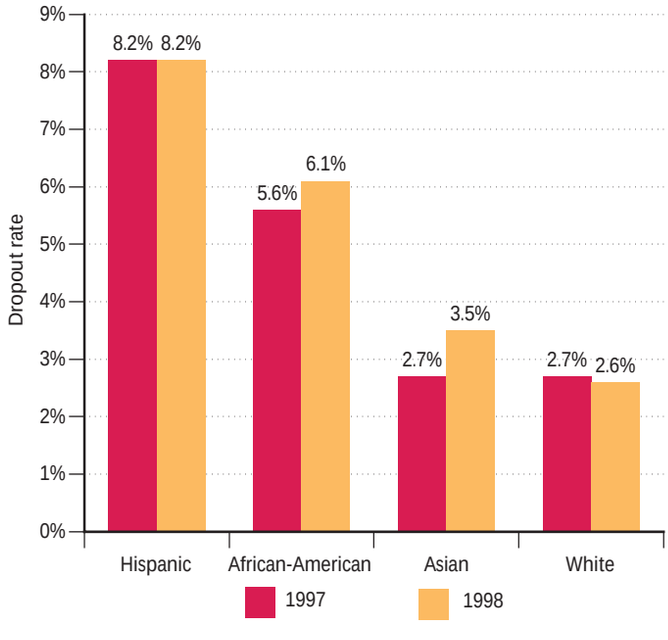
The projected cumulative dropout rate for the entering class of 1998 is estimated at 13.0% over the four-year high school period. The projected high school dropout rate has remained relatively steady since 1993.

Dropout rates vary widely across race and ethnicity. White students, at a 2.7% annual rate in 1998, are the least likely to dropout, followed by Asian students at 3.5%. Other racial and ethnic groups are at significantly higher risk, with African-American students at 6.1% and Hispanic students at 8.2%. The dropout rate in Massachusetts for each racial/ethnic group either increased or remained constant from 1997 to 1998 except for White students, whose dropout rate fell slightly from 2.7% to 2.6%.

WHAT DOES THIS TREND MEAN FOR MASSACHUSETTS?

The Commonwealth's ability to maintain a low and steady dropout rate should be acknowledged. However, it is also important for the state to focus attention on the diverse experiences of racial/ethnic groups, including the relatively high Hispanic dropout rate and the rising Asian and African-American dropout rate. Because education is a key factor in economic and social mobility, the state should work in partnership with local educators and community groups to foster programs that help all individuals graduate from high school.

Percentage of students who dropped out of high school each year by ethnicity, Massachusetts, 1997 and 1998



Source: Massachusetts Department of Education

25. NAEP Scores

Eighth Graders Score Well on Competitive Reading Test

WHY IS IT SIGNIFICANT?

The future vitality of the Massachusetts Innovation Economy depends on the skills and knowledge of the state's workforce. The academic performance of K-12 students is an indicator of the quality of that future workforce. Strong skills in reading and communications are a prerequisite for the acquisition of advanced education and experience and for lifelong learning. This is particularly the case in industry areas and occupations that are being generated by the Internet—a major communications tool.

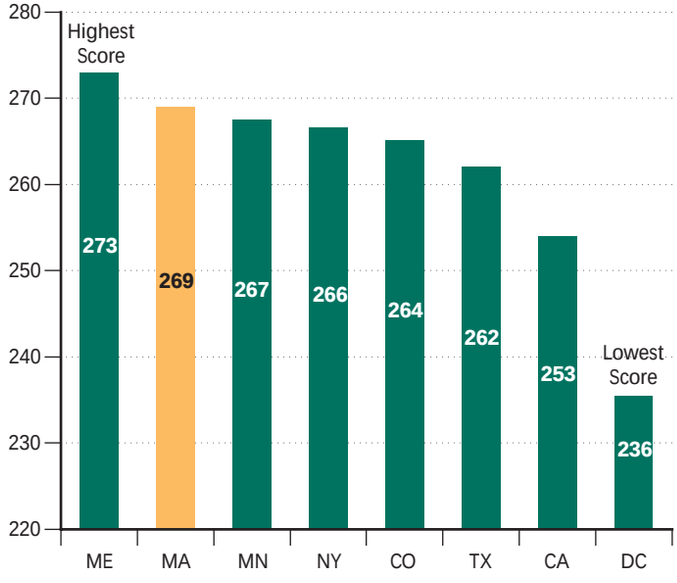
HOW DOES MASSACHUSETTS PERFORM?

Eighth graders in Massachusetts scored well in 1998, relative to eighth graders in the United States and eighth graders in the other Leading Technology States (LTS) who participated in the National Assessment of Educational Progress (NAEP). In 1998, Massachusetts eighth graders led the LTS in reading with a score of 269 out of a possible 500. When looking at "best in class," of all states that participate in NAEP, Massachusetts ranked second behind Maine (273) in the reading test scores.

WHAT DOES THIS TREND MEAN FOR MASSACHUSETTS?

Massachusetts students perform well relative to their counterparts in the other LTS states in reading. Although it is imperative that the state continue to focus on math and science competence, it cannot neglect programs which advance reading and other communications skills, which are highly valued by employers and which are of great importance in the information age. Career areas are growing as the Internet and e-commerce create a next generation of industry occupations and specialties that increasingly focus on content development. For Massachusetts to be on the cutting edge of new industries that leverage the Internet as a communications tool, it must assure excellent skills in both reading and writing on the part of its future workforce.

NAEP mean reading scores, grade eight public schools, Massachusetts, five other LTS, Maine and the District of Columbia, 1998

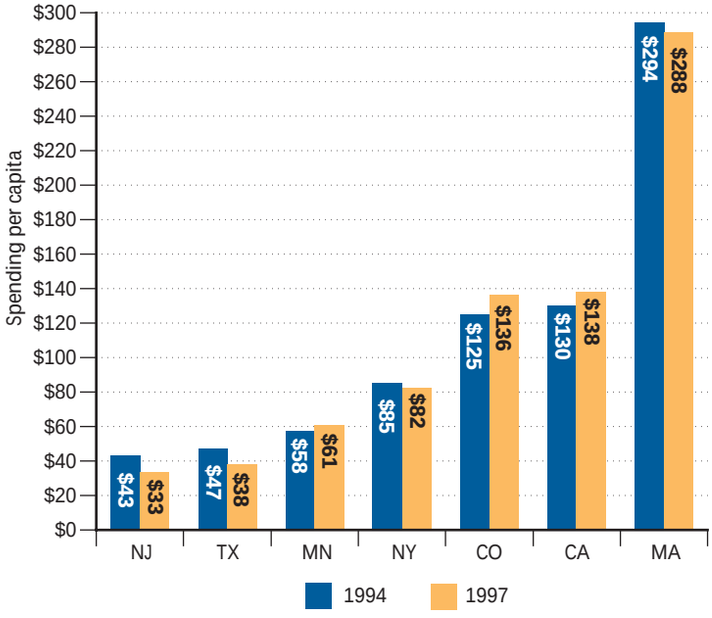


Source: National Assessment of Educational Progress

26. Federal R&D Spending

Per Capita Federal R&D Spending at Academic Institutions Is the Highest of LTS

Federal R&D expenditures in academic and nonprofit research institutions, per capita, Massachusetts and other LTS, 1994 and 1997 (1997 $ inflation adjusted)



Source: National Science Foundation

WHY IS IT SIGNIFICANT?

Research universities and other academic centers play a distinctive role in the Massachusetts economy, and federal R&D spending is a primary source of funding. R&D conducted by academic and nonprofit research institutions has a pronounced inducement effect in stimulating private-sector R&D. Federal R&D support is also important to many industry clusters in Massachusetts, including Defense, Healthcare Technology, and Innovation Services.

HOW DOES MASSACHUSETTS PERFORM?

Massachusetts has the highest per capita federally funded R&D expenditures ($288) of the Leading Technology States (LTS), with the next closest LTS, California, at 64% of the Massachusetts level. Total federal R&D spending at Massachusetts academic institutions and nonprofit research centers—such as teaching hospitals—was $1.76 billion in 1997.

From 1994 to 1997, federally funded R&D expenditures per capita at Massachusetts academic and nonprofit research institutions decreased 2%, when adjusted for inflation. This funding is in contrast to the LTS state average of more than a 6% decrease. Massachusetts researchers continue to excel at winning support for their work through the competitive, peer-review system of federal research grants.

WHAT DOES THIS TREND MEAN FOR MASSACHUSETTS?

Federally funded research in Massachusetts remains relatively high. Other states have, however, gained ground in recent years.

Federal R&D funds are a critical factor in the Innovation Economy, one that the state needs to monitor and advocate for aggressively. Activities to maintain and possibly increase the Massachusetts share of federal R&D need to be increased. The state must also adopt policies—tax and regulatory—which maintain the entrepreneurial environment in which the investment in applied research can result in downstream commercial products and services. These elements require strengthening the links in the innovation process through the facilitation of innovation networks in which collaboration between and among businesses, universities, and other research institutions can occur.

27. Federal Health R&D

Health R&D Funding Is the Highest of LTS; Gap between Competitors Continues to Grow

WHY IS IT SIGNIFICANT?

The National Institutes of Health (NIH) funds 25% of all federal and nonfederal health-related basic research in the United States. It is the largest source of federal funding for nondefense research. NIH-funded research for our universities and teaching hospitals 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 expenditures occur through the NIH.

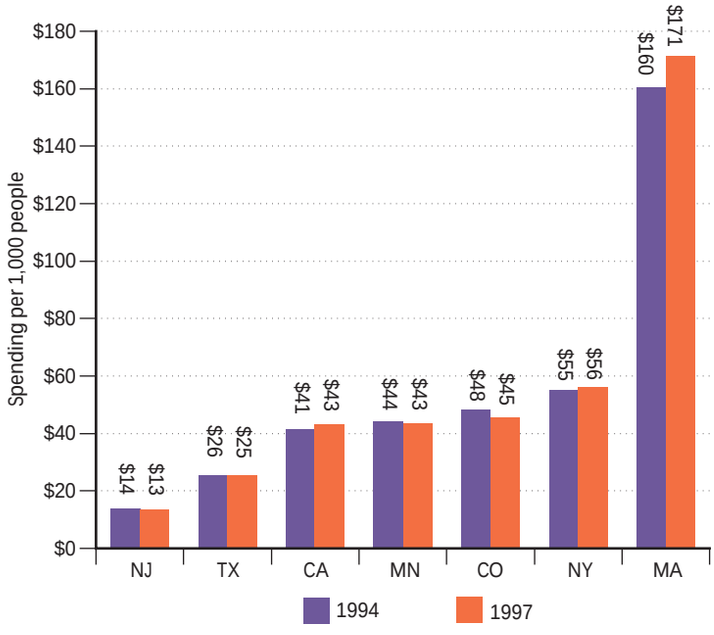
HOW DOES MASSACHUSETTS PERFORM?

Massachusetts has the highest per capita federally funded health R&D expenditures of the six other Leading Technology States (LTS). With federal health R&D spending obligations of $171 for every 1,000 residents, the state's funding is more than three times greater than that of the closest LTS, New York ($56). Funding for Massachusetts has consistently increased in inflation adjusted terms and relative to that of the other LTS. Since 1994, HHS funding for Massachusetts increased 8%, compared with 4% for the six LTS.

WHAT DOES THIS TREND MEAN FOR MASSACHUSETTS?

Massachusetts sets itself apart as a leader in health-related R&D. This situation has major positive implications for the state's ability to maintain a competitive Healthcare Technology cluster. Yet, this competitive position needs to be understood in relation to the impact of changes to the federal Medicare reimbursement system for teaching hospitals. These reimbursement changes will require teaching hospitals to scale back on many research-related activities, as they redirect funding to fill gaps in patient care and medical education costs. These research-related activities at our premier teaching hospitals are an integral part of bringing healthcare technology from concept to market.

U.S. Department of Health and Human Services R&D expenditures, per capita, Massachusetts and other LTS, 1994 and 1997 (1997 $ inflation adjusted)

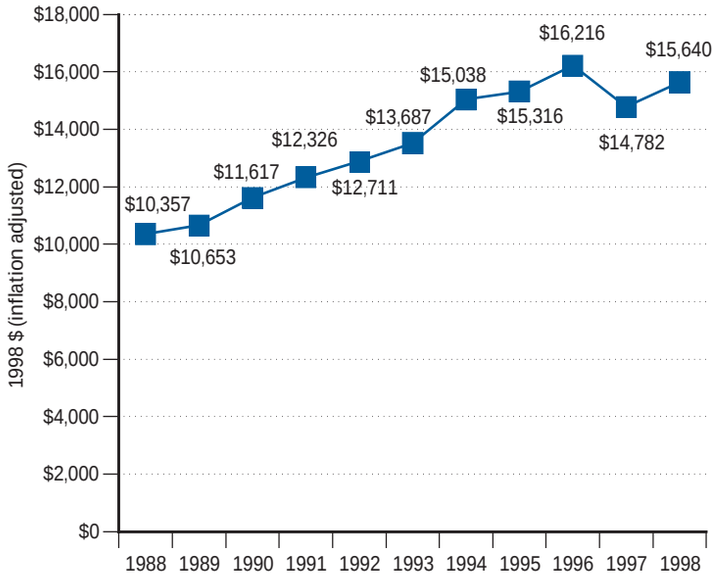


Source: National Science Foundation

28. Corporate R&D per Employee

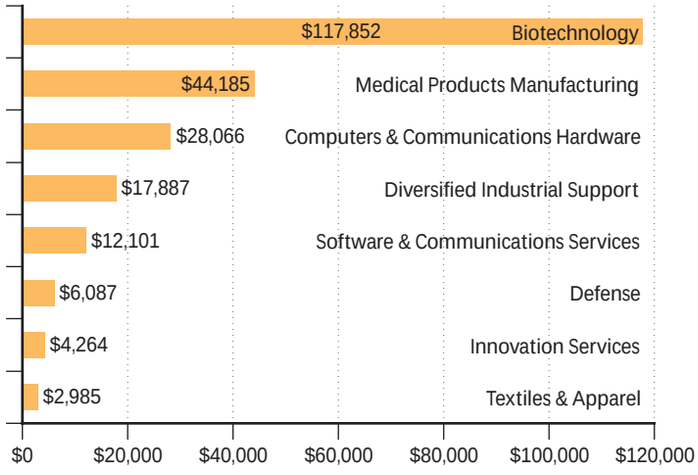
Large Variations Exist in Corporate R&D Investment among Clusters

Corporate R&D expenditure per employee, publicly traded companies with R&D expenditures, Massachusetts, 1988–1998



Source: Compustat, Collaborative Economics

Corporate R&D expenditure per employee by industry sector, publicly traded companies with R&D expenditures, Massachusetts, 1998



Source: Compustat, Collaborative Economics

WHY IS IT SIGNIFICANT?

Corporate research and development (R&D) spending is an important indicator of how companies are investing in their future. R&D is essential for developing new products and services that help companies stay on the cutting edge, grow, and produce more jobs. Nationally, companies provide about 85% of the investment dollars in R&D. Industrial R&D spending in the United States during 1998 was estimated at $163.3 billion. This spending represents more than one-third of the world's investment in research and development.

HOW DOES MASSACHUSETTS PERFORM?

Corporate R&D spending per employee has grown 51% in inflation adjusted terms from 1988 to 1998 among Massachusetts publicly traded firms. In 1998, these companies spent $15,640 per employee, an increase of 6% from 1997 but still not surpassing the 1996 level of $16,216 per employee.

Several industry sectors important to the Massachusetts industry cluster posted significant levels of R&D per employee in 1998. The biotechnology sector had the highest concentration of R&D per employee at $117,852. Medical products manufacturers also had significant levels of R&D investment per employee at $44,185.

WHAT DOES THIS TREND MEAN FOR MASSACHUSETTS?

R&D fuels the development of new technologies and goods and services that drive company growth in the Innovation Economy. The faster-growing sectors in Massachusetts are more R&D intensive, as reflected in both the level of corporate investment and the patent statistics. The national upswing in the number of inter- and intra-industry research joint ventures reflects an increasingly common strategy for advancing one's competitive position through joint R&D. These trends underscore the importance of investment in the Massachusetts research infrastructure, from skills development to the reduction of transaction costs that impede research alliances.

29. Venture Capital

State Achieves Record High Venture Capital Investment; State Maintains Its Share of U.S. Venture Funding

WHY IS IT SIGNIFICANT?

Venture capital is one of the three main sources of funding used to grow new companies. (Other sources include personal savings and investment by family, friends, and individual [angel] investors.) The amount of venture capital invested and the types of industries supported are predictors of future job and revenue growth. Venture capital investment is a market-driven economic-growth catalyst.

HOW DOES MASSACHUSETTS PERFORM?

The amount of venture capital received by Massachusetts companies reached approximately $1.9 billion in 1998, increasing by 33% from 1997 in inflation adjusted terms. Massachusetts share of the total venture capital dollars invested in the United States remained unchanged at 11%.

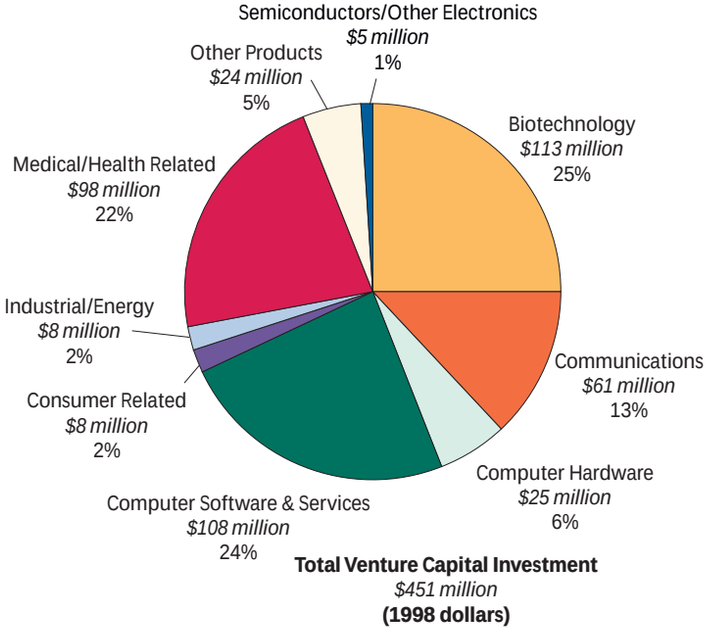
Computer software and services received the largest share (40%) of venture capital funding in 1998, nearly doubling its percentage in one year. Looking at the longer term, venture capital investments from 1992 to 1998 show that biotechnology decreased significantly from 25% to 8% of Massachusetts venture capital investments, and medical/health fell from 22% to 13%. Computer software and services rose from 24% to 40% during this period; communications remained fairly constant (between 13% and 14%).

WHAT DOES THIS TREND MEAN FOR MASSACHUSETTS?

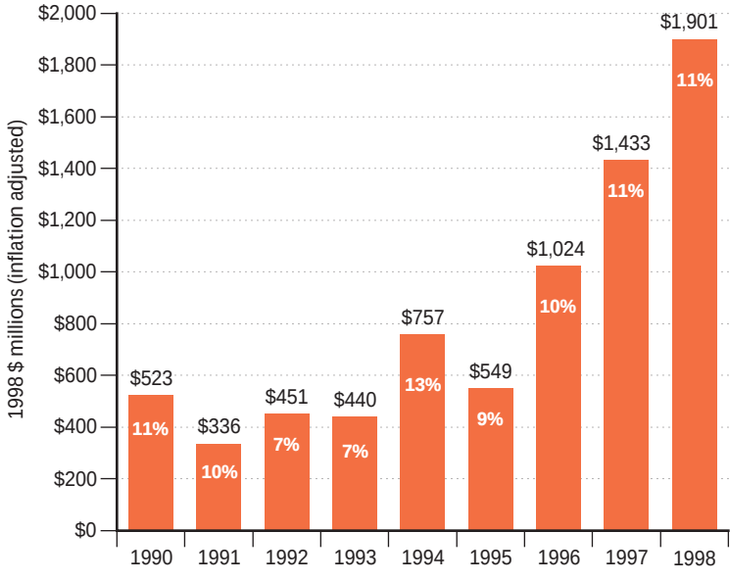
Venture financing fuels growth-oriented companies and the Innovation Economy. The strong increase in venture capital invested in Massachusetts indicates confidence in Massachusetts entrepreneurs and start-up companies. In particular, intensive investment in computer software and services reflects investor confidence that this sector offers strong growth prospects over the next several years. (Note that the E-Commerce Special Analysis showed that Massachusetts leads all Leading Technology States [LTS] in venture investment in e-commerce per capita; much of this investment is in the computer software and services sector.)

As venture investment escalates nationally, Massachusetts should work to ensure that it receives a stable or increasing share of the total venture capital dollars through creation of dynamic new companies created from new ideas and innovations fueled by the R&D infrastructure.

Distribution of venture capital investments, Massachusetts, 1992

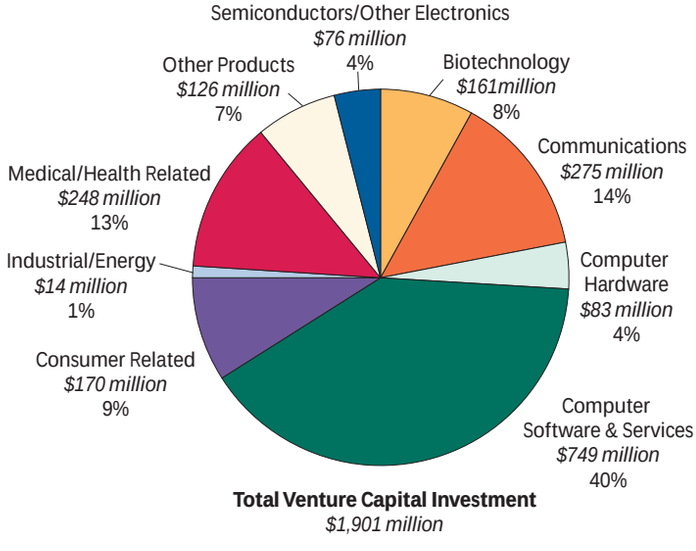


Venture capital investment received by companies and as a percent of total U.S. venture investments, Massachusetts, 1990–1998



Source: Venture Economics

Distribution of venture capital investments, Massachusetts, 1998

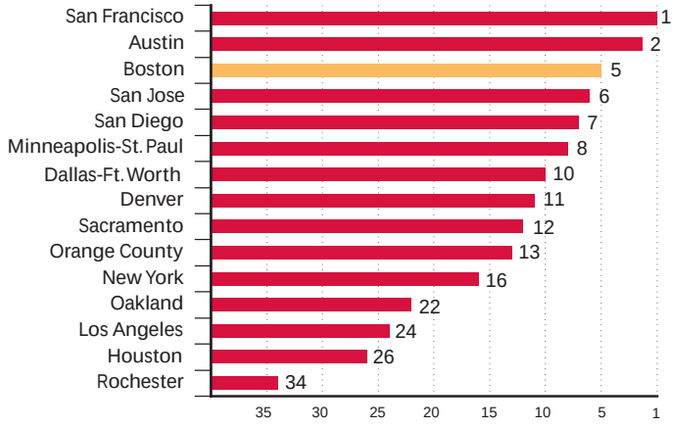


Note: Portions may not sum to 100% due to rounding
Source of pie charts: Venture Economics

30. Internet Presence

Internet Presence in State's Capital Is Competitive on a National Basis

Ranking of the 50 most "wired" cities in the United States—those cities ranked in the top 50 that are located in Massachusetts and the other LTS



Source: Yahoo!

WHY IS IT SIGNIFICANT?

Internet presence is an important indicator of an area's capacity to participate in, support, and be a leader in defining the electronic economy. A composite indicator of Internet presence is a good way to determine how advanced a region's information infrastructure is. Internet presence for this indicator is measured by the:

- Number of Internet users per capita
- Number of Internet hosts per capita, which is an estimate of the number of networked computers in a given location
- Domain name density, which captures the number of business and organizations online
- National backbone traffic, which looks at the amount of data traffic passing through a city
- Directory density, which is the per capita number of Web sites in an area

These measures were all combined to assess how "wired" American cities were in a 1999 Yahoo study.

HOW DOES MASSACHUSETTS PERFORM?

According to this composite indicator, Boston was the fifth most wired city in the United States. In the other six Leading Technology States (LTS), San Francisco ranked first, and Austin was second.

WHAT DOES THIS TREND MEAN FOR MASSACHUSETTS?

Boston's ranking among "wired" cities is something of which the state can be proud. However, Massachusetts cannot rest until an advanced communications infrastructure reaches across the entire state, so that all of its cities and regions can be competitive in the electronic economy. State policy should seek to foster a strong infrastructure across the state to allow local economies the ability to leverage opportunities, particularly in the areas of electronic commerce and distance education. Berkshire Connect and Cape Cod Connect are two examples of regional efforts that facilitate the availability of affordable, high-quality telecommunications services to underserved areas of the Commonwealth.

DATA SOURCES FOR E-COMMERCE ANALYSIS

The e-commerce analysis draws from the "1999 Information Systems and E-Business Spending" by Computer Economics, Inc., of Carlsbad, California; *The Massachusetts Directory of High Technology Companies* published by Mass High Tech; and data provided by PricewaterhouseCoopers.

1. Computer Economics
Companies surveyed by Computer Economics are comprised of sector divisions, and they include the following categories of organizations:

- Process and Discrete Manufacturing
- Retail and Wholesale Distribution
- Banking, Finance, and Insurance
- Healthcare
- Trade and Professional Services
- Utilities and Transportation
- Government Agencies

2. Mass High Tech
The Massachusetts Directory of High Technology Companies is published annually by Mass High Tech. 5,145 companies reported to the directory in 1998, of which close to 10% (491) identified themselves as e-commerce companies.

3. PricewaterhouseCoopers (PwC)
The information provided by PwC is based on data gathered each quarter. Internet companies are classified into one of the four categories listed. While many companies could fall into more than one category, PwC makes every effort to categorize them based on the company's primary line of business.

PwC Internet Categories:

Access Infrastructure – Includes communications, networking hardware, WAN/LAN equipment, modems, remote access, routers, switchers, servers, ISPs and Interactive CATV.

Content – Includes reference, magazines, news and information, directories, market research.

Services – Includes electronic retailing, e-commerce, education, travel, stock trading, home banking, search and retrieval, online entertainment, hosting/development, advertising/promotion, tracking/measurement, consulting, industry services, communities.

Software – Includes applications, browsers, server software, plug-ins, web publishing tools, security software, multimedia, telephony software.

Appendix B provides detailed information and the specific definitions and sources for each indicator. Throughout the document, numbers are presented in current dollars unless noted as real, inflation adjusted values.

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. The six other Leading Technology States (LTS) chosen are California, Colorado, Minnesota, New Jersey, New York, and Texas. Although Massachusetts is an LTS, all references and comparisons to the LTS refer to these six other states. The states are the same as those used in the 1998 *Index*.

	Employment Concentration							
State	Software	Computer/ Electronics	Healthcare Technology	Innovation Services	Financial Services	State	1999 Selection	No. of clusters above 1.1
AZ	0.87	1.96	0.59	0.97	0.79	AZ		1
CA	**1.32**	**2.15**	**1.50**	**1.21**	**0.93**	**CA**	**X**	**4**
CO	**1.84**	**1.90**	**1.22**	**1.39**	**0.99**	**CO**	**X**	**4**
FL	0.93	0.75	0.96	0.91	0.96	FL		0
IL	0.89	0.94	1.02	1.01	1.23	IL		1
MA	**1.51**	**2.14**	**1.97**	**1.63**	**1.67**	**MA**		
MI	0.73	0.24	0.78	1.06	0.74	MI		0
MN	**0.90**	**1.82**	**1.39**	**0.65**	**1.13**	**MN**	**X**	**3**
NJ	**1.61**	**0.64**	**2.25**	**1.13**	**1.39**	**NJ**	**X**	**4**
NY	**0.99**	**0.76**	**1.12**	**1.02**	**1.85**	**NY**	**X**	**2**
PA	0.80	0.65	1.07	1.24	1.10	PA		2
TX	**1.12**	**1.28**	**0.71**	**1.11**	**0.85**	**TX**	**X**	**3**
WA	1.04	0.89	0.76	1.09	0.83	WA		0

The LTS are selected on the basis of the number of innovative clusters having an employment concentration above the national level. In this way, the LTS chosen are comparable to Massachusetts in having the same breadth of innovative clusters.

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

II. Inflation Adjusted Values

Throughout the document, dollar values are presented in current dollars unless noted as real, inflation adjusted values.

Indicators related to wages and income are adjusted using the Consumer Price Index (CPI) for all urban consumers (all items, U.S. city average). All other inflation adjusted indicators use the calendar-year-based gross domestic product (GDP) implicit price deflator (1992 base equal to 1.000) published by the Office of Management and Budget. The GDP price deflator is considered the most appropriate adjustment for various kinds of R&D activity.

III. Notes on Data Sources for Individual Indicators

Results Indicators

1. Industry Clusters
Regional Financial Associates (RFA) tracks industry employment at the state level using a methodology based upon individual corporation filings with State Employment Securities Agencies (SESA) and the Bureau of Labor Statistics (BLS). Data from RFA were analyzed in comparison to information from the Massachusetts Department of Employment and Training (DET) to arrive at the number of jobs in Massachusetts cluster industries. Both sets of data do not cover self-employment or employment of military personnel. Definitions for each industry cluster are in Appendix C.

2. Employment Diversification
This indicator is developed from RFA state-level data of unemployment insurance filings between 1993 and 1998. Employment concentration is measured as the relative amount of employment in a cluster as a portion of total state employment compared with the same cluster's employment nationally as a portion of total U.S. employment. For each cluster, the level of national employment is indexed at 1.0. Therefore, Postsecondary Education employment at 3.0 is three times more concentrated in Massachusetts than at the national level. The annual average growth rate is the rate of change in industry cluster employment over the five periods from 1993 to 1998. The size of each circle on the chart reflects the relative size of employment in Massachusetts. The largest circle, Financial Services, employed 130,498 people in 1998.

3. Average Pay
Data are from RFA and are derived from payroll data reported as part of unemployment insurance (UI) filings. The average pay estimate for each cluster is the mean payroll per employee in 1998 current dollars.

4. Pay per Worker
Pay per worker data for Massachusetts and the other LTS are from analysis of RFA data. These data are derived from employers' UI filings. This source represents 96.7% of all wage and salary workers in the nation. All years shown in the chart have been adjusted into 1998 dollars using the Consumer Price Index.

5. Income Distribution
Earnings data for working families are derived from the March Supplement of the Census Bureau's Current Population Survey. Working families are defined as those families that reported any earned income above $0.

6. Skills Needs
Data were derived from a special MTC survey conducted in June 1999 in conjunction with the Massachusetts Biotechnology Council, the Massachusetts High Technology Council, the Massachusetts Medical Device Industry Council, and the Massachusetts Software Council.

Surveys were sent to 577 Massachusetts companies, of which 109 (19%) provided responses regarding their skills needs. Companies were asked to provide information on their current numbers of payroll employees, vacant positions, and contract/temporary employees all by occupational categories. In addition, Massachusetts corporations were asked to provide information on their recent hiring activities for both payroll and contract positions.

7. High-Tech CEO Rating of Massachusetts
Data are from the Massachusetts High Technology Council's annual business climate survey, 1987–1999.

8. Manufacturing Exports
The Office of Trade and Economic Analysis in the U.S. Department of Commerce tracks the dollar value of exported manufactured goods from all U.S. states through the Exporter Location Series. Percentages reported in this indicator are for the change in dollar value after adjusting for inflation using the GDP implicit price deflator.

9. Services Exports
Because no consistent annual services export data are available at the state level, services exports are projected from the exported services revenue data by state in the 1992 Economic Census for Service Industries. In this indicator, the projection to 1998 levels assumes that software exports grew at a similar rate to the growth of the gross state product in each state in the Business Services sector (SIC=73) during the 1992–1998 period. In a similar fashion, the growth of Innovation Services exports is based upon the growth of the state product in each state for the Engineering, Accounting, Research, Management, and Related Services sector (SIC=87).

Innovation Process Indicators

10. Patents per Capita
Patents per capita data for Massachusetts and the six other LTS are provided by the U.S. Patent and Trademark Office. Patent distribution data are from CHI Research.

11. Invention and Patent Applications
Indicator data are from the Association of University Technology Managers' (AUTM) annual licensing survey of universities, hospitals, and research institutions and an additional survey conducted by MTC. The 1997 AUTM survey had an overall response rate of 57%. The MTC survey returned information from those specific Massachusetts institutions that did not participate in the AUTM survey. For this analysis, the Massachusetts universities, which provided information for either of the surveys, include Massachusetts Institute of Technology, Harvard University, Boston University, Tufts University, Brandeis University, University of Massachusetts-Amherst, University of Massachusetts Medical Center, and Northeastern University. Massachusetts hospitals/research institutions included are Massachusetts General Hospital, Children's Hospital Boston, Brigham and Women's Hospital, Woods Hole Oceanographic Institute, Dana-Farber Cancer Institute, New England Medical Center, New England Deaconess Hospital.

12. Technology Licenses and Royalties
Data on licensing agreements involving Massachusetts institutions are also from AUTM and the MTC survey. These data are from the same institutions providing patent and invention disclosure information in indicator number 11.

13. FDA Approval
Information is provided by the U.S. Food and Drug Administration (FDA) via the Freedom of Information Act.

FDA approval of investigational device exemptions (IDEs) allow for clinical trials to begin on particularly high-risk medical devices. Medical device companies are also required to secure premarket approvals (PMAs) before intricate medical devices are allowed market entry. 510(k)s approvals are required of less sophisticated instruments or small product modifications and improvements.

14. New Business Incorporations
Data are provided by the Massachusetts Secretary of the Commonwealth's office. Of the 16,670 new business incorporations in 1997, 12,520 were Massachusetts based for-profit business, 1,421 were out-of-state businesses, and 605 were nonprofit enterprises.

15. SBIR Awards
Data 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.

16. M&As and IPOs
The numbers of mergers and acquisitions are provided by Securities Data Company.

Data on the total number, value, and distribution of IPOs by industry cluster are provided by Hale & Dorr, LLP, from a special data run of its tracking of IPOs throughout New England.

17. NASDAQ Firms' Market Value
The dataset contains the market capitalization/value of all publicly traded firms listed on the NASDAQ Exchange on March 31 of each year from 1994 to 1999. Market capitalization for an individual company is defined as the product of the number of shares outstanding times the share price on a given day.

18. Gazelle Companies
The number of gazelle companies is derived from a special data run conducted by Standard & Poor's Compustat of publicly traded companies headquartered in Massachusetts. This dataset tracks all publicly traded companies filing 10K and 10Q reports with the Securities and Exchange Commission (SEC) between 1992 and 1998.

19. Corporate Headquarters
Data are provided by American Business Information.

20. Value-Added per Employee
This indicator reflects annual value-added per employee. Value-added per employee is the total value-added by companies divided by these companies' total number of employees. Total value-added per company is derived by subtracting the total cost of inputs, other than direct labor costs, from the stated value of the final goods produced. Employment and value-added data for this indicator are based upon information from Regional Financial Associates.

Resource Indicators

21. Migration
Total foreign and domestic immigration data are provided by RFA and Mass Insight.

22. Workforce Education
Data on percentage changes of the adult education without a high school diploma and with a college degree from 1970 to 1997 are provided by the Census Bureau.

23. Engineering and Computer Science Degrees
The American Association of Engineering Societies (AAES) provided data on the total number of engineering degrees and degrees. The AAES tracks the number of engineering degrees awarded from accredited institutions throughout the United States each year. Data on the total number of computer science degrees are provided by the National Science Foundation.

Information on the number of engineering degrees retained in Massachusetts is compiled by MTC in partnership with the Offices of Institutional Research at the major engineering degree-granting institutions in Massachusetts. Data for this indicator are based upon information provided by Worcester Polytechnic Institute, Massachusetts Institute of Technology, University of Massachusetts-Lowell, Boston University, Northeastern University, University of Massachusetts-Amherst, and Merrimack College.

24. Dropout Rates
Data are provided by the Massachusetts Department of Education, Accountability and Evaluation Services Office. Before 1993, adjustments were not made for students who returned to school late in the year ("returned dropouts"). The Department of Education is unable to estimate the impact of this change in dropout rate calculations.

25. NAEP Scores
Reading assessment test scores are from the National Assessment of Educational Progress (NAEP), 1998, U.S. Department of Education, Office of Educational Research and Improvement, National Center for Education Statistics. The LTS average does not include scores for the state of New Jersey. New Jersey did not participate in 1998 NAEP.

26. Federal R&D Spending
Data are provided by the National Science Foundation for all U.S. federal funding obligations to universities and colleges, nonprofit institutions, and federally funded R&D centers administered by universities/colleges and nonprofit institutions. Population data are from the Census Bureau.

27. Federal Health R&D
Data are provided by the National Science Foundation. Data are for all R&D obligations by the U.S. Department of Health and Human Services. More than 95% of this figure occurs through the National Institutes of Health.

28. Corporate R&D per Employee
Data are derived from publicly traded corporations' annual 10K report filings with the SEC using information provided by Securities Data Corporation. Industry R&D per employee was calculated for all companies that reported any R&D expenditures. In 1998, 233 of 503 corporations reported R&D expenditures.

29. Venture Capital
Data for total venture capital investments in Massachusetts and venture capital investments by industry activity are provided by Venture Economics. Industry category designations are determined by Venture Economics.

30. Internet Presence
The indicator is developed from a 1999 Yahoo study that looked at how "wired" American cities were based on the number of Internet users per capita, the number of Internet hosts per capita, domain name density, national backbone traffic, and directory density.

INDUSTRY CLUSTER DEFINITIONS

I. Defining Key Industry Clusters in Massachusetts

The analysis of key industry clusters within Massachusetts begins with a disaggregation of all Massachusetts state industry activity to the four-digit Standard Industrial Classification (SIC) code level. (SIC codes are set by the Executive Office of the President, Office of Management and Budget. These codes were last revised in 1987.) Employment, payroll, and the number of establishments for all four-digit industries are examined. Industry data are analyzed through the following measures:

- Employment concentration relative to that of the nation
- Payroll per employee relative to the state average
- Employment as a share of total state employment
- Average annual growth rate, and absolute change, of employment
- Absolute number of establishments

Clusters are crafted from those interrelated SIC code industries that showed themselves to be individually significant according to the above measures.

Computers & Communications Hardware

3571 Electronic computers
3572 Computer storage devices
3661 Telephone and telegraph apparatus
3663 Radio and TV communications equipment
3669 Communications equipment, nec
3577 Computer peripheral equipment, nec
3672 Printed circuit boards
3674 Semiconductors and related devices
3675 Electronic capacitors
3679 Electronic components, nec
3695 Magnetic and optical recording media
3699 Electrical equipment & supplies, nec
3823 Process control instruments
3825 Instruments to measure electricity

Defense

3483 Ammunition, except for small arms, nec
3484 Small arms
3489 Ordnance and accessories, nec
3671 Electron tubes
3724 Aircraft engines and engine parts
3761 Guided missiles and space vehicles
3769 Space vehicle equipment, nec
3812 Search and navigation equipment
3827 Optical instruments and lenses
3829 Measuring and controlling devices, nec

Diversified Industrial Support

2821 Plastics materials and resins
2992 Lubricating oils and greases
3061 Mechanical rubber goods
3069 Fabricated rubber products, nec
3081 Unsupported plastics film and sheet
3082 Unsupported plastics profile shapes
3087 Custom compound purchased resins
3291 Abrasive products
3355 Aluminum rolling and drawing, nec
3357 Nonferrous wiredrawing and insulating
3369 Nonferrous foundries, nec
3398 Metal heat treating
3399 Primary metal products, nec
3463 Nonferrous forgings
3469 Metal stampings, nec
3471 Plating and polishing
3479 Metal coating and allied services
3491 Industrial valves
3511 Turbines and turbine generator sets
3545 Machine tool accessories
3547 Rolling mill machinery
3559 Special industry machinery, nec
3561 Pumps and pumping equipment
3568 Power transmission equipment, nec
3569 General industrial machinery, nec
3599 Industrial machinery, nec
3625 Relays and industrial controls
3629 Electrical industrial apparatus, nec
3999 Manufacturing industries, nec

Financial Services

6036 Savings institutions, not Federally chartered
6111 Federal and Federally-sponsored credit
6159 Misc. business credit institutions
6211 Security brokers, dealers, and flotation companies
6282 Investment advice
6289 Services allied with the exchange of securities
6311 Life insurance
6324 Hospital and medical service plans
6331 Fire, marine, and casualty insurance
6411 Insurance agents, brokers, and services
7323 Credit reporting services

Healthcare Technology

2833 Medicinals and botanicals
2834 Pharmaceutical preparations
2835 Diagnostic substances
2836 Biological products exc. diagnostic
3821 Laboratory apparatus and furniture
3826 Analytical instruments
3841 Surgical and medical instruments
3844 X-ray apparatus and tubes
3845 Electromedical equipment
3851 Ophthalmic goods
8071 Medical laboratories

Innovation Services

8711 Engineering services
8731 Commercial physical research
8732 Commercial nonphysical research
8734 Testing laboratories
8741 Management services
8742 Management consulting services
8733 Noncommercial research organizations

Postsecondary Education

8221 Colleges, universities and professional schools
8222 Junior colleges and technical institutes
8299 Schools and educational services, nec

Software & Communications Services

7371 Computer programming services
4812 Radiotelephone communications
4813 Telephone communications, exc. radio
4822 Telegraph and other message communications
4841 Cable and other pay television services
4899 Communications services, nec
7372 Prepackaged software
7373 Computer integrated systems design
7374 Data processing and preparation
7375 Information retrieval services
7377 Computer rental and leasing
7378 Computer maintenance and repair
7379 Computer related services, nec

Textiles & Apparel

2221 Broadwoven fabric mills, manmade
2231 Broadwoven fabric mills, wool
2257 Weft knit fabric mills
2261 Finishing plants, cotton
2262 Finishing plants, manmade
2269 Finishing plants, nec
2284 Thread mills
2295 Coated fabrics, not rubberized
2297 Nonwoven fabrics
2298 Cordage and twine
2299 Textile goods, nec
2329 Men's and boys' clothing, nec
2337 Women's and misses' suits and coats
2342 Bras, girdles, and allied garments
2385 Waterproof outerwear
2386 Leather and sheep-lined clothing
2391 Curtains and draperies
3021 Rubber and plastics footwear
3111 Leather tanning and finishing
3131 Boot and shoe cut stock and findings
3149 Footwear, except rubber, nec
3171 Women's handbags and purses
3172 Personal leather goods, nec
3911 Jewelry, precious metal
3915 Jewelers' materials and lapidary work
3961 Costume jewelry
5136 Men's and boys' clothing
5137 Women's and children's clothing
5139 Footwear

nec - not elsewhere classified

INDEX PROJECT STAFF

Director: **Thomas Hubbard**, *MTC Vice President, Technology Development & Analysis*
Coordinator: **Jennifer Banks**, *MTC Research Associate*
Contributor: **Robert Kispert**, *MTC Director of Federal Programs*
Contributor: **Jason Alexander**, *MTC Research Associate*
Graphic Designer: **Christine Raisig**, *MTC Publications Manager*

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