Massachusetts TECHNOLOGY Collaborative

Index of the Massachusetts Innovation Economy 2000

Prepared by:
Massachusetts Technology Collaborative
Westborough, Massachusetts

The Massachusetts Technology Collaborative (MTC) is an economic development organization established in 1994 by the Board of Directors of the state-created Massachusetts Technology Park Corporation (MTPC) to enhance the Commonwealth's knowledge-based Innovation Economy. MTC carries out its mission by:

- Conducting and disseminating research and analysis to promote a better understanding of the forces that shape the state's economy, and
- Facilitating productive collaborations among the business, academic and governmental enterprises that comprise the Innovation Economy.

MTC promotes sustainable economic growth by supporting regional technology-based clusters and by serving as a public policy laboratory for technology-related initiatives.

I. RESULTS INDICATORS

The most important outcome of the Massachusetts Innovation Economy is what it does for the people of Massachusetts by creating good jobs, rising wages, and a high standard of living. In this section we look at how jobs and wages changed in the Innovation Economy and nine key clusters in 1999. We also look at several measures of the Innovation Economy's resilience, to look for weaknesses or signs of trouble that may test the state's competitiveness in the months and years ahead.

II. INNOVATION PROCESS INDICATORS

The innovation process includes idea generation, technology commercialization and entrepreneurship, as well as innovation occurring 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. Positive results are created for both business and people. The innovation process has different stages, but a strong interrelationship among them is 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.

Key:

The direction of the arrows reflects the performance of the Massachusetts Innovation Economy in 1999 and the key determinants of its future growth: results, innovation process and resources.

- Denotes a strength
- Denotes a potential sign of weakness
- Denotes mixed progress

NINE KEY INDUSTRY CLUSTERS

Computers & Communications Hardware

Defense

Diversified Industrial Support

Financial Services

Healthcare Technology

Innovation Services

Postsecondary Education

Software & Communications Services

Textiles & Apparel

MEASURING RESULTS

How is the Massachusetts Innovation Economy performing? What does the state's performance tell us about this innovation-driven economy? What are the effects on businesses and people? What public and private investments and policies enhance the growth of the Innovation Economy?

*This year's **Index** shows gains in jobs and employee compensation, but a tight labor market could inhibit continued prosperity in the Massachusetts Innovation Economy.*

The Massachusetts economy continues to restructure itself towards knowledge-based, innovation-driven industries, but key industry cluster job growth has slowed. Jobs in manufacturing sectors continue to decline.

- Overall net employment in the nine industry clusters grew 1.1% from 1998 to 1999, compared to an overall state increase of 1.9%. This percentage growth is smaller than in the previous one-year period (2.7%).
- The Software & Communications Services cluster added 6,722 new jobs in 1999, the largest absolute and relative employment increase of the nine key industry clusters between 1998 and 1999. However, the annual growth rate of 6.7% fell short of the comparable LTS average growth rate (9.2%) during this period.
- Financial Services remained the largest cluster, with 137,283 jobs, adding 6,090 positions between 1998 and 1999. The average pay per worker in the Financial Services cluster ($69,514) is second only to Innovation Services ($78,481), but average pay per worker in Financial Services in Massachusetts significantly lags the other LTS ($87, 862).
- The Textiles & Apparel and Defense clusters lost 2,085 and 2,235 jobs, respectively, between 1998 and 1999. The decreases represent the continued contraction of the older and once-dominant clusters. The relatively high wage growth rate in these two clusters suggests that a fundamental restructuring in these industries may be taking place, toward application of new technologies and away from traditional manufacturing practices.
- The average wage in eight of the state's nine key clusters (excluding Postsecondary Education) is higher than both the average annual pay per worker of $40,960 in all Massachusetts industries and also the LTS average of $39,068.
- Only four (Software & Communications Services, Financial Services, Postsecondary Education, and Innovation Services) of the state's nine key industry clusters experienced a positive rate of growth in cluster employment between 1998 and 1999. The Financial Services and the Postsecondary Education clusters were the only Massachusetts clusters whose employment growth, 4.6% and 2.7% respectively, outpaced the other LTS.
- The attractiveness of Massachusetts to high-technology business leaders declined in 2000, but remains at a high level. In 2000, 91% of the executives responding to an annual survey rated the Massachusetts business climate as "good" or "outstanding," compared to 96% a year earlier.

MEASURING THE INNOVATION PROCESS

Idea generation and commercialization, reflected in patent and technology transfer activity, are vital to the early stages of the innovation process.

- Massachusetts continues to lead the LTS in patents per capita. Patent activity is diverse, and it is most active in the healthcare and transportation/aerospace sectors.

- The number of invention disclosures received by Massachusetts universities, hospitals, and research institutions decreased by 8.2%, marking a slowdown in the initial registry of inventions by these major nonprofit institutions.
- The overall number of new technology licenses issued by Massachusetts research institutions between 1997 and 1998 fell by 8.7%, despite an increase of 6.5% in new technology licenses from universities. The value of royalties received from technology licenses was $44 million, a 12.9% decrease from 1997.

Entrepreneurship is a critical factor in the innovation process. Entrepreneurs take new ideas and concepts, apply them to products and services, and connect them to the marketplace. Most indicators of entrepreneurship in Massachusetts are very positive.

- On a per-capita basis, Small Business Innovation Research (SBIR) awards to Massachusetts businesses are double those of Colorado, our next closest competitor. Despite a $6 million decrease in awards reported, the Massachusetts market share increased from 13.8% of total dollars awarded in fiscal year 1997 to 15.2% in fiscal year 1998.
- New business starts in Massachusetts declined 3.3% in 1999. All the LTS experienced decreases in new business starts during the period 1994 to 1999, but Massachusetts had the largest percentage decline.
- IPOs continued an upward trend, increasing 80% to 36 IPOs in Massachusetts in 1999, the highest number of IPOs since 1990. Massachusetts also made gains in closing the gap in its average IPO dollar value compared to the LTS average.
- Measured in dollar volume, merger and acquisition (M&A) activity in the state held steady as a percentage of the overall U.S. M&A market. The number of M&A deals increased in the state by 7.4%; among the LTS, only New York experienced a similar increase (6.8%).
- Market value of Massachusetts-based NASDAQ companies grew from $35 billion to $90 billion in real terms from 1995 to 2000. The average annual growth in market value of NASDAQ companies in Massachusetts (48%) was tied for second among LTS, and trailing only California (70%).

MEASURING RESOURCES

Innovation resources take many forms. Critical elements include early-stage and venture funding, executive talent, strategic services (legal, engineering, etc.) and access to skilled workers. In Massachusetts these fundamentals are strong relative to the six other LTS. Massachusetts remains a leader in federally-sponsored R&D, and venture capital continues on a strong upward path.

- Massachusetts showed steady growth in the number of its corporate headquarters with 241 in 1999, a 12.6% increase from 1998 (214).
- In 1998, Massachusetts had the highest per capita federally funded R&D investments of all the LTS, at $295. The next closest LTS, California, was at only 47% ($139) of the Massachusetts level.
- At $178 per 1,000 people, Massachusetts is substantially ahead of its nearest competitor in per capita health R&D investments . Of the six other LTS, New York ranks second with just one-third ($58) of the Massachusetts per capita spending amount.
- Venture capital investment in Massachusetts soared to $3.6 billion in 1999, a 125% increase from 1998. The Massachusetts share of venture capital funds in the U.S., however, fell from 11.9% in 1998 to 10.3% in 1999.
- In 1999, Massachusetts received over $2.1 billion in venture capital for Internet-related and e-commerce companies, more than four times the 1998 investment ($514 million). The $2 billion represents a 10.7% share of the total U.S. venture capital investment in e-commerce and Internet-related firms.
- Companies in the Software sector received the highest amount (26%) of all venture capital investments in Massachusetts in 1999.

LEADING TECHNOLOGY STATES

Massachusetts

and

California

Colorado

Minnesota

New Jersey

New York

Texas

In a knowledge-driven economy, well-educated and highly skilled people are a critical resource. An Innovation Economy requires a long term commitment to education and workforce development.

- In 1998, 31% of Massachusetts residents had a bachelor's degree or higher, compared to 24% nationwide.
- The total number of graduates awarded degrees in engineering in Massachusetts decreased in 1999 by 4.6%, reversing the slight increase experienced in 1998 (1.4%).
- In 1999, Massachusetts had an unemployment rate of 3.2%, the third lowest among the LTS and well below the national rate of 4.2%.
- From 1995 to 2000, the Massachusetts population grew 2.1%, the second lowest among the LTS and less than half the U.S. growth rate of 4.5%.
- An MTC skills needs survey of technology-intensive companies indicated that in May 2000, 25.7% of web design developer positions, 15.2% of computer scientist/ programmer positions, and 11.0% of life scientist jobs were unfilled.

What if we built a new economy and nobody came?

A chronic shortage of high-tech workers remains the biggest threat to the Massachusetts Innovation Economy

The 2000 *Index of the Massachusetts Innovation Economy* finds Massachusetts and its Innovation Economy robust. The Commonwealth continues to attract the greatest volume of venture capital investment in the United States after California. In 1999 Massachusetts firms registered the largest number of Initial Public Offerings (IPOs) after California and New York. The state's universities and teaching hospitals attracted record levels of competitively awarded research funding, financial support that stimulates new discoveries and new products in a broad range of fields.

Yet, in 1999 employment growth in the nine key clusters tracked by the *Index* fell short of the state's overall job growth. Employment growth among the nine clusters was essentially a zero-sum game, as healthy increases in Software & Communications Services and Financial Services were offset by corresponding job losses in the Computer & Communications Hardware industries, and in Healthcare Technology.

Meanwhile, growth in even the fastest-growing cluster, Software & Communications Services, fell far short of comparable job growth in this cluster in the Leading Technology States (LTS) examined by the *Index*.

A shortage of workers, particularly in scientific, engineering and IT positions, is a serious constraint on growth in the Massachusetts Innovation Economy.

- Unemployment is at an historically low level falling to 3.2% in 1999, third lowest among the LTS, and one full percentage point below the national rate of 4.2%.
- Job vacancies in scientific, engineering and information technology (IT) positions are at high levels. The Massachusetts Technology Collaborative (MTC)/Northeastern University workforce survey discloses a job vacancy rate of over 8% in the state's software, computer hardware, biotechnology and healthcare technology firms. Vacancies in computer scientist/programmer jobs exceed 15%.
- Industry CEOs cite the tight labor market as the biggest negative factor in the state's business climate.

The worker shortage is chronic and deep-rooted.

The Commonwealth's population growth is extremely low. Massachusetts population grew 1.7% from 1990-1997, while the U.S. population grew 7.3%.

- Despite the state's hot economy, Massachusetts residents continue to migrate to other states, with about 8,600 in leaving in 1999 alone.
- Almost all of the net growth in labor supply in Massachusetts over the last decade has been provided by international immigrants. Temporary workers holding H-1B visas have become a critical source of talent for the state's technology companies. The MTC/Northeastern University workforce survey found that 7% of new technology industry hires were from the H-1B program, including almost half of all physical scientists, and one third of all life scientists.
- A declining rate of workforce participation among older men (45-69) nationally is particularly acute in Massachusetts, where it has declined by more than 17% over the last thirty years. A projected 6% increase in the state's labor force by 2005 will be due mostly to a rising rate of labor force attachment among older women workers.
- Job vacancies could be as high as 268,000 positions by 2006, or 7% of the current state workforce.
- A shortage of scientific, engineering, and IT workers is pervasive nationwide, but the Massachusetts situation is far more critical given that the workforce growth rates of all other LTS are in excess of the Commonwealth's.

How real a problem is this worker shortage? The case for action:

The worker shortage in Massachusetts creates higher costs for the state's businesses. But is this necessarily a negative factor for the state and its people? After all, skilled workers who find themselves in demand should expect to be rewarded with higher wages and a higher standard of living. Doesn't that benefit the Commonwealth as a whole? Won't high wages pull new entrants into the labor market?

High skills and high productivity *are* rewarded in the Massachusetts Innovation Economy. Average pay in the high-growth clusters tracked in the *Index* is 46% above the state average. This year's *Index* demonstrates again that young people growing up and wanting to remain and prosper in the Commonwealth would do well to explore the many opportunities offered by the industry clusters identified in the *Index*.

Yet there is little evidence to suggest that Massachusetts overpays its skilled workers. To the contrary, workers may not earn enough to resist the attractions of other, perhaps lower cost, competing states and regions.

For example, the *Index* finds average pay among several of the Massachusetts clusters lagging average pay in similar clusters in competing states.

More important, the state's relatively high cost of living reduces the purchasing power of the state's workers, including skilled workers in the key technology-intensive clusters. Analysts estimate that in the mid-1990s, when compared to nearly identical counterparts in other U.S. cities, average workers in metropolitan Boston earned 8-10% less after adjustments for cost of living.

The single most important factor in the state's high cost of living is housing. The state's housing costs not only rank among the highest in the nation, but also are disproportionately borne by younger workers, who have come into the housing market since the large run-up in real estate values that started in the 1980s, and resumed in the late 1990s. High housing costs appear to be a key factor in the continued out-migration of Massachusetts residents, and the further depletion of the state's workforce.

Scientific, engineering and IT workers who want to leave Massachusetts have plenty of options, since the entire U.S. economy faces a serious shortage of workers in these fields. The Information Technology Association of America estimates that 1.6 million IT jobs will be open in the next year, and 850,000 will go unfilled.

New initiatives in Massachusetts that will increase workers' purchasing power and decrease costs, particularly housing costs, will go at least part of the way towards firming up the state's pool of workers. Unfortunately, even the most successful new initiatives are unlikely to shift the state's cost of living significantly in the short run, if ever. Moderating the Massachusetts cost of living is not likely to be sufficient to reverse the state's skilled workforce deficit. Skilled scientific, engineering and IT workers are a product of years of study that begin in a child's school years, or a product of the hard work of training and professional education undertaken by non-technology workers who make a mid-career change. For Massachusetts to reverse its workforce crisis, it must find ways to "grow its own," by enabling its own citizens to gain the skills necessary for entry into the Innovation Economy.

Necessity being the mother of invention, firms in Massachusetts will undoubtedly respond to the workforce crisis with more innovation. The state's continuing strength in research and development, and its success in nurturing entrepreneurial firms, will become even more important in an era of workforce scarcity.

Massachusetts can hardly be complacent about its workforce deficit. In an increasingly global economy, *all* of the state's competitive advantages will be tested, including its leadership in research and development. Applied research and product development is now a global enterprise, and can be conducted on an around-the-clock basis with teams located throughout the world. Cities, regions, and countries that can provide an ample supply of highly skilled scientists, engineers and IT and other technical workers will intensify their competition with Massachusetts, matching their brain power with the Commonwealth's own.

Massachusetts must "grow its own" workforce by enabling its own residents to acquire necessary skills for the New Economy.

How can Massachusetts respond?

A call to action:

Massachusetts is adapting to a new era of labor scarcity. For years *labor surplus* was a central feature and problem of the state's economy. Adjusting to the new era of labor scarcity means we must rethink our assumptions about economic development and about what it will take to preserve a healthy business climate in the Commonwealth. Many initiatives are in place, both public and private, to address pieces of the problem. But Massachusetts needs to attack its workforce crisis on all fronts, and it needs to promote initiatives that will have a broad and lasting impact. Successful initiatives need to be identified and scaled-up; unsuccessful ones terminated, with funding redeployed to successful ventures. Gaps in the current patchwork of services should be identified and filled.

The workforce crisis in Massachusetts must be considered as a whole. Public sector and private sector leaders should analyze the facts, particularly as they relate to *where* and *how* the state can establish the pool of new professional and technical workers it needs to sustain its Innovation Economy.

Several industry groups in the U.S. today are assessing their workforce needs by creating a *roadmap.* Workforce roadmaps are a tool for synthesizing data to demonstrate the status of the workforce today, and to determine if workforce needs will be met in the years ahead given current trends or new initiatives.

Creating a workforce roadmap for Massachusetts is a substantial undertaking, but in the last two years several of the state's most distinguished economists and policy analysts have looked closely at major aspects of the state's workforce, as has the *Index.* By examining and coordinating this extensive body of work, the following pages of the *Index* provide an outline for a Massachusetts workforce roadmap.

Massachusetts must adapt itself to a new era of labor scarcity. It can begin by creating a workforce roadmap.

K-12 Students: the Innovation Workforce of Tomorrow

Massachusetts must recruit several thousand math and science teachers over the next decade, but the state's public colleges currently graduate only a handful of math and science teacher candidates each year.

ROAD MAP

for the Commonwealth's workforce future

Massachusetts Advantages:

Massachusetts is a national leader in keeping kids in school with the lowest dropout rate of all LTS. Massachusetts sends a higher proportion of high school graduates to college than any other state. Massachusetts ranks high in the percentage of high school students taking Advanced Placement examinations (third among the LTS), and the participation rate has increased significantly. Recently, Massachusetts had the highest proportion of high school students participating in the Computer Science AP exam (13 per 1000).

Disadvantages:

Fifty-eight percent of tenth grade students are expected to fail the Massachusetts Comprehensive Assessment (MCAS) Test examination. Comparatively few college-bound students from Massachusetts intend to major in engineering or computer science in college: only 6% of Massachusetts SAT-takers indicated an intention to major in engineering, the lowest of any of the LTS.

Strategies:

Improving math and science performance in public schools.

Improving math and science performance is a major goal underlying Lieutenant Governor Swift's recent call for 30,000 tutors to assist students at risk of failing the MCAS exam. Dozens of initiatives have been created by private firms, trade associations, government agencies, colleges and universities to encourage interest in math and science and to improve K-12 performance. To cite three examples: Boston University's CityLab program sends its lab-equipped bus throughout the Boston public schools encouraging students to better understand the disciplines of biology and chemistry; the Massachusetts Telecommunications Council sponsors a summer "Telecom Boot Camp" that introduces high school students to the exploding opportunities in the local telecom industry; and raises awareness of the skills needed to succeed in the industry. Northeastern University has recruited dozens of retired engineers to serve as tutors in public schools through its RE-SEED program. These and other "best practice" initiatives have been identified and are now promoted by the Engineering in Massachusetts Collaborative (http://www.eimc.org), a coalition of engineering school deans, private corporations and workforce development organizations. The Governor's Economic Development Council has recommended that the work and scope of the Engineering in Massachusetts Collaborative be greatly expanded.

Improving math and science performance will require public schools to recruit scores of new and qualified teachers.

Signing bonuses and forgiveness of student loan debt have attracted new teacher candidates to the field, but Massachusetts still needs to recruit several thousand mathematics and science teachers over the next ten years. Math and science teacher training programs in the public colleges and universities currently graduate fewer than a dozen math and science teacher candidates per year. Only recently state leaders have begun to debate the creation of pay differentials – creating higher salaries for math and science teachers – as a way to attract new candidates to public schools. In the meantime, the state has created a new goal for attracting teacher candidates through alternative certification programs that will allow older teacher candidates to bypass traditional educational schools and other requirements. Massachusetts has created the Massachusetts Institute for New Teachers (MINT) to recruit new teachers through alternative certification, but the Governor's Council on Economic Development reports that only about 2% of the state's new teachers enter the profession through alternative certification. Governor Cellucci has called for the state Department of Education to certify at least 10% of new teacher candidates through alternative certification. One-quarter to one-third of new teachers in Texas and New Jersey are recruited through alternative certification.

Raising student awareness of scientific, engineering and IT careers and the need to prepare students with adequate course work in math and science.

Studies consistently find that students know little about both the rewards and the prerequisites of careers in scientific and technical fields. Better information and awareness of careers in these fields among students, guidance counselors, parents and teachers would give students greater incentive to prepare adequately in high school and elect scientific, technical and IT majors in college.

In Massachusetts, the federal School-to-Work Opportunities Act has seed-funded school-to-work consortia based at the state's sixteen Regional Employment Boards. Several consortia have targeted partnerships between schools and IT industries, but federal funds for the school-to-work consortia expired this year as part of a planned sunsetting of federal support. The law's sponsors expected private employers to pick up the funding of consortia, and several school-to-work programs have mounted campaigns to win private support.

College Students: Poised to Enter the Innovation Workforce

College enrollments have increased, and several new undergraduate engineering programs have been started in the Commonwealth, but the state's engineering schools have yet to reverse a decade-long decline in the total number of engineering graduates.

Massachusetts Advantages:

Massachusetts has one of the highest concentrations of institutions of higher education of any state in the U.S. According to the National Center for Education Statistics, Massachusetts enjoys the highest net influx of college freshmen of any state in the nation, a yearly net gain of more than 8,000 students (defined as the number of incoming college freshmen at Massachusetts campuses, minus the number of Massachusetts residents who enter college as freshmen elsewhere). Massachusetts has one of the highest numbers of engineering schools in the nation (13), and it is growing, with the addition of the Smith College engineering program, and establishment of the new Olin College of Engineering in Needham.

Massachusetts colleges and universities also draw a comparatively large group of international students to the state. The state ranks fourth among the states, behind California, New York, and Texas, as a destination for international students. Over the years, international students have often proven to be a valuable talent pool for the state; several of the state's fastest-growing companies were founded by entrepreneurs who came to the state as foreign students.

Disadvantages:

The number of students graduating with engineering and computer science degrees in the state continues to decline. The number of engineering and computer science students graduating nationwide also continues to decline, but at a slower pace, (1.2% nationally, 4.6% in Massachusetts). Meanwhile, the "market share" of U.S. college students employed by Massachusetts-based institutions has fallen, and will likely continue to fall, eroding the state's historical leadership position and heightening competition for the nation's best and brightest students.

Strategies:

Recruit more of the state's high school seniors for admission to Massachusetts colleges and universities.

Massachusetts enjoys a large influx of college students every year, but enrollment of Massachusetts residents at institutions in the state is relatively flat. Enrollment by Massachusetts residents in the state's private institutions increased 1.9% from 1990-1997. Enrollment at the state's public colleges and universities is still about 6% below the high point reached in the 1980s.

Fortunately, enrollment in the engineering and computer science programs at the University of Massachusetts campuses have increased significantly in recent years. UMass has stepped up recruitment of talented Massachusetts high school students by offering free admission to the state's high school valedictorians and salutatorians.

The cost of both public higher education and private higher education in Massachusetts is relatively high. Many Massachusetts high school students and their parents can find cheaper alternatives elsewhere in the U.S. The state's public colleges and universities have responded with efforts to cap or reduce tuitions.

At the same time, private colleges educate most of the scientific, engineering and IT students in the Commonwealth. Thus the competitive position of these institutions must also be an important consideration in the state's workforce strategy. Both state government and the private sector should re-examine its level of support for college loan and scholarship aid programs. The Commonwealth's scholarship aid programs are currently rated as about average when compared to similar programs nationwide.

Improve the accessibility and quality of science, engineering and IT programs within Massachusetts colleges and universities.

Public higher education in the Commonwealth has embarked on a major effort to upgrade its course offerings in IT. The University of Massachusetts is leading the Commonwealth IT Initiative, a campaign to update computer science curriculum throughout the UMass network, and community college systems. A special task force of the state Board of Higher Education continues to deliberate on other initiatives to make the state's public higher education system more responsive to the workforce needs of Massachusetts employers. These initiatives must be supported by private sector leaders and funded by state government. Some private institutions, including Bentley College and Worcester Polytechnic Institute (WPI), have greatly expanded their programs that integrate business and IT.

Create closer relationships between Massachusetts employers and Massachusetts colleges and universities.

Northeastern University's cooperative education program was one of the first in the country, and remains one of the largest, enrolling approximately 6,000 students. The workforce crisis has sparked new interest in cooperative education and internship programs, which employers often see as a source of future employees. A new program is the Scholar/Intern Program, initiated by the Analog Devices Corporation. The Scholar/Intern Program offers tuition assistance and a guaranteed four-year internship for engineering students at the University of Massachusetts/Lowell. Over twenty corporations now participate in the program. Other employers and trade associations are acting on their own initiative. One example: member companies of the Semiconductor Industry Association in Massachusetts have created their own coordinated outreach campaign to students of two-year colleges in Massachusetts and other New England states. Massachusetts should encourage, recognize and support such initiatives.

The Massachusetts Incumbent Workforce: One of the Most Flexible in the Nation

Continuing and professional education has become a highly competitive business in Massachusetts.

Massachusetts Advantages:

High levels of educational attainment make the state's workforce one of the most flexible in the nation. Studies by MTC and others also show that Massachusetts benefits from the out-of-state college students electing to remain in the state to work.

Disadvantages:

A relatively low number of Massachusetts students graduate from high school with the intention to major in scientific and technical fields. As a consequence, the state's colleges graduate an inadequate number of students for the burgeoning number of scientific, engineering and IT jobs in Massachusetts industry.

Strategies:

Educate current workers in scientific and technical fields through programs of continuing education, corporate education and professional development.

- Continuing and professional education has become a highly competitive business in Massachusetts. Several of the state's leading private institutions offer MBA, IT, computer programming and engineering courses at their home campuses, and through a network of satellite campuses. In the I-495 Corridor alone, UMass, Clark, WPI, Northeastern, and Suffolk University now offer continuing education. An increasing number of institutions also offer adult learners instruction on-line, and the Massachusetts Board of Higher Education approved the entry of the University of Phoenix and Harcourt Online to the state in the summer of 2000.

Train incumbent employees for skill upgrades.

- Training is not a highly competitive business in Massachusetts. Publicly funded training is delivered through Service Delivery Areas (SDAs) with exclusive jurisdictions. Other forms of publicly funded training, including adult basic education and some occupational education are provided through the state's community colleges, community action programs and through other nonprofit organizations. These are not currently coordinated under a single statewide strategy for workforce development.
- Studies completed for MassINC suggest that private sector employers in the state underinvest in employee training, providing skill training programs to only one quarter of clerical and production workers, well below the national average of 35%. Only 38% of Massachusetts companies offer training to managers, compared to a 50% national average.
- The state is currently implementing the federal Workforce Investment Act (WIA). The objective of the Act is to transform the former Job Training Partnership Act (JTPA) program to meet the new challenges posed by skilled labor shortages. The state's WIA implementation plan refocuses federally supported worker training funds away from services to the unemployed and into training for incumbent workers. Small scale and pilot programs have been started to demonstrate effective practices for retraining non-technical workers for high-tech positions; the High Tech Entry Ramp program of the Corporation for Business, Work and Learning is one such program.
- The Commonwealth's single largest initiative in incumbent worker training is the Workforce Training Fund created by the Legislature in 1997. The program receives $18 million per year from the state's Unemployment Insurance Fund. Grants are awarded on a competitive basis to employer-designed training programs. The program is broad in reach but small in scale. As of this writing the program has made $18 million in grants to 305 businesses, for an average grant of approximately $60,000. The expansion of the H-1B visa program promises to provide another source of limited funding for technical training programs. This year's 2000 expansion of the program will divert revenues from visa application fees to training programs funded through the Workforce Investment Act and local Workforce Investment Boards, formerly Regional Employment Boards. The new H-1B visa program is expected to generate approximately $125 million in training funds for allocation throughout the entire U.S. A small number of local training programs funded through H-1B funds began operation in Massachusetts in 2000.

Some of the state's larger employers and trade associations have created their own incumbent worker training programs in recent years to "reskill" non-technical workers or upgrade the skills of current technical workers. The Massachusetts Software & Internet Council recently graduated its 500th student from its Software Fellows program, which trains experienced, non-software workers for entry into local software firms. EMC Corporation, one of the state's fastest-growing firms, has instituted its own in-house "university," in collaboration with the private, two-year New England Institute of Technology.

Recruitment and Retention: Attracting Workers from Outside, and Keeping the Workers We Have

High housing costs are a major obstacle to recruiting and retaining workers. A recent study estimates that housing production will have to double in Greater Boston just to keep price inflation in line with family incomes.

Massachusetts Advantages:

Engineers and others who receive their technical education in Massachusetts often wish to remain. An *Index* survey of Massachusetts engineering schools finds that, on average, 56% of the state's undergraduate engineering Class of 1999 remained in the state after graduation, a proportion that has remained relatively constant over the last few years. Anecdotal evidence from industry recruiters suggests that Massachusetts-based employees resist leaving the state for jobs elsewhere.

Disadvantages:

Despite an unemployment rate of 3% and lower, Massachusetts residents continue to migrate out of state, albeit at a much-reduced level than a decade ago. In 1999 approximately 8,600 people in the Massachusetts workforce left the state for opportunities elsewhere. Research indicates that over the last ten years more than half of those departing the state were aged 25-34, relatively younger workers entering the prime years of their careers, and workers no longer available to the state's growing Innovation Economy. About two-thirds of this group held college degrees. The departing 25-34 year-olds are among the workers most directly affected by the state's high housing costs. The Commonwealth is among the five most expensive states in the nation for homeowners in the 25- to 34-year-old age cohort. The high cost of housing is also a source of acute "sticker shock" for out-of-state workers who are recruited to move to the state.

Strategies:

Encourage the state's recent college graduates to work in Massachusetts.

- This objective is the subject of a proposal currently before the state's Board of Higher Education. The proposal would aid graduates of the state's private colleges, and would offset student loan debt for every post-graduation year graduates remain in Massachusetts to work.

Reduce housing costs by significantly expanding the housing supply.

- Recently the Governor, the Archdiocese of Boston and other statewide groups have proposed new "supply side" strategies for housing in Massachusetts. Their objective is to house the homeless, and to moderate inflation in the entire housing market by expanding housing supply. A recent report completed by Northeastern University for the Archdiocese of Boston estimates that home prices and rents in Greater Boston will rise nearly 40% faster than average family income unless the region takes the pressure off housing prices by producing a greater volume of housing every year. The study estimates that 72,000 net new housing units per year (or 360,000 units over five years) must be built simply to hold housing prices in line with family incomes. This is about double the current rate of production.

Studies suggest that Greater Boston universities should respond to the housing crisis by significantly expanding student housing. At least two universities, Northeastern and Harvard, have responded to the housing crunch by launching new housing initiatives. Northeastern's new $50 million complex in Roxbury, Davenport Commons, creates housing for both students and neighborhood residents, while Harvard's $21 million low-interest loan program is designed to build or renovate housing for residents in Boston and Cambridge.

Older Workers: What Incentives Will Sustain Participation by Older Workers

Workers aged 45-69 will account for two out of every five workers in the Massachusetts economy by the year 2010.

Massachusetts Advantages:

Increased workforce participation among older women (45-69 years), along with foreign immigration provided Massachusetts with the margin of labor growth necessary to sustain its economic recovery in the 1990s.

Disadvantages:

Workforce participation among older men (45-69 years) in Massachusetts has fallen 17.1% over the last 30 years. This is equivalent to removing 120,000 workers from the market over the same period. Analysts cite a wave of early retirements as responsible for the trend. Massachusetts now ranks twenty fifth among the fifty states for workforce participation by older males.

The ranks of still-active older workers will grow over the next decade and will likely provide *all* of the net growth in labor supply through the year 2006. Older workers will account for two out of every five workers by 2010. "Older workers represent the single largest labor reserve in the Commonwealth available to offset (the state's) labor market deficit," according to the Commonwealth's Blue Ribbon Commission on Older Workers.

Strategies:

In April 2000, the Commonwealth's Blue Ribbon Commission on Older Workers completed a detailed report on the status of older workers in the state's workforce. The report includes detailed recommendations on initiatives that would upgrade the skills of older workers, provide incentives to older workers to remain in the workforce, and eliminate discrimination barriers that prevent the state's companies from fully utilizing qualified older workers.

As noted above, the Commission found that the state's older worker cohort will provide most of the net increase in workforce within the state over the next several years. The Commission also found that older workers as a group are less likely to benefit from all forms of training (public sector and private sector) than other workers; that older workers are more likely than other workers to suffer from skill mismatches; that small businesses, with limited ability to fund training, nevertheless employ a higher proportion of older workers than larger businesses; and that older workers continue to face financial disincentives to continuing in the workforce (including earnings limits for social security recipients.)

Conclusion:

Only ten years ago the Commonwealth suffered through its worst recession since the Great Depression, a recession that threw thousands out of work, including thousands of skilled professional and technical workers. While the state is now enjoying one of the longest economic expansions in its history, inevitably the expansion will end, and the Commonwealth's workforce crisis will ease. We may lose our sense of urgency as a result.

That would be a mistake. The fundamental trends that have created our workforce crisis are not likely to abate over the long term. It is not likely that Massachusetts will enjoy an influx of new workers, either from outside or through natural population growth. It is not likely that the global economy will reverse its increasing dependence upon constant innovation, or upon greater and greater integration of Information Technology in all aspects of our lives. In the long run, those regions that can respond flexibly to the world's demand for innovation will be the regions that best assure their continuing prosperity. The Massachusetts workforce crisis erodes our ability to meet this demand, and it is so deep-rooted that we must take action now before we suffer a slow and punishing loss of our competitiveness. We must begin by looking at ourselves – our own fellow citizens and residents of the Commonwealth – and mount an all-out effort to expand the ranks of skilled workers who will determine our economic future.

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 the **process** of innovation. 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 Processes**: 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 processes**. It concludes by setting out a number of **resources** that fuel 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 on-going 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

MTC believes that Massachusetts should be able to track the Innovation Economy over time. This monitoring capacity is crucial for regularly assessing its strength and resilience.

At the same time, benchmark comparisons can provide an important context for understanding how Massachusetts is doing in a relative sense. Thus, in some cases, the Massachusetts indicator is compared with the national average or with a composite measure of six competitive Leading Technology States (LTS). The six LTS chosen for comparison throughout the 2000 *Index* are California, Colorado, Minnesota, New Jersey, New York, and Texas. Appendix B describes the methodology for selecting the LTS.

NINE KEY INDUSTRY CLUSTERS

It is important to monitor the impact of innovation through those key industry clusters critical to the state's economy. MTC has a program devoted to facilitating cluster development in Massachusetts. We have identified nine industry clusters that significantly affect the state and are linked uniquely to the Innovation Economy. These clusters range from the long established, such as Postsecondary Education, Defense, and Textiles & Apparel industries, to Software & Communications Services (which includes telecommunications), and Innovation Services (which includes engineering services and management consulting services). Appendix C provides a detailed definition for each of these clusters.

Together, these nine clusters account for 25% of non-government employment in Massachusetts and 35% of total private sector payroll. Government employment is a fairly large industry in terms of total number of employees; government employment includes federal, state and local workers, postal workers, and education workers at the state and local level. Public sector payroll includes all government employees and the military.

At $60,004, the average wage paid by the nine key industry clusters is 46% higher than the Massachusetts average for all workers ($40,960).

RESULTS INDICATORS

"The Massachusetts economy of the 1960s, 1970s and 1980s 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."

Patricia M. Flynn, PhD
Dean, Graduate, Executive and Professional Education
McCallum Graduate School of Business
Professor of Economics, Bentley College

RESULTS INDICATORS

The most important outcome of the Massachusetts Innovation Economy is what it does for the people of Massachusetts by creating good jobs, rising wages, and a high standard of living. In this section we look at how jobs and wages changed in the Innovation Economy and nine key clusters in 1999. We also look at several measures of the Innovation Economy's resilience, to look for weaknesses or signs of trouble that may test the state's competitiveness in the months and years ahead.

1. Industry Clusters

Job Growth in Key Industry Clusters Slows below Overall State Growth Rate; Software & Communications Services and Financial Services Continue to Lead Job Growth

WHY IS IT SIGNIFICANT?

Nine key industry clusters comprise 25% of all non-government jobs in Massachusetts. Each cluster is more highly concentrated within the Massachusetts economy than similar clusters on average elsewhere in the U.S. Such high concentration is a reflection of current or past competitive advantage that has helped the cluster grow in Massachusetts.

HOW DOES MASSACHUSETTS PERFORM?

Total employment in the nine key industry clusters grew by only 1.1% from 1998 to 1999, to approximately 700,000 people. This increase compares to a 1.9% increase in total jobs statewide. Financial Services continues to be the largest employer with 137,283 people, while Defense remains the smallest at just under 31,000.

Overall, knowledge-intensive services clusters continued to add jobs, but at a lower rate between 1998 and 1999. Although the Massachusetts Software & Communications Services cluster registered the largest increase in jobs since 1998 (6,722 new jobs, a 6.7% increase), Colorado and California led the LTS in Software & Communications Services growth with job gains of 17.9% and 11.4%, respectively. In contrast, the Massachusetts Financial Services cluster (6,090 new jobs, 4.6%) remains the job growth leader among all LTS (2.5%) and the U.S. (2.8%) in 1999. Other gainers in Massachusetts were Innovation Services (3.1%) with more than 2,800 new jobs; and Postsecondary Education (2.7%) adding nearly 2,900 new jobs.

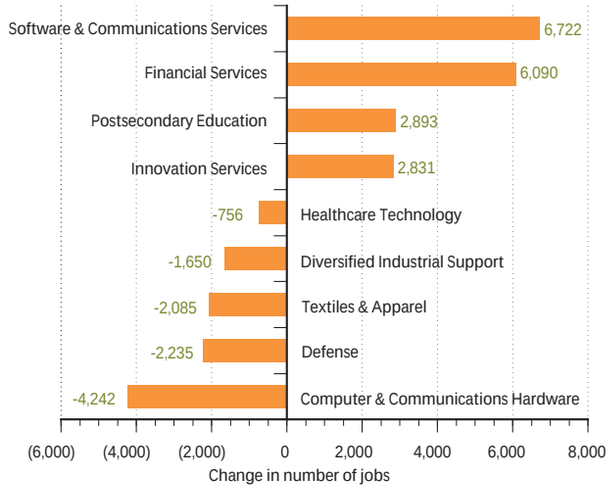
Jobs in the state's Computer & Communications Hardware cluster fell by 5.2% in 1999; compared to (-4.2%) in the U.S. and (-3.0%) in the other LTS. The Healthcare Technology, Diversified Industrial Support, and Computer & Communications Hardware clusters, which experienced employment growth a year earlier, lost jobs (756; 1,650; and 4,242, respectively) between 1998 and 1999. Massachusetts (-2.3%) and Texas (-4.7%) were the only two LTS to see Healthcare Technology jobs fall in 1999; in contrast, California experienced growth in the Healthcare Technology cluster (3.8%).

WHAT DOES THIS TREND MEAN FOR MASSACHUSETTS?

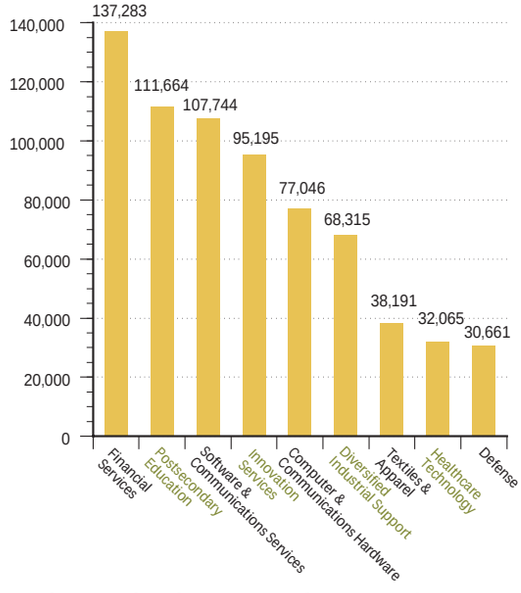
Job creation among the key industry clusters continues to move towards knowledge-based service jobs, and away from manufacturing jobs. Given the state's slow workforce growth rate, the relatively fast-growing clusters such as Software & Communications Services are attracting workers from other clusters. At the same time, the growth in the Massachusetts Software & Communications Services cluster contrasts with much stronger job growth in the LTS and the U.S.; hence, the state's low workforce growth may be constraining this cluster.

Over time, low growth in available skilled workers may limit overall growth in the economy, as measured by employment, sales, new product development, and market leadership. Massachusetts has recovered from repeated economic downturns over the years through a resurgence of innovation in industry. Shortages of well-educated and highly skilled workers pose a threat to the state's competitive advantage in innovation and high technology.

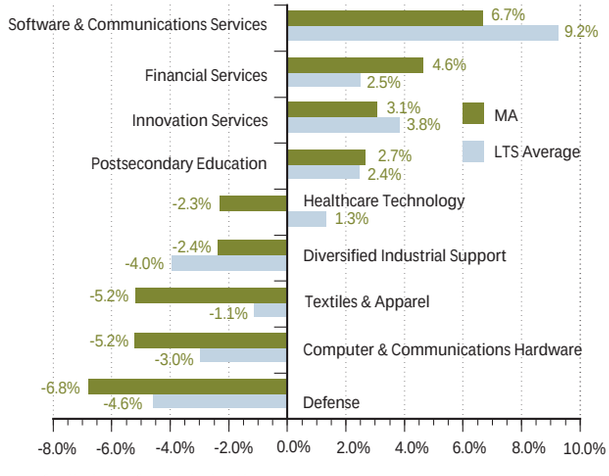
Net employment change, nine key industry clusters, Massachusetts, 1998–1999



Total employment, nine key industry clusters, Massachusetts, 1999



Percent change in cluster employment for Massachusetts and other LTS, 1998–1999



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

2. Employment Diversification
Massachusetts Continues to Have a Highly Diverse Economy

WHY IS IT SIGNIFICANT?

Specialized industry clusters create a competitive advantage for Massachusetts by bringing together the accumulated expertise of companies, research institutions, investors and other supporting organizations in a constant process of innovation. The Innovation Economy is sustained by a diverse base of clusters, which cushions the state against failure in any one cluster.

HOW DOES MASSACHUSETTS PERFORM?

Over the last decade several older, once-dominant clusters in the Massachusetts economy have given way to newer, high-growth clusters, such as Software & Communications Services. The transition has been accompanied by historically low levels of unemployment and rising wages. The high-growth Software & Communications Services and Innovation Services clusters are more highly concentrated in Massachusetts than in the nation as a whole, but not nearly as concentrated as the Defense and Textiles & Apparel industries are in Massachusetts, even in the midst of decline.

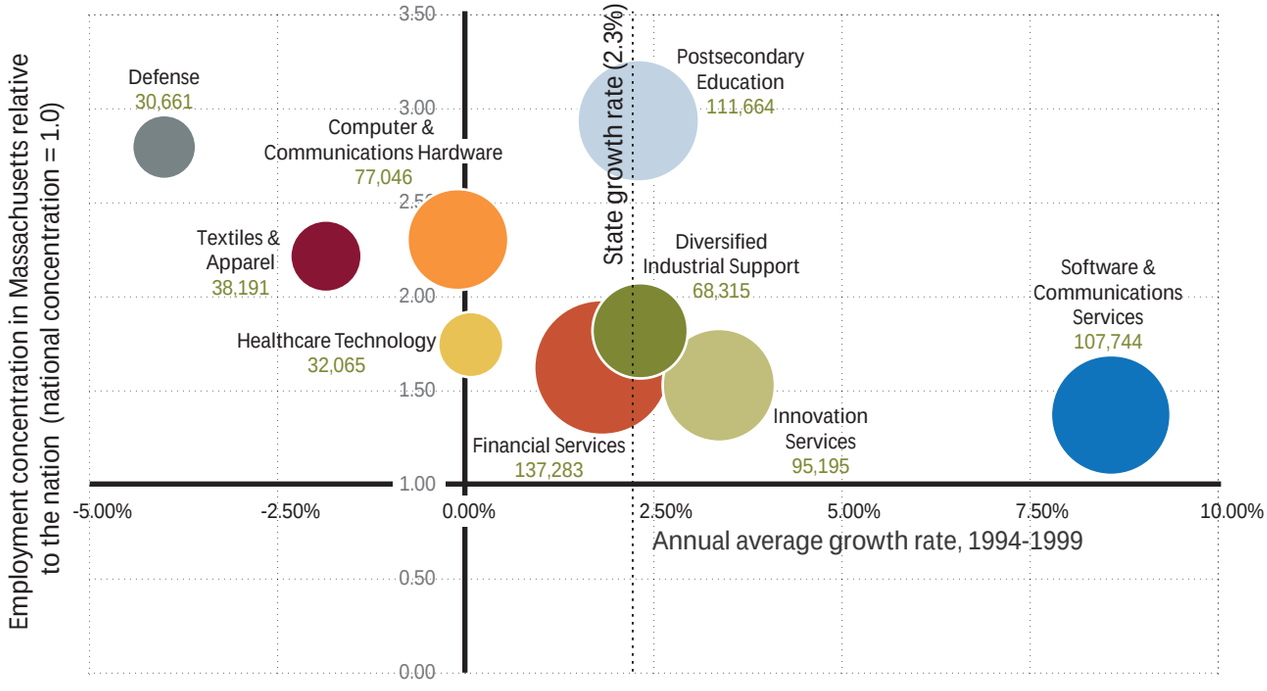
The state's Postsecondary Education cluster is among the most highly concentrated of any state in the U.S. (2.9 times more concentrated). Other key industry clusters, highly concentrated in Massachusetts relative to the nation are Defense (2.8 times), and Computer & Communications Hardware (2.3 times).

Of the nine key industry clusters, Financial Services is the largest, with 19.6% of total cluster employment. (The size of each circle on the chart reflects the relative size of employment in Massachusetts.) The Postsecondary Education, Software & Communications Services, and Innovation Services clusters have 16%, 15.4%, and 13.6% of total cluster employment, respectively. The Defense cluster has the smallest at 4.4%. Between 1994 and 1999, the growth rate of Software & Communications Services (8.5%) was more than three times the state's average annual growth rate (2.3%); and Innovation Services grew at 3.3%. Financial Services (1.8%), Computers & Communications Hardware (-0.1%), Healthcare Technology (0.1%), Textiles & Apparel (-1.9%), and Defense (-4.0%) grew at a lower rate than the state's overall growth rate, or contracted during this period.

WHAT DOES THIS TREND MEAN FOR MASSACHUSETTS?

The nine key industry clusters represent a significantly higher share (25.0%) of Massachusetts total employment than they do in the other LTS (16.0%) and in the nation as a whole (13.5%). These nine industry clusters have consistently comprised around 25% of the state's employment throughout the 1990s. At the same time, the Massachusetts key industry portfolio is one of the most diverse of the LTS; six of our key industries have a 10% or greater share of the total employment in these sectors, with no one sector having more than a 20% share of employment. In the past, Massachusetts has been particularly vulnerable to downturns in one or two industries, (recall the impact of the defense industry downsizing and the decline of the minicomputer industry in the late 1980s and early 1990s). The diversity of the state's Innovation Economy is an important source of resilience for the state's economy in the years ahead.

Portfolio of nine key industry clusters by employment concentration and growth, Massachusetts, 1994–1999



Note: Numeral below name of industry cluster is 1999 total employment
Source: Collaborative Economics, Regional Financial Associates

3. Average Pay

Average Pay in Key Clusters Remains Relatively High Compared to All Industries in the State, but Massachusetts Pay Lags Its Competitor States in Several Key Industry Clusters

WHY IS IT SIGNIFICANT?

Growth in average pay per worker, adjusted for inflation, is a measure of job quality and a key factor in 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. Key industry clusters generate wealth through national and international sales of their innovative products, processes and services. Strong demand for their innovative offerings enables cluster firms to pay higher wages to their knowledge workers.

HOW DOES MASSACHUSETTS PERFORM?

Workers in the faster growing, knowledge-intensive service clusters continue on average to earn the highest wages. The Innovation Services cluster had the highest average pay at $78,481 per year in 1999, a 3.0% increase from 1998. Continuing the trend from 1998, Financial Services ranks second at $69,514 per year, followed by Software & Communications Services at $68,418. The average annual increase in pay (inflation adjusted) for the nine key clusters was 3.8% between 1998 and 1999, compared to 3.2% in the previous year.

Relative to the other LTS, Massachusetts has higher average wages in five industry clusters: Innovation Services, Healthcare Technology, Diversified Industrial Support, Textiles & Apparel, and Postsecondary Education. In several clusters, however, including Financial Services, Software & Communications Services, and Computer & Communications Hardware, the state lags other LTS in average pay. In 1999, the salary gap between Massachusetts and its competitors narrowed in Software & Communications Services, but widened in Financial Services. Pay per worker in Financial Services was 20.9% lower in Massachusetts than the average for the LTS.

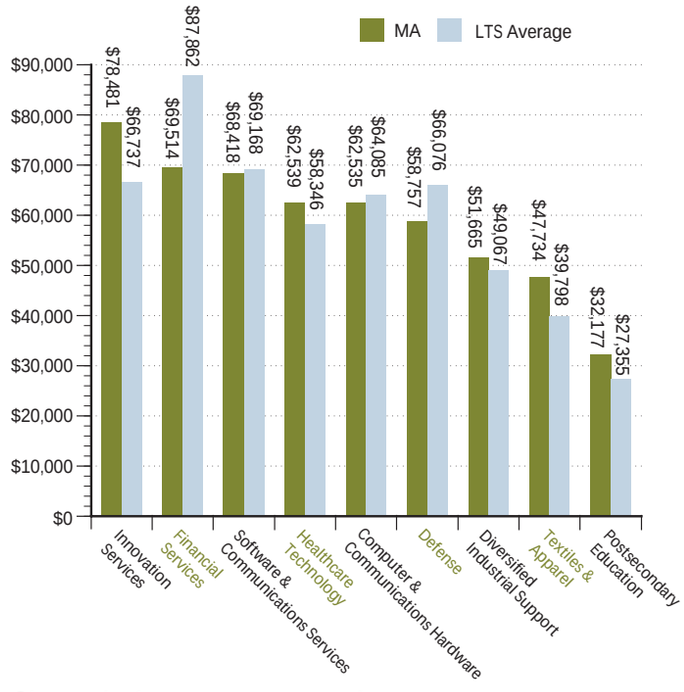
From 1995 to 1999, wages in Textiles & Apparel increased by 5.4% annually in inflation adjusted terms. Wages in Innovation Services grew by 4.9%, closely followed by Financial Services at 4.7%. The average annual wage rate growth for Computer & Communications Hardware (2.6%), Defense (2.0%) and Postsecondary Education (1.2%) fell below the state's overall average annual wage growth rate for all employees (3.2%). This overall growth rate for Massachusetts is slightly higher than the LTS overall annual wage growth rate of 3.1% from 1995 to 1999.

The average wage in eight of the state's nine key clusters (excluding Postsecondary Education) is higher than the average annual pay per worker of $40,960 in all Massachusetts industries and above the LTS average of $39,068.

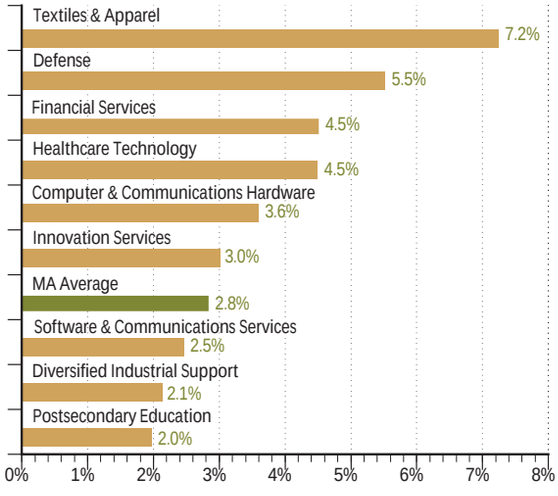
WHAT DOES THIS TREND MEAN FOR MASSACHUSETTS?

Pay in most of the key industry clusters continues to far outpace the average pay for all jobs in Massachusetts, while the skills shortage in the state means that many jobs in the clusters are going unfilled. Our technology-based clusters remain the source of some of the best opportunities for workers to remain in Massachusetts and prosper. The fact that average pay in some of the clusters lags that of the other LTS does not necessarily mean local salary levels are low in comparison; they may reflect the brisk rate of hiring for entry-level positions in these industries. Nevertheless, many analysts contend that average pay in Massachusetts does lag that of competitor states when our state's high cost of living is factored against prevailing rates of pay. Diminished purchasing power may help explain the continuing out-migration of Massachusetts residents, including residents who are of prime working age.

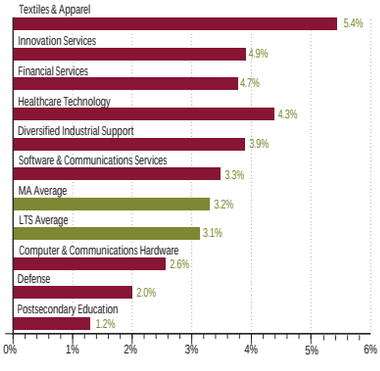
Average pay per worker, nine key industry clusters, Massachusetts and LTS average, 1999



Cluster industry wage growth rate, Massachusetts, 1998–1999 (1999 $ inflation adjusted)



Annual average cluster industry wage growth rate, Massachusetts, 1995–1999 (1999 $ inflation adjusted)

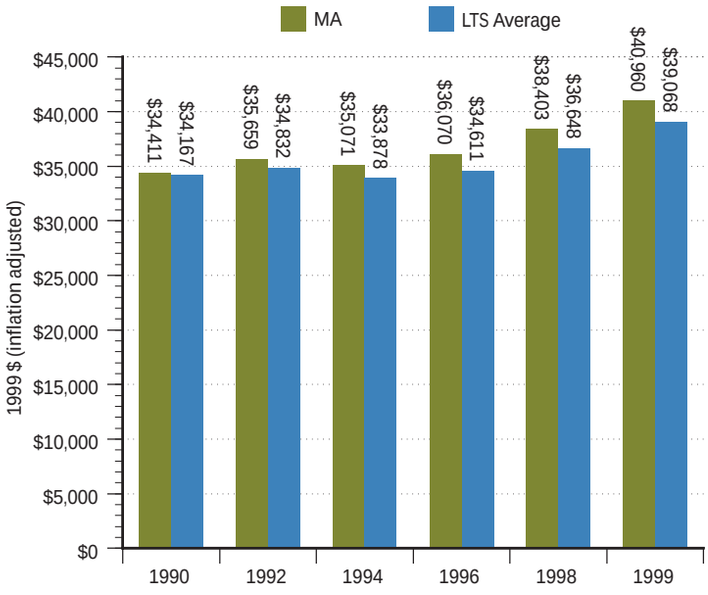


Source of all data for this indicator:
Collaborative Economics, Regional Financial Associates

4. Pay per Worker

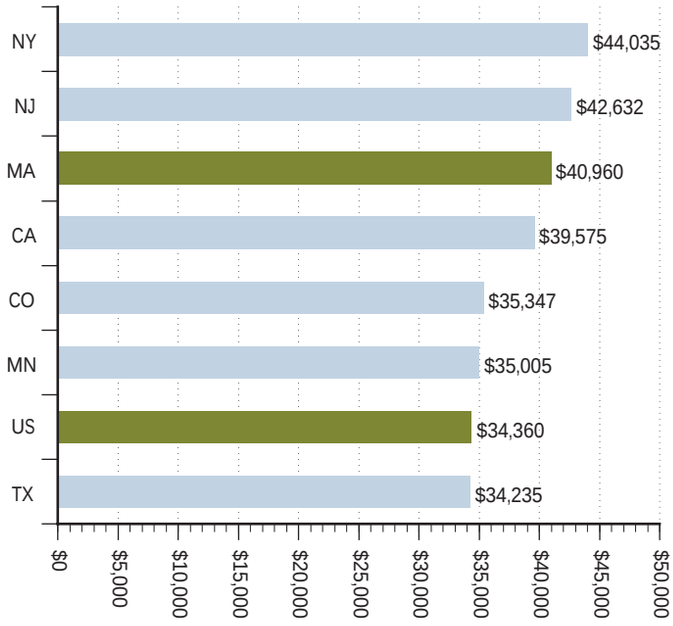
Average Pay Remains High in the State Compared to Other LTS and National Average

Average annual pay per worker, Massachusetts and LTS average, 1990-1999 (1999 $ inflation adjusted)



Source: Bureau of Labor Statistics

Average annual pay per worker, Massachusetts, LTS and US, 1999



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

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. High pay per worker can also provide a state with competitive advantage in attracting or retaining a skilled workforce.

HOW DOES MASSACHUSETTS PERFORM?

In 1999, the average annual pay for all workers in Massachusetts was $40,960 compared to an LTS average of $39,068. From 1998 to 1999, average annual pay per worker increased 6.7% in inflation adjusted terms in Massachusetts, which was slightly higher than the 6.6% average increase in the six other LTS.

Between 1990 and 1999, average annual pay of Massachusetts workers increased 19.0% in inflation adjusted terms, compared with 14.3% in the six other LTS. Of the LTS, Massachusetts consistently reported the third highest average annual pay per worker ($40,960), behind New York ($44,035) and New Jersey ($42,632), and just ahead of California ($39,575).

WHAT DOES THIS TREND MEAN FOR MASSACHUSETTS?

Rising pay per worker means that, on average, Massachusetts workers are benefiting from the growth of the Innovation Economy. The comparatively high level of average pay in the state is consistent with the state's high level of workforce educational attainment and resulting returns in worker productivity. The Commonwealth's advantage in average pay is qualified by the its relatively high cost of living, which erodes purchasing power, and its ability to keep and attract workers at a time when technically skilled workers are in great demand nationwide.

5. Median Household Income

Growth in Massachusetts Median Household Income Flat, While Other LTS Continue to Outpace US

WHY IS IT SIGNIFICANT?

Successful economies create opportunities for households to increase incomes. They promote a rising standard of living and the opportunity for families to work and prosper in the state.

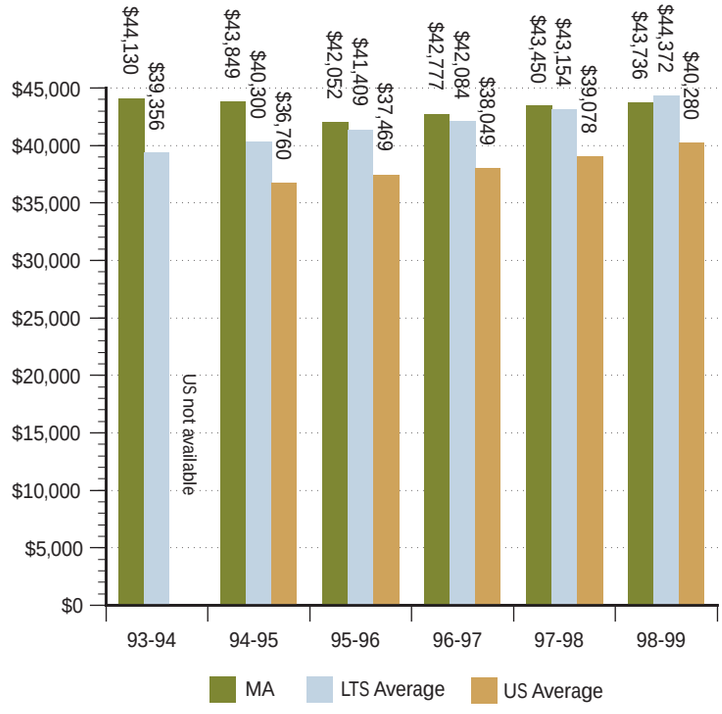
HOW DOES MASSACHUSETTS PERFORM?

After adjustment for inflation, Massachusetts median household income is little changed from its level during the 1993-1994 period. The state's median household income has risen slowly to the point that it has almost returned to its higher level during the 1993-1994 period. This stands in marked contrast to the performance of the other LTS and the U.S. as a whole. On average, median household income for the other LTS has risen 2.5% annually during the period, outpacing the 2.4% annual growth rate of the U.S. as a whole. In general, growth among the LTS and the U.S. has been accelerating during the past three periods, while that of Massachusetts has been slowing. Among the LTS, median household income is growing fastest in Minnesota and Colorado. The other LTS, while exhibiting growth during this period, grew at rates below that of the U.S. as a whole. Median household income grew less than 1% in Massachusetts and New Jersey during the most recent period, while all of the other LTS grew at rates equal to or greater than the annual U.S. growth rate of 3.1%.

WHAT DOES THIS TREND MEAN FOR MASSACHUSETTS?

Massachusetts households no longer earn substantially more than their peers in the other LTS. In the past, higher household income has helped Massachusetts residents absorb the relatively high cost of living and housing costs in the state. If living costs outpace income increases, workers may leave the state for lower cost areas or for states that offer higher income opportunities. While many factors, such as changing labor participation rates, may affect household income, it is clear that this competitive advantage once enjoyed by Massachusetts residents has eroded. In order to regain this advantage, Massachusetts should accelerate policies that promote upward job mobility and which positively impact family disposable income (e.g., relative housing costs).

Median household income, Massachusetts, LTS and US (2 year moving average, 1999$)

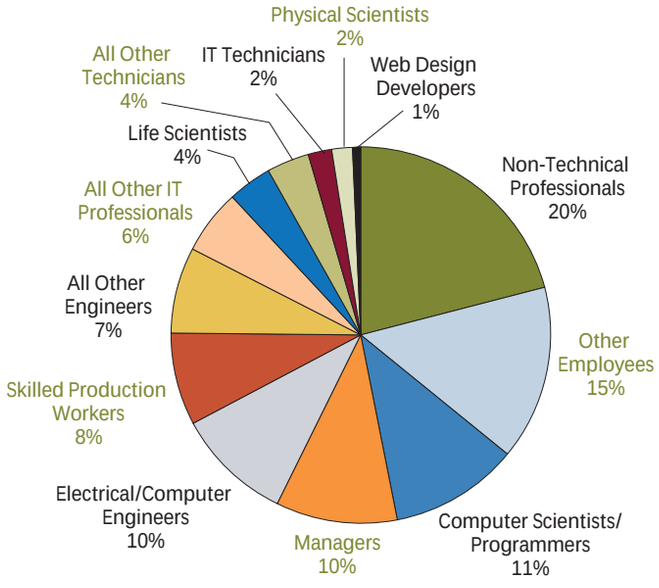


Source: U.S. Census Bureau

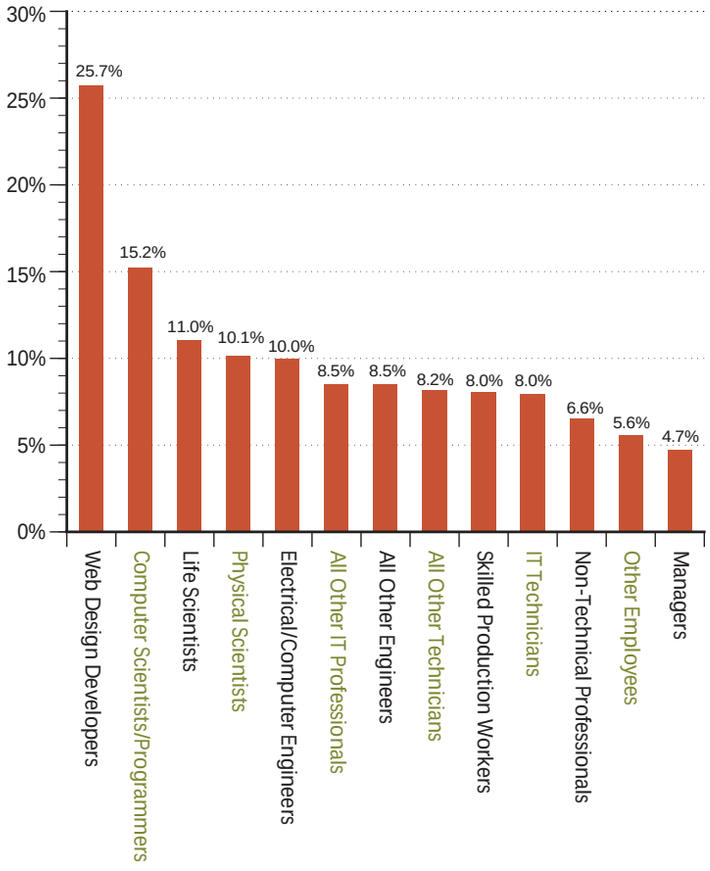
6. Skills Needs

High-Tech Firms Continue to Search for Professional and Technical Talent

Distribution of current occupations within technology-intensive companies surveyed, Massachusetts, 2000



Vacancy rate by occupation within technology-intensive companies surveyed, Massachusetts, 2000



Note: Portions may not sum to 100% due to rounding
Source of all data for this indicator:
MTC / Northeastern University Workforce Needs Survey

WHY IS IT SIGNIFICANT?

The nine key industry clusters we examine in the *Index* rely on a high concentration of technical and professional talent. Scientists, engineers, and information technology (IT) workers are at the heart of the Massachusetts Innovation Economy. Massachusetts firms cite the limited availability of these skilled workers as a serious impediment to continued growth.

HOW DOES MASSACHUSETTS PERFORM?

In May 2000, the Massachusetts Technology Collaborative and Northeastern University's Center for Labor Market Studies surveyed companies in a wide range of industries within our nine key clusters. The membership of the Massachusetts Biotechnology Council, the Massachusetts High Technology Council, the Massachusetts Medical Device Industry Council, the Massachusetts Software and Internet Council, and the Massachusetts Telecommunications Council participated in the survey.

The workforce survey revealed that over 8% of scientific, engineering, and IT jobs with the surveyed firms were vacant at the time of the survey, despite persistent attempts by firms to fill the jobs. Over 15% of computer scientist/programmer positions at the responding firms were vacant, as were 11% of life scientist jobs. Over 25% of web designer/developer jobs were vacant.

The Northeastern/MTC survey also revealed that Massachusetts firms are relatively heavy users of temporary foreign workers who hold H-1B visas. This group constituted 13.1% of all new staff hires at the firms surveyed. Over a third of all life scientists, a quarter of electrical engineers, and over 20% of computer scientist/programmers were hired under the H-1B program.

WHAT DOES THIS TREND MEAN FOR MASSACHUSETTS?

Massachusetts faces a chronic shortage of workers, particularly in scientific, engineering and IT occupations. The Commonwealth is not alone; the entire U.S. economy is constrained by a shortage of skilled technical workers. However, as we describe in the "Implications" section on page 6, the shortage in Massachusetts is acute, chronic and not easily remedied. The state's low rate of population and workforce growth deepens the crisis and the challenge for the business community and for policymakers. The crisis demands an all-out and collective response from the public and the private sectors. Current initiatives to address the crisis are outlined (above) in the "Implications" section of the *Index*.

7. High-Tech CEO Rating of Massachusetts

State's Business Climate Rating by High-Tech Business Leaders Declines, but Remains Very Favorable

WHY IS IT SIGNIFICANT?

Confidence of resident business leaders in a region reflects not only current conditions but also influences future prospects. Positive or negative perceptions of a state affect investment patterns. The perception by high technology 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.

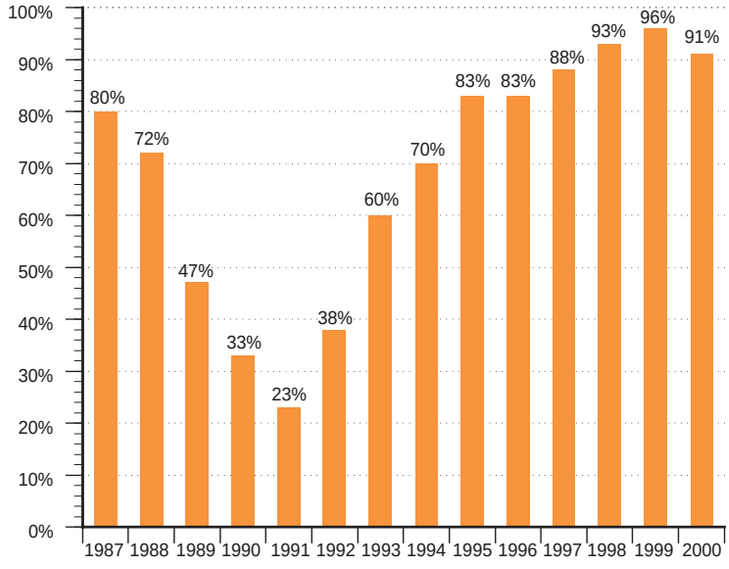
HOW DOES MASSACHUSETTS PERFORM?

The attractiveness of Massachusetts to high technology business leaders declined slightly in 2000, but remains at a high level. Local CEOs continue to rank the state very favorably as a place to conduct business. In 2000, 91% of the executives responding to the Massachusetts High Technology Council annual survey rated the Massachusetts business climate as "good" or "outstanding," compared to 96% a year earlier. As a 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 and expansion of firms and jobs in the state. The Massachusetts High Technology Council reported that the two most frequently cited reasons for the decline in the ratings this year were "…a tight labor market for skilled and technical management and personnel, and a reemergence of an 'anti-business' attitude in the state legislature… ." Public policies that foster the conditions for the growth of knowledge-based businesses are essential if the state is to remain a leader in the Innovation Economy.

Percentage of high-tech CEOs rating Massachusetts "good" or "outstanding," as a place to create, operate, expand high-tech businesses, 1987–2000

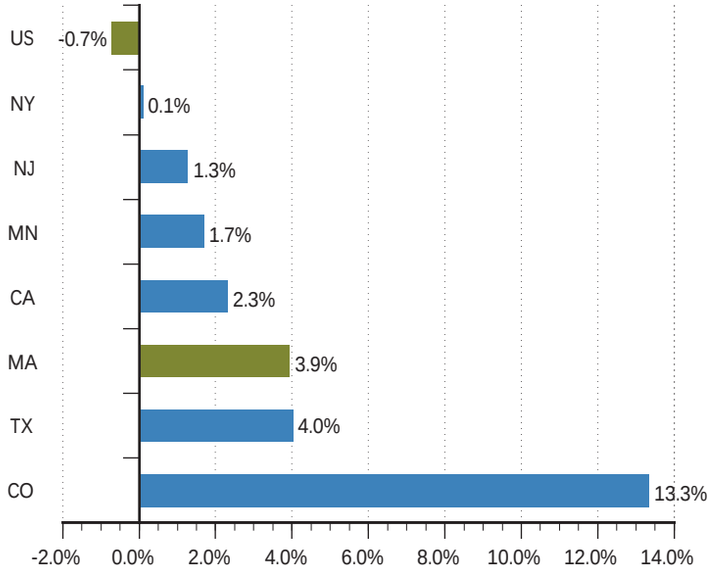


Source: Massachusetts High Technology Council

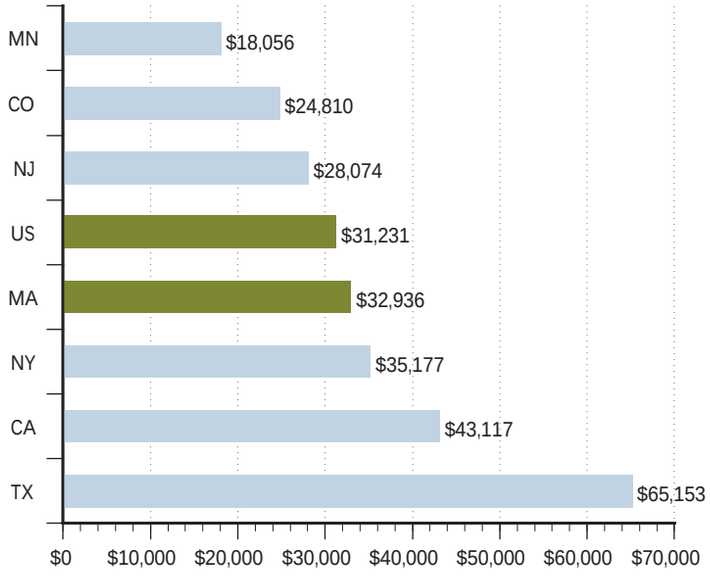
8. Manufacturing Exports

Value of Manufacturing Exports Increases in Massachusetts and the Other LTS

Change in value of manufacturing exports per employee, Massachusetts, LTS and US, 1998–1999 (1999 $ inflation adjusted)



Value of manufacturing exports per employee, Massachusetts, LTS and US, 1999



Source of all data for this indicator: MISER; Office of Trade and Economic Analysis, International Trade Administration, U.S. Department of Commerce

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 counter-cyclical hedge against downturns in any single market.

HOW DOES MASSACHUSETTS PERFORM?

Massachusetts and each of the other LTS experienced modest increases in the value of their manufacturing merchandise exports between 1998 and 1999. The value of Massachusetts manufacturing exports increased by 3.9% in inflation adjusted terms during that period as compared to the U.S. value which fell by 0.7%. Colorado ranks first among the LTS in growth in value of manufacturing exports per employee at 13.3% from 1998 to 1999. Massachusetts manufacturing exports have increased by 39.2% since 1991.

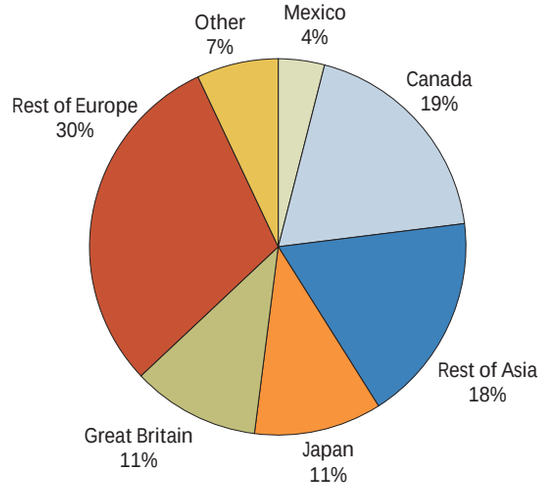
Per employee, Massachusetts manufacturing exports ($32,936) place the state fourth among the LTS, and the state ranks just above the national average ($31,231). Texas ranks first among the LTS with $65,153, followed by California ($43,117), and New York ($35,177).

The markets for Massachusetts manufacturing exports remained steady between 1998 and 1999, with the largest percentage going to Europe, excluding Great Britain, (30%); followed by Canada (19%); and then Asia, excluding Japan, (18%). Japan and Great Britain each received 11% of Massachusetts exports with Mexico receiving 4%.

WHAT DOES THIS TREND MEAN FOR MASSACHUSETTS?

In 1999 the state's manufacturing exports rebounded more strongly than those of the other LTS and the nation as a whole. This is a sign that the state's manufacturers have recovered from the Asian financial crisis that had a negative effect on the export of goods such as semiconductor manufacturing equipment. The resurgence in Massachusetts exports is a reminder of the state's continued integration into the global economy. As the Asian financial crisis demonstrated, our key industry clusters have found substantial opportunities abroad, but these opportunities carry increased vulnerability to international market fluctuations. Massachusetts has a very real stake in the continued, successful evolution of the global trading system, and, as a consequence, in the successful outcome of U.S. negotiations on such issues as establishment of the World Trade Organization, and bilateral agreements on the exchange of technology products.

Destination of Massachusetts exports, 1999



Note: Portions may not sum to 100% due to rounding

INNOVATION PROCESS INDICATORS

"The process of fostering innovation is extremely complex. It is the interplay of many factors, some more visible than others, that makes the innovation process work."

Patrick M. Gray, Sr., *Partner*
High Technology Group
PricewaterhouseCoopers, LLP

INNOVATION PROCESS INDICATORS

The innovation process includes idea generation, technology commercialization and entrepreneurship, as well as innovation occurring 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. Positive results are created for both business and people. The innovation process has different stages, but a strong interrelationship among them is critical for success.

9. Patents per Capita

State Continues to Lead in Patents Per Capita; Other States Accelerate Their Patent Activity at a Faster Rate than Massachusetts

WHY IS IT SIGNIFICANT?

Patents reflect the initial discovery and registration of innovative ideas. Strong patent activity usually reflects significant conduct of commercially relevant research and development. The primary reason to secure patent protection is the potential relevance of an invention or discovery to a marketable product or process.

HOW DOES MASSACHUSETTS PERFORM?

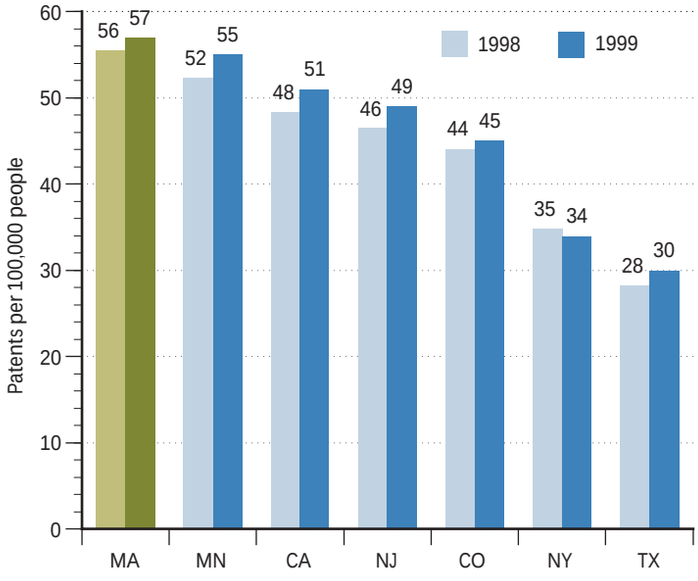
Massachusetts continues to rank above all the LTS in patents per capita. In 1999, innovators were granted 57 patents per 100,000 residents. This rate is slightly higher than the next closest states of Minnesota (55) and California (51). The absolute number of patents in Massachusetts has increased from 2,161 in 1995 to 3,521 in 1999, a 62.9% increase. There has been a recent slowdown in the growth of patent activity on a per capita basis for all the LTS. From 1998 to 1999, Texas (7.0%), Minnesota (6.4%) and New Jersey (5.4%) led the LTS in terms of growth in patent activity on a per capita basis. Massachusetts ranked fourth among the LTS with a per capita patent growth rate of 2.7% for the year.

Patents in Massachusetts cross a wide range of sectors. From 1995 to 1999, healthcare was the most active area, with 27% of all patents, as compared to 19% between 1990 and 1994. Miscellaneous industry & transportation/aerospace was the second most active in the 1995-1999 period, with 24% of all patents, followed by computers (10%) and industrial equipment/ machinery (9%).

WHAT DOES THIS TREND MEAN FOR MASSACHUSETTS?

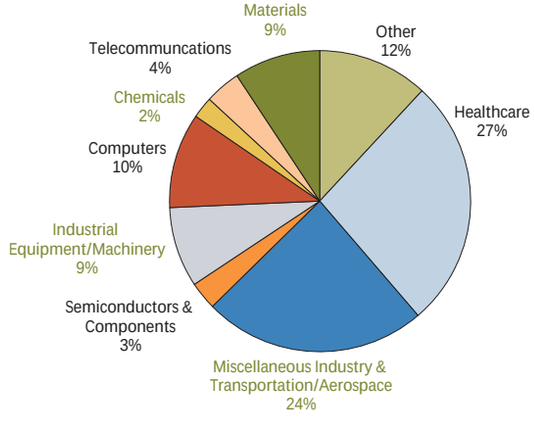
In many sectors of the Innovation Economy, strong patent positions are critical elements in establishing dominant market leadership. Massachusetts continues to enjoy a position of strength in the development of intellectual property, but the relative growth rates among the LTS are but one example of increasing competition in this indicator. At the same time, one of the key strengths of the Massachusetts patent portfolio is its diversification. Research institutions and corporations in the state must continue to invest in the technology and patents that establish their basic competitive advantage. In particular, public and private research institutions should continue to develop and implement patent policies that encourage faculty and other research staff to identify and develop potentially patentable technology.

Number of patents issued to state residents, per capita, Massachusetts and LTS, 1998 and 1999

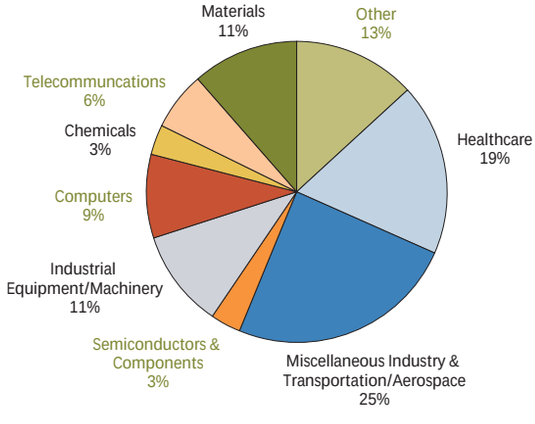


Source: U.S. Patent and Trademark Office, U.S. Census Bureau

Distribution of patents issued, Massachusetts, 1995–1999



Distribution of patents issued, Massachusetts, 1990–1994

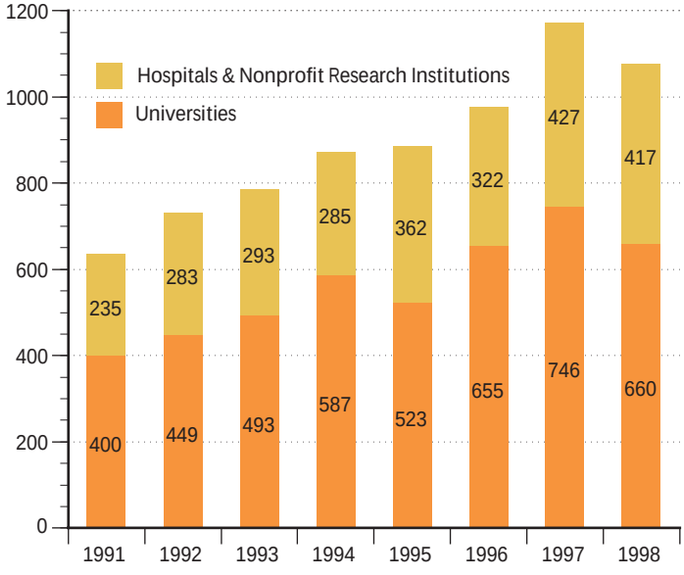


Note: Portions may not sum to 100% due to rounding
Source of pie charts: CHI Research

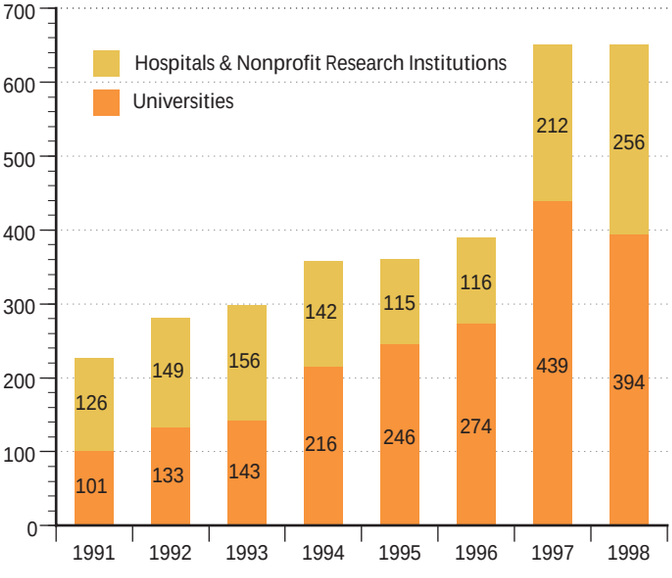
10. Invention and Patent Applications

Patent Applications and Invention Disclosures Experience a Decrease, but Activity Remains Strong over Time

Number of invention disclosures received by major universities, hospitals, and nonprofit research institutions, Massachusetts, 1991–1998



Number of new patent applications filed each year by major universities, hospitals, and nonprofit research institutions, Massachusetts, 1991–1998



Source of all data for this indicator:
Association of University Technology Managers,
Massachusetts Technology Collaborative

WHY IS IT SIGNIFICANT?

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

Research conducted by major universities, hospitals and research institutions has a two-fold "spillover" effect in the state's economy. Institutional research induces private research to capitalize on innovations, and as a result, the new companies, goods, and services created downstream spur economic vitality.

HOW DOES MASSACHUSETTS PERFORM?

The number of invention disclosures received annually by Massachusetts academic and nonprofit institutions decreased 8.2% from 1,173 in 1997 to 1,077 in 1998. Since 1991, universities have accounted on average for two-thirds of invention disclosures, with the remainder by hospitals and other nonprofit research institutions.

Among the universities, the Massachusetts Institute of Technology (MIT) was responsible for more than half (53.7%) of all the inventions disclosed between 1997 and 1998. Harvard University and the University of Massachusetts continued to rank second and third respectively. Boston University and Harvard University also showed growth in invention disclosures, increasing 10.5% and 4.2%, respectively, between 1997 and 1998. Of the hospitals and research institutions, Massachusetts General Hospital (MGH) accounted for the most invention disclosures (34.8%) in 1998. Significant growth occurred at Beth Israel Deaconess Medical Center over this period as well.

New patent applications in Massachusetts remained constant between 1997 (651) and 1998 (650), however the institutional mix shifted. Patent applications filed by universities dropped by 10.3% between 1997 and 1998, while those filed by hospitals and other research institutions increased 20.8%.

WHAT DOES THIS TREND MEAN FOR MASSACHUSETTS?

The state continues to demonstrate considerable strength in the early phases of innovation, as evidenced by the total number of invention disclosures over time and the continued generation of new patent applications. It is important to the early stage of the innovation process that universities, research institutions and hospitals continue to work with key industries to realize the maximum potential of this idea-generation.

11. Technology Licenses and Royalties

New License Royalties Decline, but Universities Continue to Increase License Activity

WHY IS IT SIGNIFICANT?

Technology licenses provide a vehicle for the transfer of intellectual property (e.g., patents, experimental findings) from universities, hospitals and other research organizations to companies that will commercialize the technology. Royalties from these licenses reflect the perceived value of the intellectual property in the commercial marketplace.

Licensing revenues are affected by the disciplines in which the research is undertaken and by the degree to which university and other institutional research is focused on marketable products. 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?

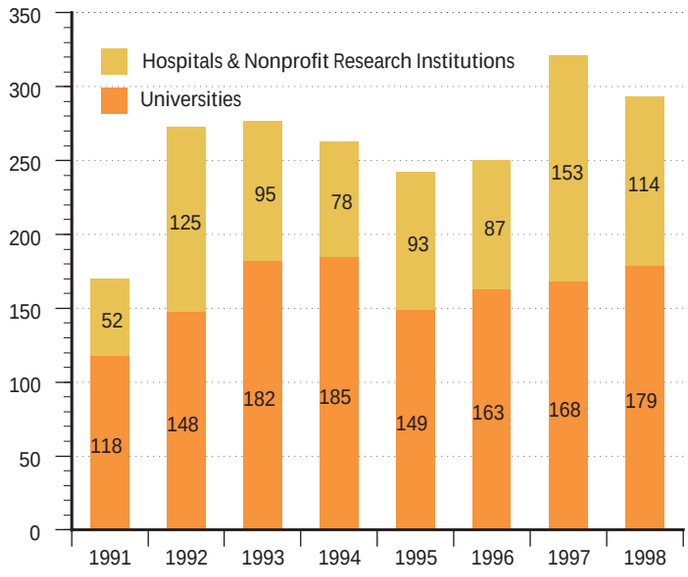
New technology licenses issued by major universities, hospitals and research institutions in Massachusetts dropped 8.7%, from 321 in 1997 to 293 in 1998. New technology licenses at universities, however, increased 6.5% during this period. The Massachusetts Institute of Technology (MIT) and Harvard University together generated 77.5% of the technology licenses in 1998.

Gross royalties received from technology licensing in Massachusetts decreased 12.9%, from $50 million in 1997 to $43 million in 1998. In 1998, the four institutions in Massachusetts receiving the highest amount of royalties were, in descending order, MIT, Harvard University, Brigham & Women's Hospital, and the University of Massachusetts (all campuses). The UMass system experienced sharp increases in both its total number of licensing agreements and in its license income.

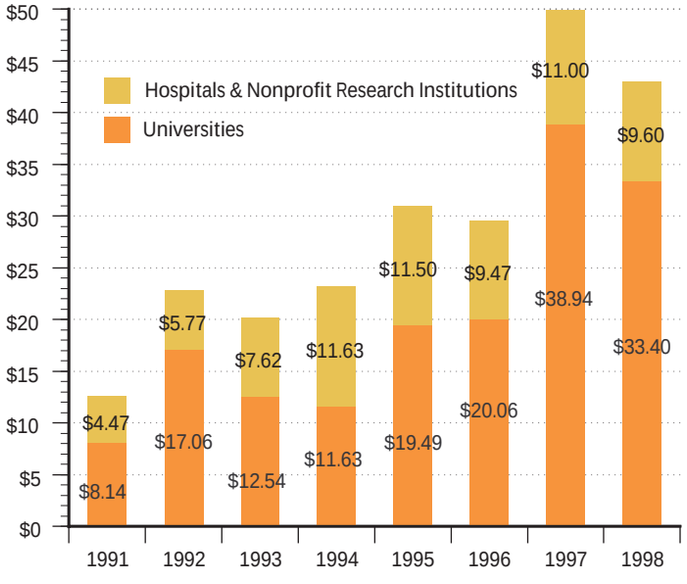
WHAT DOES THIS TREND MEAN FOR MASSACHUSETTS?

After a record year in 1998, license activity by nonprofit universities, hospitals and research institutions, combined, experienced a decrease. Since 1995, however, Massachusetts universities have steadily increased their license activity, suggesting that connections between the universities and business community are getting stronger. The linkages throughout the innovation process, and policies to support and facilitate such activities, should be monitored closely to ensure that Massachusetts maintains its leadership position as a generator of new technology in the Innovation Economy.

Number of technology licenses issued by major universities, hospitals, and nonprofit research institutions, Massachusetts, 1991–1998



Value of gross licensing received, Massachusetts, 1991–1998 (1998 $ inflation adjusted)

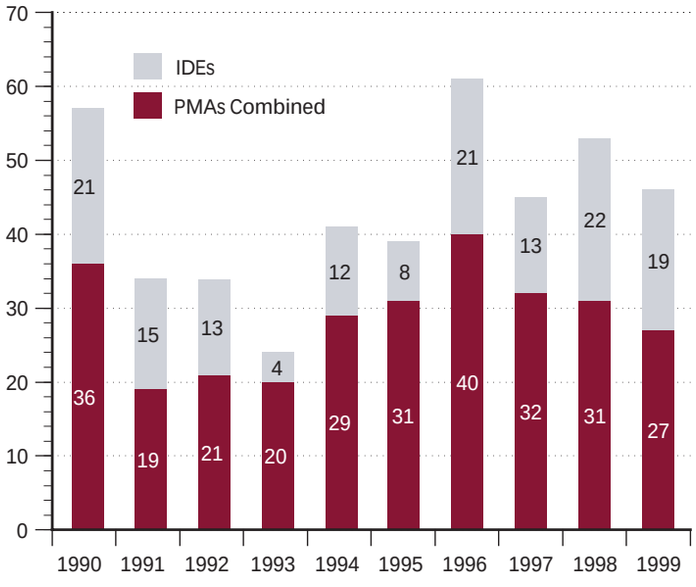


Source of all data for this indicator:
Association of University Technology Managers

12. FDA Approval

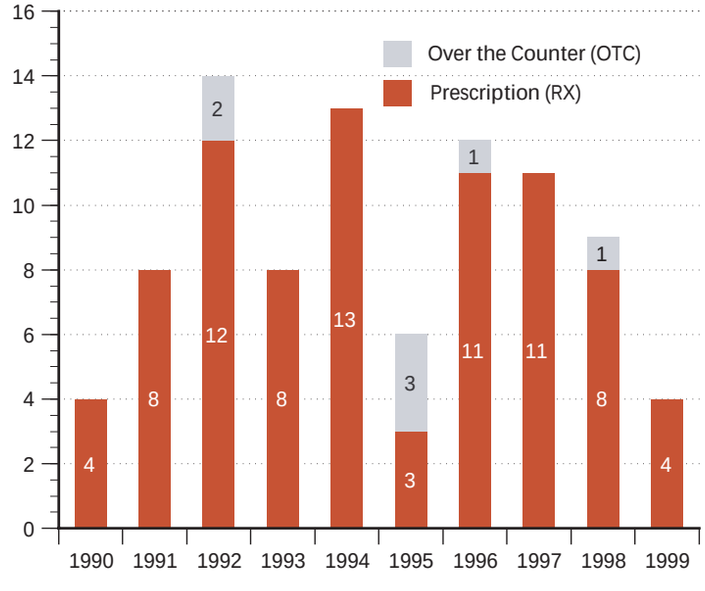
FDA Approval of Medical Device Applications and New Drug Approvals Slows in 1999

Number of FDA application approvals for advanced medical devices, Massachusetts, 1990–1999



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

Total number of drug approvals, prescription (RX) and over the counter (OTC), Massachusetts, 1990–1999



Source: 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 effective linkages to the teaching hospitals, where many of these instruments undergo clinical investigation.

The new drug approval (NDA) process is comprehensive, involving clinical trials and an extensive review process. Since 1938, every new drug has been the subject of an NDA process before U.S. commercialization. Human drug approvals fall into two FDA classifications—prescription (RX) and over-the-counter (OTC). Drug approvals reflect innovation in health research and pharmaceutical manufacturing as well as strong connections to the biotechnology and healthcare technology industry sectors.

HOW DOES MASSACHUSETTS PERFORM?

Although Massachusetts has consistently ranked among the top states in the nation for approval of IDEs, the total number of IDEs decreased by 13.6% from 1998 to 1999. Among the LTS, California, Texas, Colorado, and Minnesota also experienced a similar percent decrease in IDE approvals. In addition, PMAs in Massachusetts dropped by 12.9% between 1998 and 1999. With 27 approvals, Massachusetts ranks a distant third among the LTS, behind California and Minnesota, with 110 and 97 approvals, respectively. According to MassMEDIC, the association of medical device manufacturers in the state, 232 medical device companies are based in Massachusetts. These firms account for 4.5% of the state's total manufacturing and employ more than 23,000 people.

Massachusetts received four drug approvals (RX) in 1999, ranking sixth among the LTS (Texas was last with 1 RX approval). New Jersey ranks first among the LTS in total number of drug approvals—57 RX and 5 OTC in 1999, due in large part to the major pharmaceutical companies located there. Since 1996, the total number of drug approvals has declined in Massachusetts, a trend experienced by most of the LTS during this period. For example, New Jersey had 72 RX and 12 OTC drug approvals in 1996.

WHAT DOES THIS TREND MEAN FOR MASSACHUSETTS?

FDA approval for advanced medical devices and pharmaceuticals is an important step in moving from innovative ideas and health research to commercial products and medicines in the healthcare field.

Timely approval of medical devices and pharmaceuticals enhances the state's competitiveness in the biotechnology and healthcare industries. In the case of pharmaceutical firms, because of the length of the total development time for a new drug (the average is 15 years, according to Boston Consulting Group) and the high costs to discover and develop a new drug, these companies have responded by forming alliances with research institutions, other pharmaceutical firms, and biotech firms. Enactment of the FDA Modernization Act of 1997 is expected to reduce the time required for drug development and approval. The timely approval by the FDA of new drugs and devices and a greater collaboration of our bio-medical businesses with local academic and research institutions should enhance the level of new drug and device research and commercialization.

13. New Business Starts

New Business Starts Decline in Massachusetts and Other LTS

WHY IS IT SIGNIFICANT?

The formation of new businesses is strong evidence of the entrepreneurial spirit and innovative thinking in Massachusetts. Increasing numbers of new business starts are an indicator of an economic environment that encourages innovation and risk taking and that promotes real commercial activity. New business starts not only provide new jobs but also new products, services, and ideas.

HOW DOES MASSACHUSETTS PERFORM?

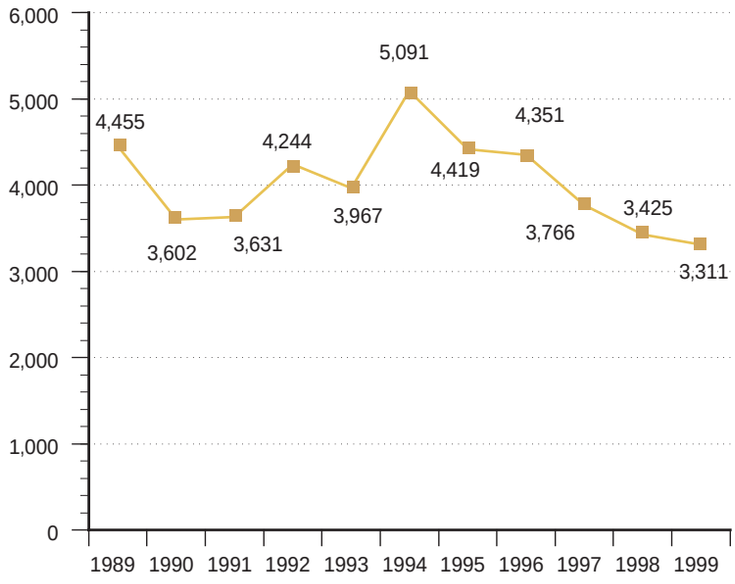
In 1999, 3,311 new businesses were recorded in Massachusetts by Dun & Bradstreet, a 3.3% decrease from 1998. The state had 35.0% fewer business starts in 1999 than in 1994. While all the LTS have experienced a drop in new business activity, Massachusetts had the largest percentage decline during this time period.

The Services sector (which includes a diverse mix of industries, from prepackaged software, computer programming services, and engineering and research services, to hotels and amusement services) accounts for the largest share of new business starts with 36% in 1999. Retail trade was second (19%), followed by the construction sector (8%).

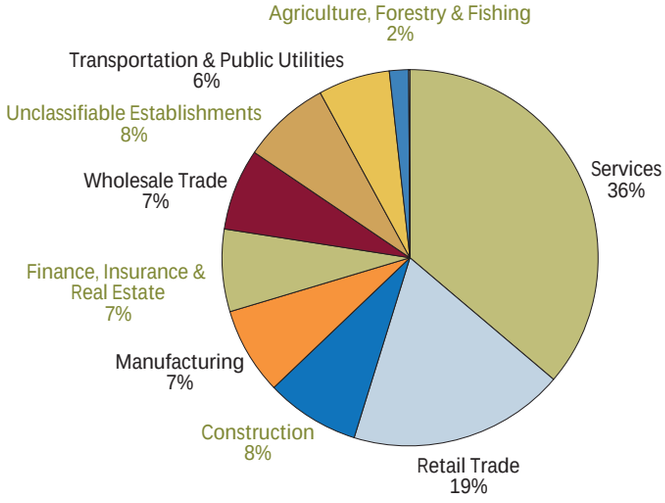
WHAT DOES THIS TREND MEAN FOR MASSACHUSETTS?

According to Dun & Bradstreet, business start-up activity in the nation as a whole declined in 1999; 35 of the 50 states posted a drop in new business starts. However, the biggest decrease in the total number of new business starts was in New England (-7%). During periods of strong economic growth, new business ventures may decrease because of the strong levels of employment in already-established firms. However, it is still critical for future growth to foster new business support systems (e.g., incubator programs, access to capital) so entrepreneurs can prosper and bring their business concepts and ideas to fruition.

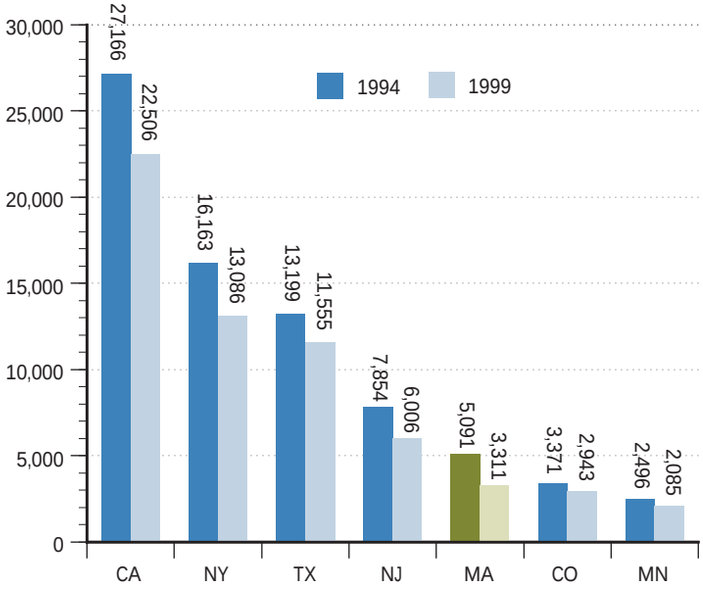
Total number of new business starts, Massachusetts, 1989–1999



Distribution of new business starts, Massachusetts, 1999



Total number of new business starts in Massachusetts and other LTS, 1994 and 1999

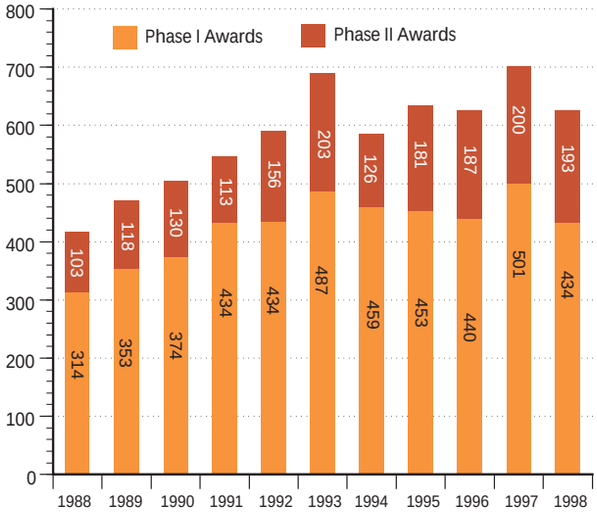


Source of all data for this indicator: Dun & Bradstreet

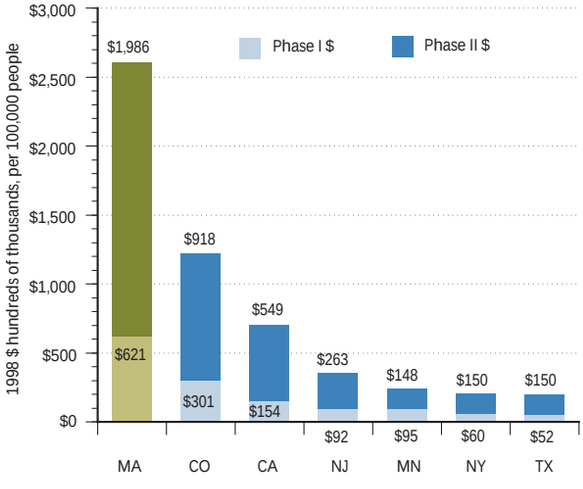
14. SBIR Awards

Despite Declines in the State and Nationally, State's Small Business Innovation Research Funds Increase in Market Share

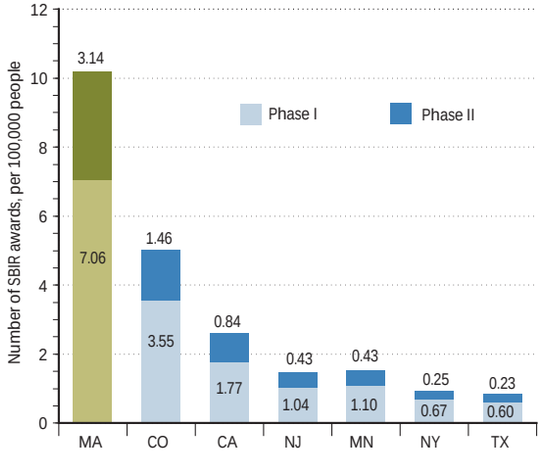
Number of SBIR awards to Massachusetts companies by phase, 1988–1998



Dollar value of SBIR awards for Massachusetts and other LTS companies by phase, per 100,000 people, 1998



Number of SBIR awards to Massachusetts and other LTS companies by phase, per 100,000 people, 1998



Source of all data for this indicator:
Small Business Administration

WHY IS IT SIGNIFICANT?

The Small Business Innovation Research (SBIR) Program provides competitive grants to entrepreneurs seeking to conduct "Phase I" proof-of-concept research on the technical merit and feasibility of their ideas, and "Phase II" prototype development to build on these findings. The federal SBIR program is reputed to be the world's largest seed capital fund for development of new products and processes, and often provides the initial revenue stream for start-up companies. Nationally, companies that receive funding from Phase II of the SBIR program significantly outperform similar companies that do not receive such support. Participants in the SBIR program are often able to use the credibility and experimental data developed through their research to attract strategic partners and outside capital investment.

HOW DOES MASSACHUSETTS PERFORM?

Massachusetts companies continue to have exceptional success in the national SBIR competitions. Despite a $6 million decrease in awards reported by the Small Business Administration (SBA), Massachusetts market share increased from 13.8% of total dollars awarded in FY 97 to 15.2% in FY 98. (Nationally, awards reported by the SBA decreased from $1.2 billion to $1.05 billion during this period, with the largest decreases at the National Aeronautics and Space Administration [NASA] and NIH.)

Since the inception of the program in 1983, Massachusetts has consistently ranked second in total number and dollar amount of awards received, behind California. On a per capita basis, however, Massachusetts has the highest award rate in the country. In 1998, Massachusetts received twice the per capita awards of Colorado, its closest competitor among the LTS, and four times the per capita awards of California.

In 1998, the total dollar value of SBIR awards to Massachusetts companies was $160 million. Phase II awards are significantly larger in dollar value than Phase I awards and comprise about 76% of all SBIR funding in the state. Of the 255 Massachusetts companies that received one or more awards in FY 98, 67 (25%) were new to the program.

WHAT DOES THIS TREND MEAN FOR MASSACHUSETTS?

The SBIR program continues to provide Massachusetts technology entrepreneurs with an important source of seed capital to start and grow their companies. Success in the SBIR program is not simply about obtaining federal support. Forty-three Massachusetts SBIR awardees have gone public, many in the healthcare technology sector. Some of these companies, such as Genzyme Corporation, have become top performers in their respective markets. In a recent *Boston Globe* listing of the ten fastest growing companies in Massachusetts, seven were current or former SBIR awardees. Since January 1, 2000, four Massachusetts SBIR awardees have been acquired for an aggregate valuation in excess of $2.5 billion. Massachusetts has a substantial stake in the future of this highly successful innovation program, which is currently up for renewal.

15. Initial Public Offerings

State's IPO Market Rebounds Strongly in 1999; Makes Gains in Closing the Gap in Average IPO Dollar Values

WHY IS IT SIGNIFICANT?

The number of initial public offerings (IPOs) is one indicator of future high-growth companies. "Going public" raises significant capital to invest and stimulate next-stage growth in a company. A successful IPO reflects confidence by investors that a company can generate increases in shareholder value, sustain growth, and produce satisfactory returns on investment.

HOW DOES MASSACHUSETTS PERFORM?

Massachusetts IPO activity increased significantly in 1999. In Massachusetts there were 36 IPOs in 1999, an 80% increase from 20 in 1998. In 1999, Massachusetts placed third among the LTS, with California leading in IPO activity (175), followed by New York (65).

Business services (e.g., consulting, advertising, legal services and website development) accounted for 31% of the IPOs in Massachusetts in 1999, followed by Software & Communications Services (23%) and Computers & Communications Hardware (17%). Among the LTS, the industry sectors with the highest IPO activity in 1999 included: business services (California), prepackaged software (Minnesota), savings institutions (New Jersey), security brokers & dealers (New York), telephone communications (Colorado), and water supply (Texas).

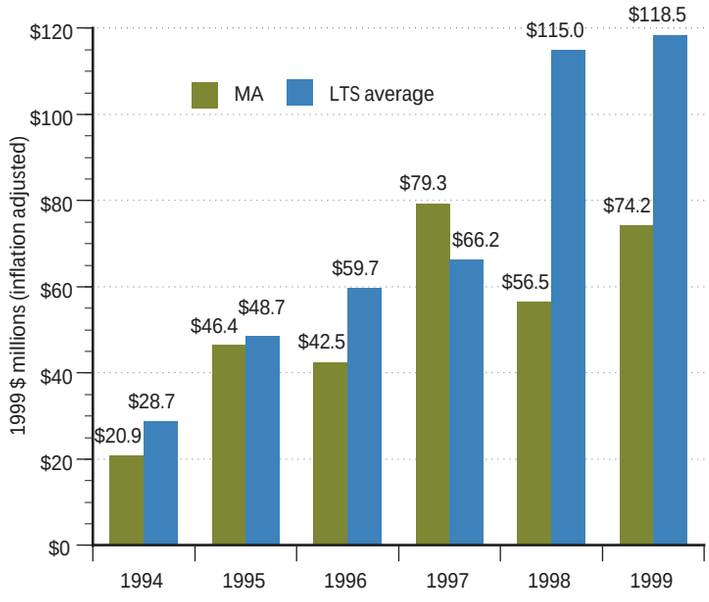
The state's IPO "Class of 1999" was the highest since 1996 (54 IPOs), and raised the largest volume of capital ($2.7 billion) in a decade, a 137% increase from 1998. The state's IPO "Class of 2000" promises to be even bigger; through the first two quarters of the year, Massachusetts firms completed 24 IPOs, raising over $5 billion.

In 1999, the average dollar value of Massachusetts IPOs was $74.2 million, a 31.3% increase from 1998. This increase compares favorably with the 3.0% increase for the other LTS in 1999. The state continues to lag the other LTS in the value of IPOs, however, as the average value of IPOs in the LTS in 1999 was nearly $119 million.

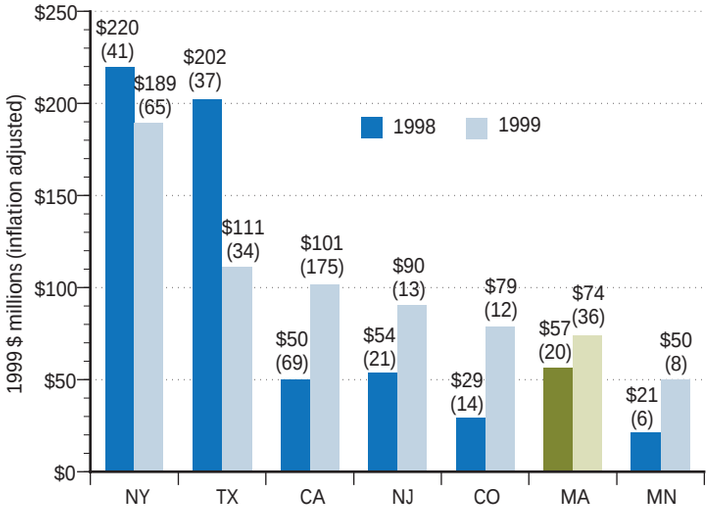
WHAT DOES THIS TREND MEAN FOR MASSACHUSETTS?

In today's entrepreneurial economy, successful IPOs are a make-or-break point for many of the most promising young companies. The promise of a successful IPO is often an important factor in a firm's ability to recruit top-flight talent, and a critical factor in its ability to raise capital. The capital raised through IPOs often determines whether a young, high-growth firm can successfully scale-up its operations, and whether the firm will be able to buy other firms, or be bought itself. In recent years, Massachusetts-based firms as a group have lagged the other LTS in their ability to raise large sums of IPO capital, fueling fears that the state's leadership in technology industries might erode over time. The success of the state's IPO "Class of 1999" is an encouraging sign that our high-growth firms are more than holding their own in the technology marketplace.

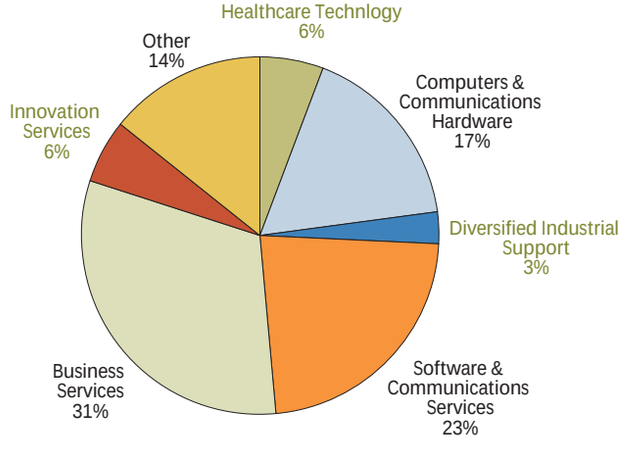
Average dollar value of initial public offerings (IPOs), Massachusetts and LTS average, 1994-1999



Average dollar value and total number of IPOs, Massachusetts and other LTS, 1998 and 1999



Distribution of IPOs, Massachusetts, 1999



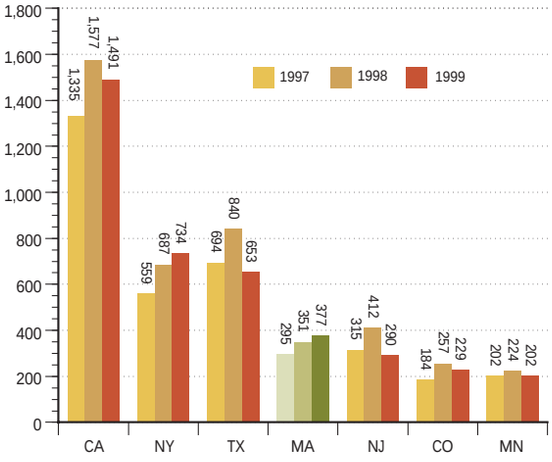
Note: Portions may not sum to 100% due to rounding

Source of all data for this indicator: Arthur Andersen

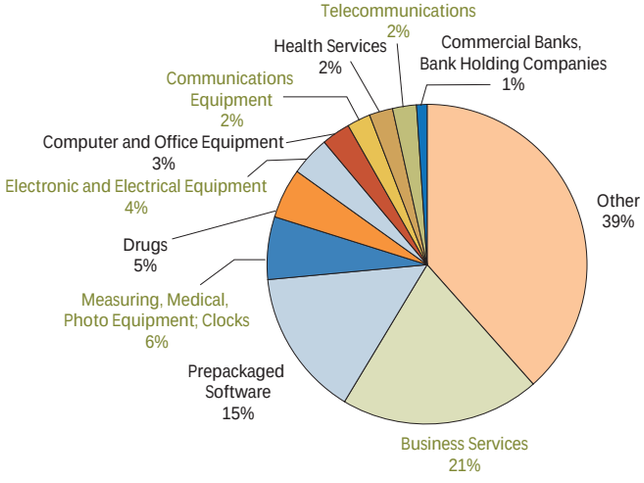
16. Mergers and Acquisitions

The M&A Market Increases in the State, with the Highest Activity in the Technology Sectors

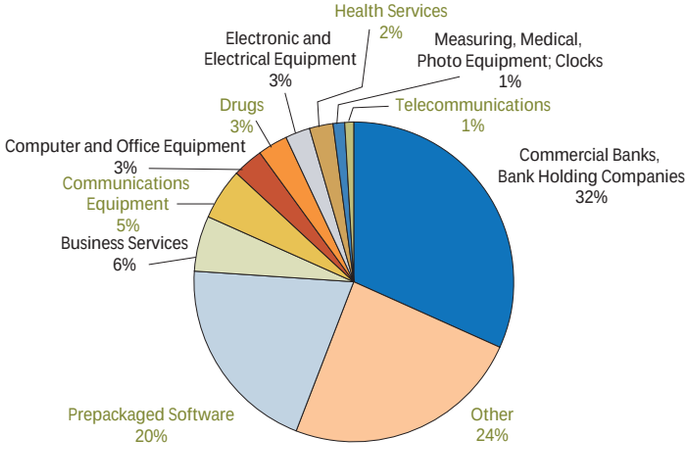
Total number of mergers and acquisitions (M&As), Massachusetts and other LTS, 1997-1999



Distribution of M&A activity by total number of deals, Massachusetts, 1999



Distribution of M&A activity by market share, Massachusetts, 1999



Note: Portions may not sum to 100% due to rounding

Source of all data for this indicator:
Arthur Andersen Corporate Finance

WHY IS IT SIGNIFICANT?

Mergers and acquisitions (M&As) are another important avenue to liquidity for entrepreneurs and investors in rapidly growing companies. Innovation-based niche companies may be attractive to other firms seeking to diversify, expand sales or market share, and create an integrated service model that can further develop technologies and products. M&As can have disruptive impacts on workers and career paths. Also, if acquiring firms have out-of-state headquarters, control over operations and focus of corporate philanthropic support may also shift out of state. (See Indicator 19)

HOW DOES MASSACHUSETTS PERFORM?

The total number of M&As in Massachusetts (those firms that have been acquired by another) continued its steady climb to 377 for 1999, a 7.4% increase from 1998. New York was the only other LTS to experience an increase (6.8%) in the total number of M&As for that year. Compared with other states, Massachusetts placed fifth among the sellers (acquired), behind California, New York, Texas and Florida in 1999. Massachusetts placed sixth in the country that year in its total number of buyers (acquirers) of firms. The total national M&A transaction count increased 18% and deal value increased 61% from 1998 to 1999. Among the LTS, Massachusetts has maintained a relatively consistent 8% market share (expressed as deal share) during the past five years. The market share of companies merged/acquired in California, on the other hand, has risen from 33% to 45% during the same period.

Thirty-nine percent of the distribution of M&A deal activity in 1999 was categorized as "other," which covers many industries, such as radio & television broadcasting, hotels and casinos and construction. M&A deal activity in Massachusetts was spread across a wide range of industries, including the business services (21%), (primarily driven by the IT solutions segment), and prepackaged software (15%) sectors.

By market share (which represents the total dollar value of all M&A deals in each industry sector), commercial banks & bank holding companies (32%) led, followed by other (24%), and prepackaged software (20%). Massachusetts M&A activity remains high, based on the attractiveness of its technology sectors, specifically telecommunications, software, IT solutions, and Internet/e-commerce.

WHAT DOES THIS TREND MEAN FOR MASSACHUSETTS?

Recent increases in total M&A activity in Massachusetts reflect dynamism and change in the economy. M&A activity can make capital markets more efficient by bringing buyers and sellers together to maximize business value. It can also provide an avenue for entrepreneurs to create shareholder liquidity. M&As continue to be a preferred exit strategy to IPOs—they allow an alternative source of liquidity even when capital markets are not receptive to IPOs. Further, M&As are more appropriate sources of capital/liquidity for most markets. M&A activity often gives rise to serial entrepreneurs, who use their new liquidity to go on to start or invest in new companies. Despite significant growth in M&A activity, Massachusetts companies appear to be following the overall trends for the LTS, maintaining a constant market share.

17. NASDAQ Firms' Market Value

NASDAQ Firms in Massachusetts Have Outstanding Year in 1999, Sharply Increasing Average Growth in Market Value

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?

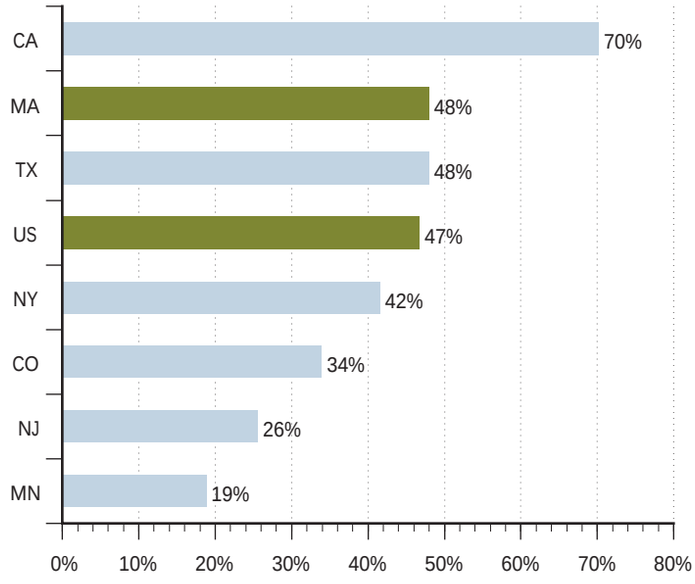
The market value of Massachusetts-based NASDAQ companies grew from $35 billion in 1995 to $90 billion in 2000, inflation adjusted. This annualized growth rate of 48% was slightly better than the 47% annual growth of all NASDAQ firms in the U.S., and placed the state second only to California (70%). From 1999 to 2000, Massachusetts NASDAQ firms experienced a growth rate of 181.5%, ranking second only to California (226.2%).

The annual average growth rate of Massachusetts NASDAQ companies between 1995 and 2000 was strongest in Innovation Services (78%), followed by Healthcare Technology (54%), and Software & Communications Services (49%).

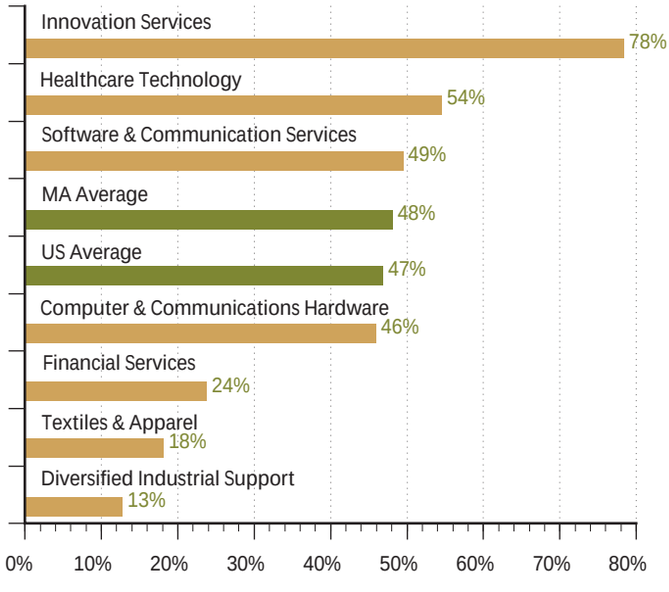
WHAT DOES THIS TREND MEAN FOR MASSACHUSETTS?

Massachusetts small-capitalized firms had an historic year in 1999 when measured by average market value. The growth of Massachusetts emerging technology sectors (e.g., software, e-commerce/Internet-related technologies, and telecommunications) produced strong performers in the NASDAQ market.

Annual average growth rate of NASDAQ companies' market value for Massachusetts, other LTS and US, 1995–2000 (inflation adjusted)



Annual average growth of NASDAQ companies' market value by clusters, Massachusetts, 1995-2000 (inflation adjusted)

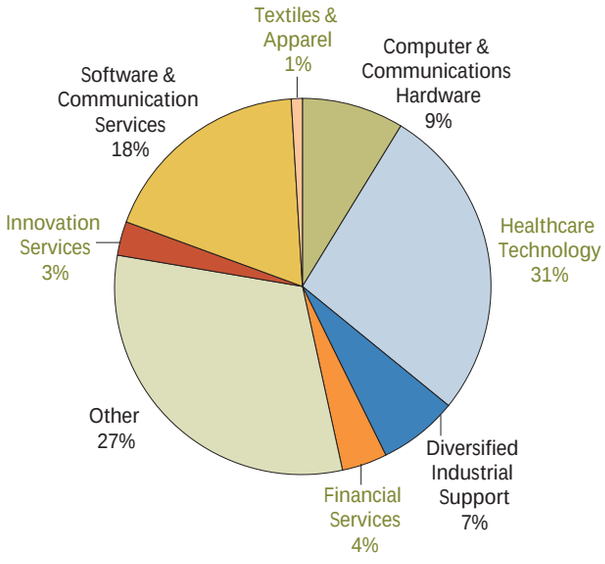


Source of all data for this indicator: NASDAQ, Collaborative Economics

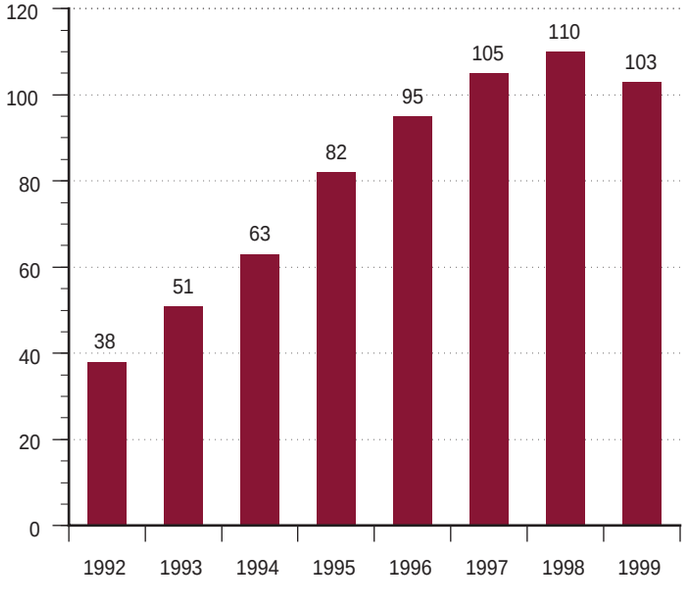
18. Gazelle Companies

Although Total Number of "Gazelles" Declines, Almost Half of all 1999 Gazelle Firms in Massachusetts Are New to the List

Distribution of publicly traded "gazelle" companies, Massachusetts, 1999



Number of publicly traded "gazelle" companies, Massachusetts, 1992–1999



Note: Portions may not sum to 100% due to rounding
Source of all data for this indicator: Compustat, Collaborative Economics

WHY IS IT SIGNIFICANT?

As the U.S. has made the transition to 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 that have grown at an annual average compound rate of 20% or more for the last four years. By generating accelerating increases in output and jobs, gazelles stimulate the growth of other businesses and personal spending. (David Birch of Cognetics, Inc., in Cambridge, first coined the term "gazelle.")

HOW DOES MASSACHUSETTS PERFORM?

The total number of gazelle companies in Massachusetts declined from 110 in 1998 to 103 in 1999. Of the LTS, Minnesota, New York and Texas also experienced a decrease in the total number of gazelles from 1998 to 1999. California, which had the highest number of gazelles (359) in 1999, experienced an increase in gazelles of 8.1% from the previous year. Gazelle growth in Massachusetts over time has remained strong; from 1992 to 1999, the number of Massachusetts gazelle companies has grown by 171.1%.

Over half of all gazelles in the state are in three clusters: Healthcare Technology (31%), Software (18%), and Computers & Communications Hardware (9%). Twenty-seven percent of the gazelles fall into the "other" category, which spans retail, restaurants, and other diverse services and products.

WHAT DOES THIS TREND MEAN FOR MASSACHUSETTS?

Although the number of gazelles dropped slightly in 1999, it is worth noting that some new and aggressive high-tech companies did not make the list because they are relatively young and have limited historical data. As importantly, the 1999 gazelle list included 42 new companies that were not on the 1998 list.

19. Corporate Headquarters

Corporate Headquarters Increase, but State Has Small Number of Fortune 500 Firms Compared to Other LTS

WHY IS IT SIGNIFICANT?

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

HOW DOES MASSACHUSETTS PERFORM?

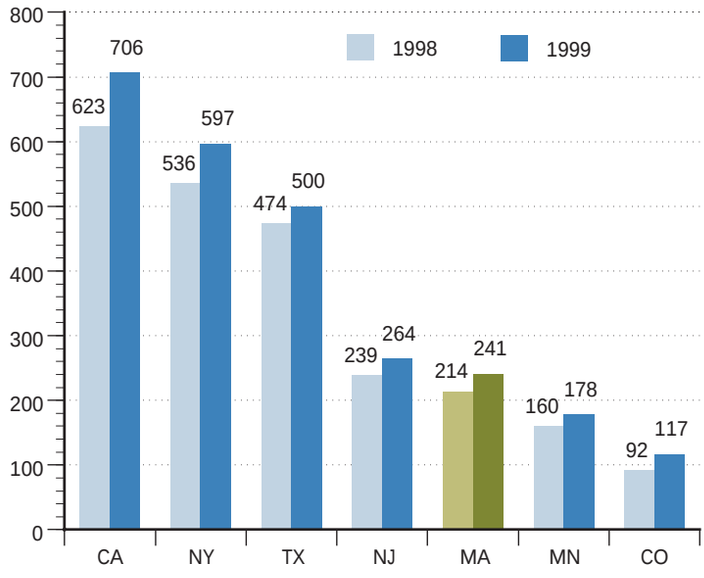
In 1999, Massachusetts was home to the corporate headquarters of 241 firms with 500 or more employees, a 12.6% increase over 1998. Of the other LTS, Colorado (27.2%) experienced the most growth in corporate headquarters during this period, while Texas (5.5%) had the smallest growth rate.

Among the LTS, Massachusetts was home to 13 of the Fortune 500 firms as of April 2000, ahead of only Colorado (5). New York is home to 56 Fortune 500 companies, followed by California with 53. Massachusetts Fortune 500 firms are distributed mostly among the banking, insurance, retail, and technology sectors. Fortune 500 companies located in the state include: Allmerica Financial, BJ's Wholesale Club, EMC, Fleet Boston, Gillette, John Hancock Mutual Life, Liberty Mutual Group, Mass. Mutual Life Insurance, Raytheon, TJX, Staples, State Street Boston Corporation, and Thermo Electron.

WHAT DOES THIS TREND MEAN FOR MASSACHUSETTS?

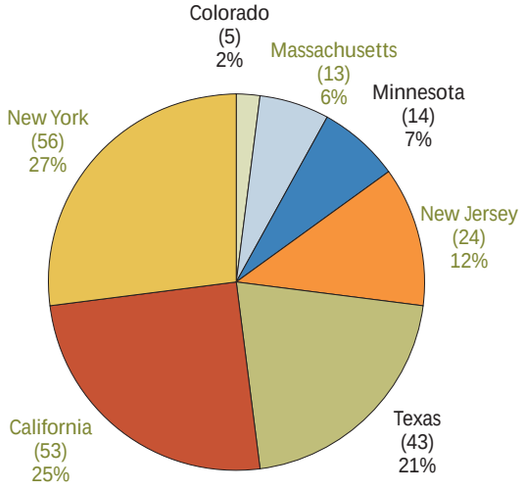
The number of headquarter companies has grown over the past several years for Massachusetts and all the LTS. With its highly skilled professional and technical workers and strong professional services base, Massachusetts is an attractive site for corporate headquarters, which are often the primary location for the firm's research, entrepreneurial, and philanthropic activities. Massachusetts can retain its corporate headquarters and attract new and emerging industries to the state by assuring an environment that nurtures innovation, business development and knowledge-based enterprise.

Number of corporate headquarters located in Massachusetts and the other LTS, corporations with more than 500 employees, 1998 and 1999



Source: American Business Information

Number of Fortune 500 companies located in Massachusetts and other LTS, 2000



Note: Portions may not sum to 100% due to rounding
Source: Fortune Magazine

RESOURCE INDICATORS

"The labor shortage problem is not merely a cyclical phenomenon; it is a longer-term structural problem created by a slowdown in labor force growth."

Paul E. Harrington
Associate Director, Center for Labor Market Studies
Northeastern University

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.

20. Population Growth Rate and Unemployment Rate

State Continues to Experience a Low Unemployment Rate; Projected Near-Zero Population Growth Rate Threatens State's Labor Force Growth

WHY IS IT SIGNIFICANT?

Projected state population growth rates represent changes in demographics through the process of births, deaths, aging, and movement from state-to-state or to other countries. Population growth rates are also an indicator of the size of the potential available workforce for a region. The unemployment rate is indicative of a state's ability to employ its residents in the economy, and of its untapped pool of potential workers.

HOW DOES MASSACHUSETTS PERFORM?

In 1999, Massachusetts had an unemployment rate of 3.2%—the third lowest unemployment rate among the other LTS and the nation. Minnesota had the lowest unemployment rate of 2.8%, followed by Colorado at 2.9%. California and New York had the highest rate among the LTS with 5.2%. From 1997 to 1999, all the LTS and the nation have experienced a decrease in the unemployment rate.

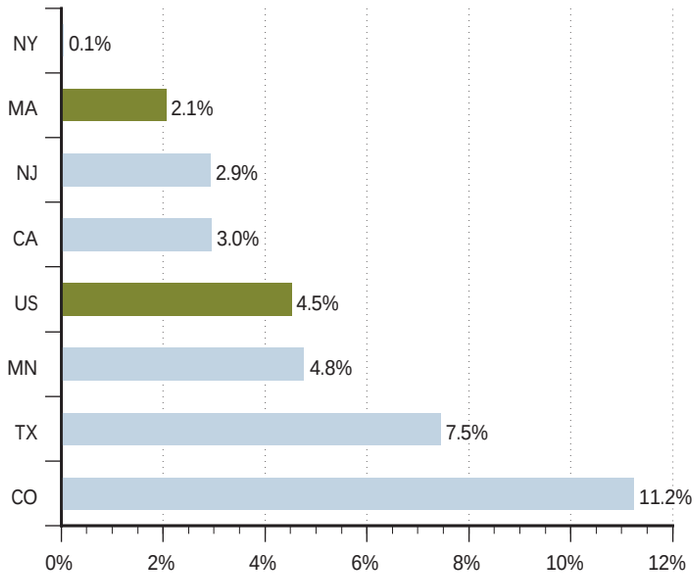
From 1995 to 2000, Massachusetts experienced a population growth rate of 2.1%, which was the second lowest among the LTS (New York had a 0.1% growth rate during the same period). Colorado has experienced the highest population growth rate at 11.2%, followed by Texas at 7.5%.

The projected population growth rate for Massachusetts over the next ten years is 3.7%—the second lowest among the LTS. New York will experience the lowest population growth rate at 2.1% during the decade. California is projected to have the highest percentage growth rate at 15.8%, followed by Texas at 13.6%.

WHAT DOES THIS TREND MEAN FOR MASSACHUSETTS?

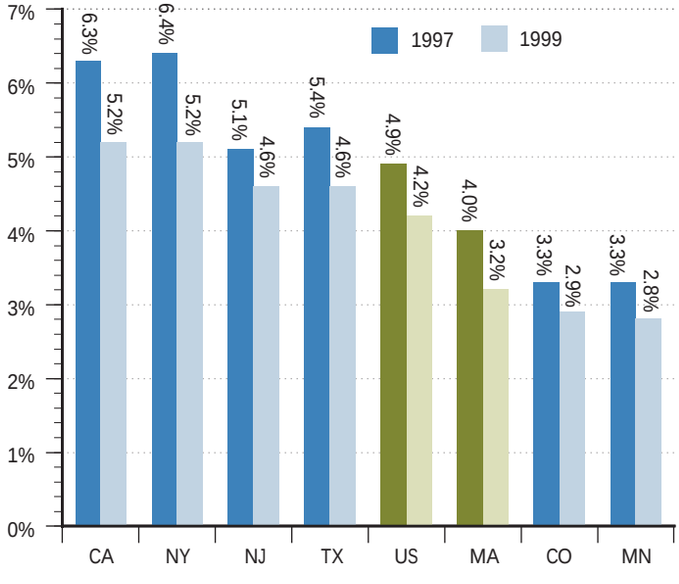
Continuing low population growth is a genuine cause for concern for Massachusetts. The state is projected to be one of the slowest growing states in terms of population growth over the next 25 years, while several of the LTS, such as California and Texas, are among the fastest growing. Massachusetts is also negatively affected by a tight labor force market, as evidenced by the low unemployment rate. As a result, it is critical that the Commonwealth identify the elements contributing to its low population growth and then to explore ways to attract people to work and live in the state to sustain the Innovation Economy.

Percent change in population growth rates, Massachusetts, LTS and US, 1995-2000



Source: U.S. Census Bureau

Unemployment rate, not seasonally adjusted, Massachusetts, LTS and US, 1997 and 1999

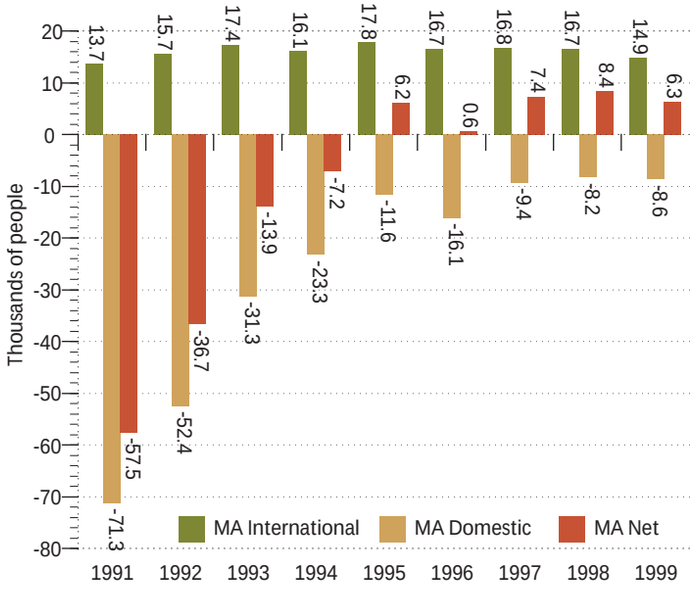


Source: Bureau of Labor Statistics

21. Migration

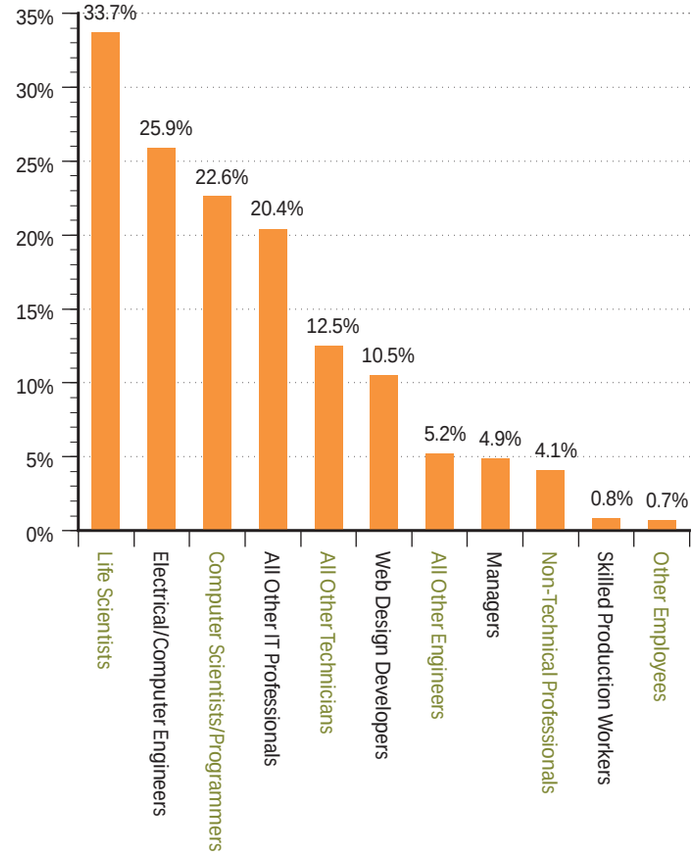
Significant Percentage of New Scientific and Technical Hires Are Immigrants

International in-migration and domestic out-migration, Massachusetts, 1991–1999



Source: U.S. Census Bureau

Percentage of new staff hires that held H-1B visa hires within Massachusetts technology-intensive companies surveyed, April 2000



Source: MTC / Northeastern University Workforce Needs Survey, 2000

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.

HOW DOES MASSACHUSETTS PERFORM?

Immigration plays an important role in the growth of the Massachusetts population and the dynamism of the Massachusetts Innovation Economy. Each year from 1991 to 1999, Massachusetts experienced net domestic out-migration. In 1999, 8,600 people moved from Massachusetts to other states, a slight increase from 8,200 people in 1998, but far fewer than left the state during the recession of the early 1990s.

International immigration supplements the skilled workforce required to drive a range of innovation needs from basic research at university and teaching hospitals to successful product development in businesses. In 1999, Massachusetts experienced strong international migration, with close to 15,000 people moving into Massachusetts from outside the U.S. A recent MTC survey of technology-intensive firms in the state disclosed that workers with H-1B visas account for 13.1% of total new staff hires as of April 2000. The surveyed firms also reported that scientific and technical occupations are particularly dependent on workers with H-1B visa. More than 20% of new hires who are life scientists, electrical and computer engineers, and other IT professionals held H-1B visas.

WHAT DOES THIS TREND MEAN FOR MASSACHUSETTS?

The international migration of highly skilled workers is a vital ingredient for the economic success of the Massachusetts Innovation Economy. Given the near-zero workforce growth, low unemployment rate, and declining number of engineering and computer science degree holders in the state and in the nation, Massachusetts will continue to rely on the in-migration of talented workers from other states and countries to satisfy high skill demands, at least in the short term. The state should encourage businesses to retrain their incumbent workers. In the long term, state government and the private sector must work together to identify effective ways for Massachusetts citizens to acquire the education and skills training necessary to fill key positions in the Innovation Economy. The state should also identify and respond to the causes of out-migration by skilled and well-educated individuals.

22. Workforce Education

Massachusetts Has a Well-Educated Population, but Needs More to Retain Its Competitive Edge

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 skill levels reflect labor force quality and are of primary concern to employers. Strong mathematical, scientific and communications skills are a prerequisite for many occupations, often requiring a high school diploma at a minimum, but more likely a college degree.

HOW DOES MASSACHUSETTS PERFORM?

In 1998, 14.4% of the population did not have a high school diploma, as compared to 14.1% in 1997. This represents a slight increase in the number of people without secondary school degrees in Massachusetts. The national percentage continues to decrease, from 17.9% in 1997 to 17.2% in 1998. Between 1970 and 1990, the percentage of Massachusetts residents without high school diplomas has declined by over one-half.

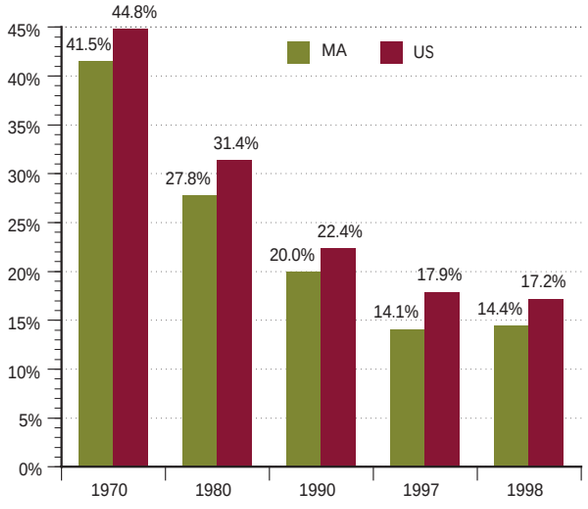
The percentage of Massachusetts high school graduates planning to attend college varies by racial/ethnic group. In 1998, 80% of Asian students planned to attend college, followed by 74% of White students. Only 53% of Hispanic students, 55% of Native American students and 56% of African-American students planned to attend college.

Thirty-one percent of the Massachusetts population had a bachelor's degree or higher in 1998, compared to 24% nationwide. The percentage of the adult population with a college degree in the state has nearly tripled between 1970 and 1998, with the percentage nationwide also increasing by a comparable amount. Massachusetts ranked second only to Colorado (34%) among the LTS in 1998 in population holding a bachelor's degree or higher.

WHAT DOES THIS TREND MEAN FOR MASSACHUSETTS?

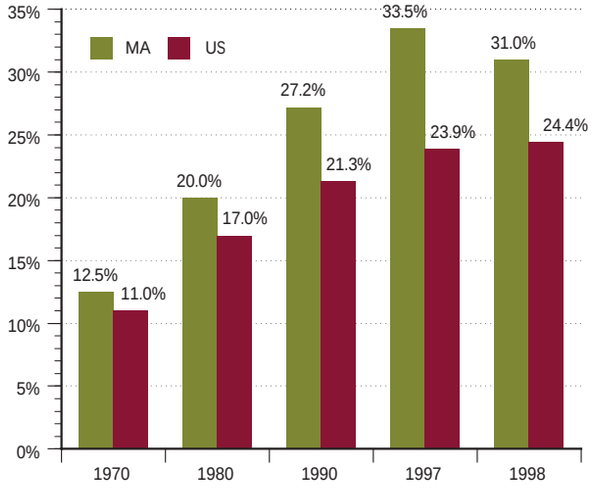
Massachusetts continues to have a well-educated workforce, which for decades has provided a vital competitive advantage in fostering the growth of technology-based, entrepreneurial companies. Given its critical need for skilled and well-educated workers, the state must increase its efforts to ensure access to education, training and retraining for all of its citizens. The state and the nation's populations are increasingly diverse, and the relatively smaller percentages of Hispanic, Native American, and African-American populations planning to attend college requires immediate attention if these citizens are to actively participate in the New Economy. Promoting mentoring, tuition affordability, and skills training are several ways to help expand the number of workers participating in the Massachusetts Innovation Economy.

Percentage of the adult population without a high school diploma, Massachusetts and the US, 1970–1998



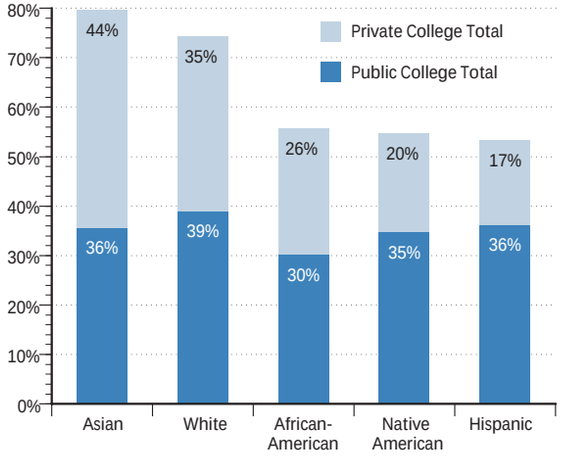
Source: U.S. Census Bureau

Percentage of the adult population with a college degree, Massachusetts and the US, 1970–1998



Source: U.S. Census Bureau

Massachusetts graduates planning to attend college by racial/ethnic group, 1998

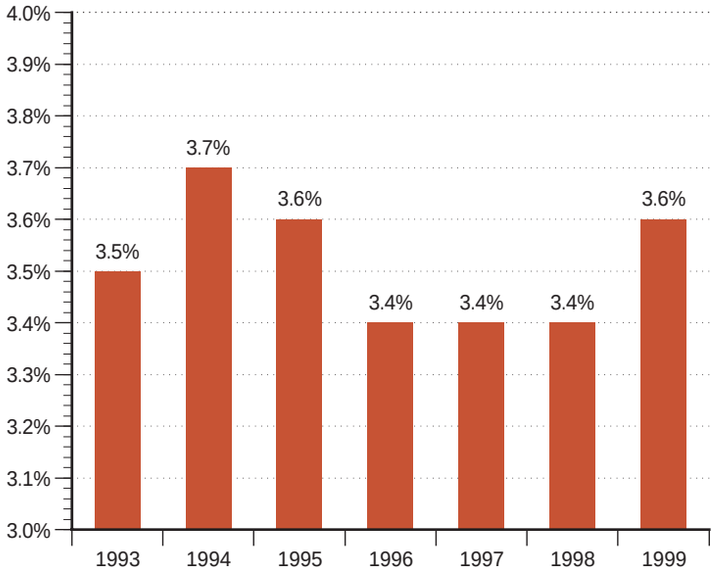


Source: Massachusetts Department of Education

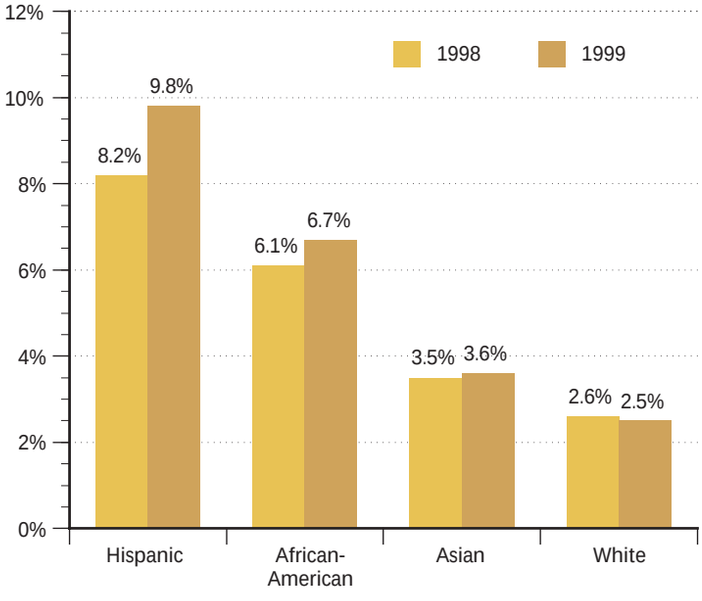
23. Dropout Rates

Massachusetts Dropout Rate Increases

Percentage of all high school students who drop out each year, Massachusetts, 1993–1999



Percentage of students who dropped out of high school each year by ethnicity, Massachusetts, 1998 and 1999



Source of all data for this indicator: Massachusetts Department of Education

WHY IS IT SIGNIFICANT?

Most quality jobs require a high school degree, at a minimum. According to U.S. Department of Commerce statistics, high school graduates have an annual median income that is 25-30% higher than those that drop out. The high school dropout rate is a risk indicator that warns of lost potential and future societal costs. The need to fully develop human resources is especially critical in a Massachusetts environment of slow labor force growth.

HOW DOES MASSACHUSETTS PERFORM?

The annual dropout rate in Massachusetts for high school students was 3.6% in 1999, a 0.2% increase from 1998. (This annual rate means that 3.6% of the ninth to twelfth graders enrolled in the state's public schools in the fall of 1998 did not return in 1999 for reasons other than transfer.)

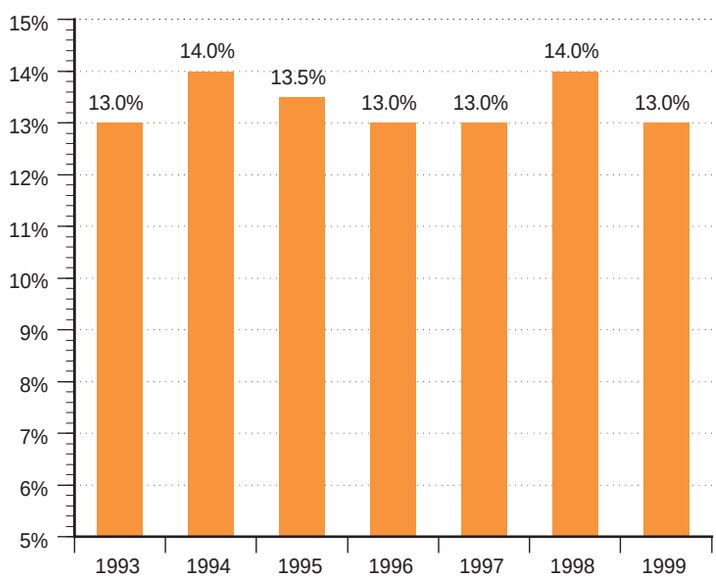
The projected cumulative dropout rate for the entering class of 1999 is estimated at 13.0% over the four-year high school period. The projected high school dropout rate has remained relatively steady since 1993.

Dropout rates vary widely across race and ethnicity. White students, at a 2.5% annual rate, are the least likely to drop out. Other racial and ethnic groups are at significantly higher risk, with Hispanic students at 9.8%, African-American students at 6.7% and Asians at 3.6%. The dropout rate in Massachusetts for all racial/ethnic groups increased from 1998 to 1999 except for White students, whose dropout rate fell slightly from 2.6% to 2.5%. The dropout rate for Hispanic students increased from 8.2% in 1998 to 9.8% in 1999.

WHAT DOES THIS TREND MEAN FOR MASSACHUSETTS?

The Commonwealth's ability to maintain a consistently low total dropout rate is a positive sign for the future. However, it is important for the state to focus additional attention on the diverse experiences of racial/ethnic groups, and to explore why there has been a sharp increase in the Hispanic dropout rate, and a continued increase in the African-American and Asian dropout rates. Because education is a key factor in economic and social mobility, the state should encourage and engage in partnerships with local educators and community groups to foster programs that enable all segments of our population to attain a high school diploma or equivalency at a minimum.

Estimated percentage of ninth grade students dropping out before high school completion, Massachusetts, 1993–1999



24. Engineering and Computer Science Degrees

Number of Engineering Degrees Awarded in Massachusetts Declines Greater Than the US; Total Number of Computer Science Degrees Shows Small Increase

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 and a magnet for new knowledge- and technology-based industries.

HOW DOES MASSACHUSETTS PERFORM?

The total number of engineering degrees awarded in Massachusetts decreased 4.6% in 1999, from 4,578 in 1998 to 4,368 in 1999. The number of bachelor's degrees awarded in engineering by Massachusetts schools decreased by 5.9% (from 2,533 to 2,384). Nationally, bachelor's degrees granted in engineering decreased by only 1.2% during the same period.

At the graduate level, the number of master's engineering degrees awarded by Massachusetts institutions increased from 1997-1998 to 1998-1999, at a rate higher than the nation, 1.2% versus 0.1%, respectively. The total number of engineering PhD degrees awarded in Massachusetts fell by 20.5%, however, compared to a 11.2% drop nationwide, during the same period.

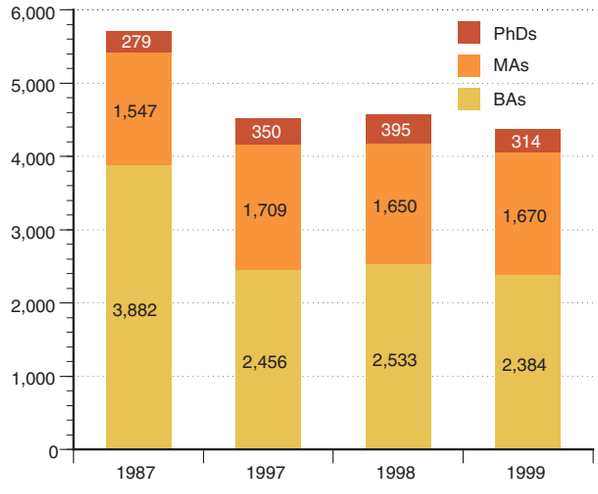
The total number of computer science degrees in Massachusetts decreased 0.9% in 1997, from 1,195 in 1996 to 1,184 in 1997 (latest data available). The number of undergraduate degrees awarded by Massachusetts institutions increased by 0.9% between 1996 and 1997. At the graduate level, there was a strong increase in doctorates (23.5%), but a decrease in the number of master's degrees granted over the same period (-6.5%).

A survey of engineering colleges and universities by the Massachusetts Technology Collaborative found that on average 56% of the engineering graduates remained in the state after graduation in 1999. This is two percentage points higher than in 1998 and five percentage points above the rate in 1995. Among surveyed Massachusetts institutions, the average retention rate of undergraduate engineering students is 80.7% (i.e., those students who enter the engineering program and obtain the degree). While retention rates in engineering have improved overall, some schools still retain less than 40% of their entering students.

WHAT DOES THIS TREND MEAN FOR MASSACHUSETTS?

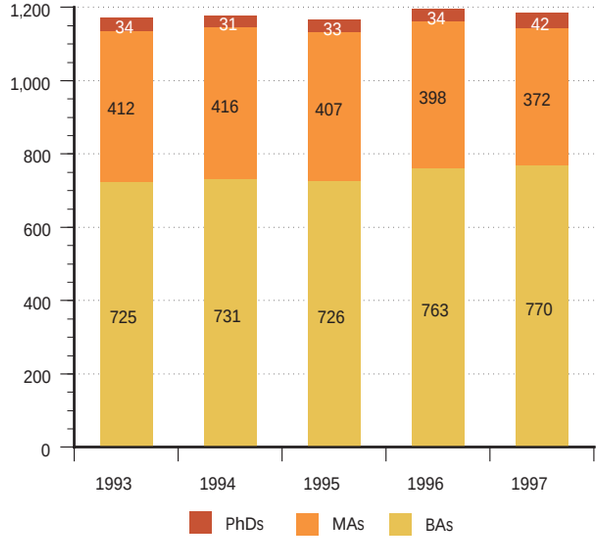
The fields of engineering and computer science play a critical role in the Innovation Economy. Declining and/or stagnant numbers of engineering and computer science graduates can inhibit growth in high technology sectors. Universities, the state government, and private sector executives need to support programs that encourage and prepare more young people to enter and complete engineering and computer science programs. Also, more progress needs to be made in encouraging women and underrepresented minorities to enter these fields. A University of Washington report documented that significantly more women than men drop out of engineering programs, and women still represent only 8.5% of the country's engineers while comprising 46% of the overall labor force. In order for the state to maintain a competitive advantage in the Innovation Economy, it is imperative that more individuals are introduced to and encouraged to participate in the fields of engineering and science.

Number of engineering degrees awarded by Massachusetts schools, by degree level, 1987–1999



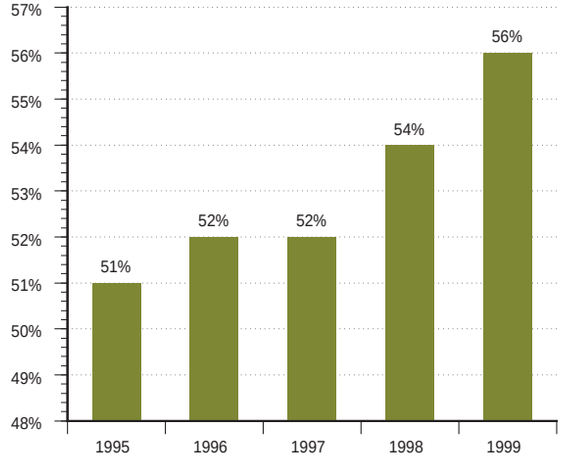
Source: American Association of Engineering Societies

Number of computer science degrees awarded by Massachusetts schools, by degree level, 1993–1997



Source: National Science Foundation

Percentage of Massachusetts engineering graduates still living in state, by year of graduation, 1995-1999

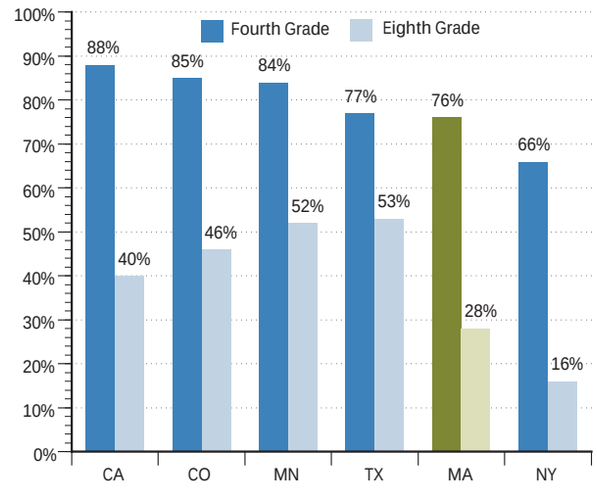


Source: MTC Engineering Retention Survey

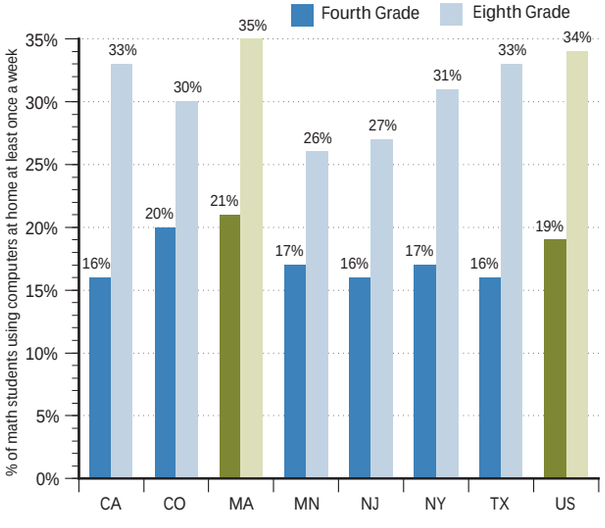
25. Computers in Education

Infrastructure Lags, but Computer Use at the Elementary and Middle School Levels Leads the Other LTS

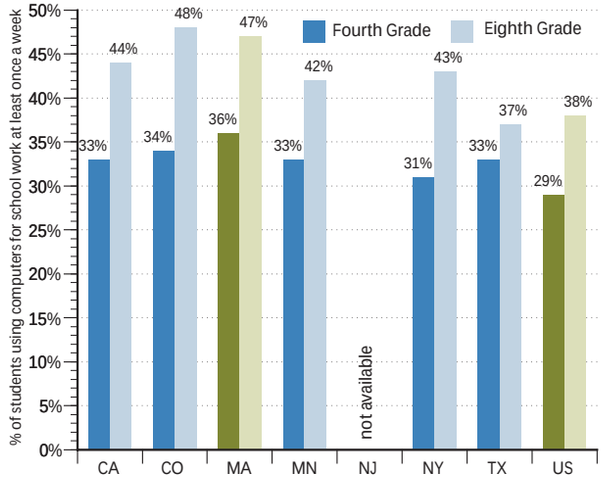
Percentage of schools that make computers available in all classrooms, Massachusetts and other LTS, 1998



Frequency of computer usage by math students at home, Massachusetts and other LTS, 1996



Frequency of computer usage by students for school work, Massachusetts and other LTS, 1998



Source of all data for this indicator: Education Week

WHY IS IT SIGNIFICANT?

Access to computers and utilization for school work enable children to develop computer skills and expand their horizons at an early age. As a result, students will have the opportunity to acquire technical expertise and an understanding of the demands of the Innovation Economy and will be better prepared for higher education and future jobs.

HOW DOES MASSACHUSETTS PERFORM?

In 1998, 76% of Massachusetts fourth graders had computers available to them in their classrooms, which ranks the state fifth among the LTS. California ranks first, at 88%, followed by Colorado at 85%.

At the eighth grade level, only 28% of Massachusetts students have access to computers in their classrooms. In contrast, Texas, which ranks first among the LTS has 53%, followed closely by Minnesota at 52%.

Somewhat in contrast to computer infrastructure, Massachusetts ranks at or near the top among the LTS in computer usage. In *Education Week's, Technology Counts 1998 Report*, Massachusetts students were among the most frequent users of computers for math, both in the classroom and at home. Furthermore, almost 65% of all fourth graders and 75% of all eighth graders had access to a computer at home, the highest level among the LTS (and the nation). These math usage statistics suggest that Massachusetts students are developing computer skills that go well beyond basic word processing.

Computer usage by Massachusetts students continued to rank high among the LTS in the *Technology Counts 1999 Report*. While comparable math data was not available, 36% of Massachusetts fourth grade students use a computer at least weekly for school work, increasing to 47% by eighth grade. This ranks Massachusetts first among the LTS for overall 4th grade usage and second for the eighth grade. The same report, however, highlights the impact of major computer initiatives among several non-LTS states, including Kansas, Kentucky, and Maine. Usage among these states was in some instances 10 points or more above the highest ranking LTS.

WHAT DOES THIS TREND MEAN FOR MASSACHUSETTS?

According to *Education Week* , Massachusetts has made great strides in increasing the number of computers in the state's classrooms, but is not yet among the top few LTS in computer access. Computer access in middle schools is more limited than it is in elementary schools, although this is also true of the other LTS. Home computer use by the state's eighth graders is as good or better than most LTS and the national average. Computer use by eighth graders and other middle schoolers is an important issue for the state, since education research shows that it is in the middle school grades that American students begin to lag their best-performing international peers in mathematics and science achievement.

26. Student Interest in Technical Careers

High School Students in Massachusetts Less Interested in Computer Science and Mathematics than in Most LTS

WHY IS IT IMPORTANT?

Postsecondary education is a basic requirement for many jobs in innovation-based companies. In particular, the fields of science, engineering, and information technology (IT) are especially important to the growth of the Innovation Economy. Most colleges and universities require the Scholastic Aptitude Test (SAT) as part of the admissions requirement. The profile of intended majors of college-bound seniors who take the SAT is an important indicator of the interests that secondary school students have in those fields that are important to the growth of the Innovation Economy.

HOW DOES MASSACHUSETTS PERFORM?

In 1999, of those Massachusetts students taking the SAT, only 6% indicated an intention to major in engineering in college, the lowest percentage of the LTS. This trend has remained relatively constant over the past several years. Minnesota students ranked first among the LTS, with 12% of students intending to major in engineering, followed closely by Colorado at 11%.

The most popular intended majors of Massachusetts students taking the SAT in 1999 are Business and Commerce (16%), Health and Allied Services (13%), Social Affairs and Services (11%), Education (8%), and Biological Sciences (6%). Hardly any Massachusetts students surveyed expressed an intention to major in Mathematics.

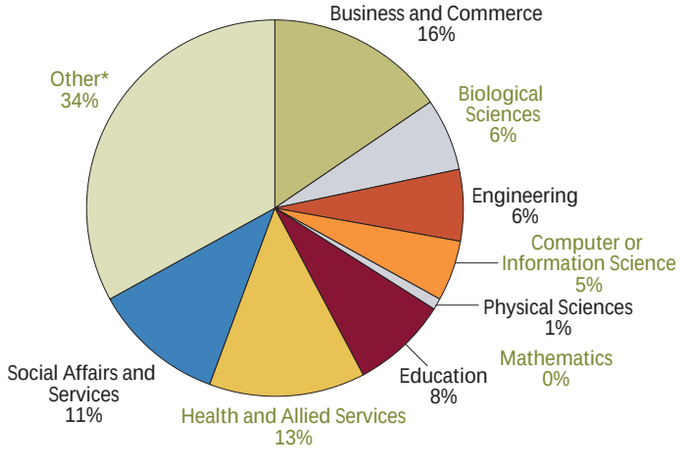
The intended major of Computer or Information Science of students taking the SAT in 1999 ranked low across the board, with the highest percentage in the LTS at 7% and the lowest at 4%. Massachusetts was at 5%.

Massachusetts was third among the LTS and the nation in total number of candidates who took an Advanced Placement (AP) exam in 1999. New York ranked first, with 426 candidates per 1,000 high school graduates, followed by California (370) during this period. Massachusetts had the highest share of high school students (13%) taking the Computer Science AP exam when compared to the other LTS.

WHAT DOES THIS TREND MEAN FOR MASSACHUSETTS?

Massachusetts needs to produce far greater numbers of engineers, scientists and IT workers in order to maintain its leadership in the Innovation Economy. But the state's colleges and universities cannot simply supply new engineers and technical workers on demand. They need an expanded pool of applicants who are interested in pursuing technical careers, and who have the mathematics and science skills to succeed at college-level work. The relatively low level of interest manifested by Massachusetts high school students in pursuing engineering and computer science in college is a telling indicator that the technical workforce "pipeline" is too small. To expand the pipeline Massachusetts must not only heighten students' awareness of technical careers, but also intensify efforts to ensure that high school students pursue the high school math and science courses that are a prerequisite for successful college work in science, engineering, and IT.

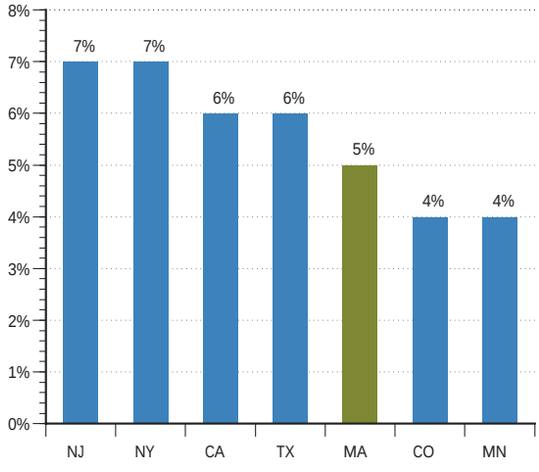
Distribution of intended college majors, Massachusetts students taking the SAT, 1999



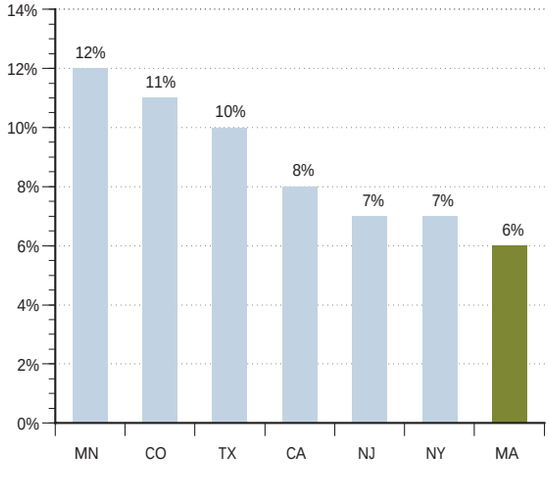
*Examples: Arts: Visual and Performing, Foreign or Classical Languages, Public Affairs and Services, Undecided

Note: Portions may not sum to 100% due to rounding

Percentage of students taking the SAT I intending to major in Computer or Information Science, Massachusetts and other LTS, 1999



Percentage of students taking the SAT I intending to major in Engineering, Massachusetts and other LTS, 1999

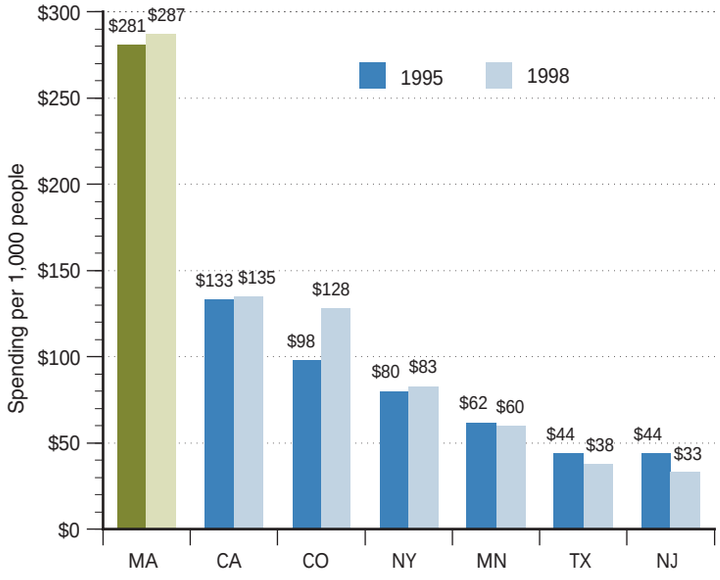


Source of all data for this indicator: College Board Online

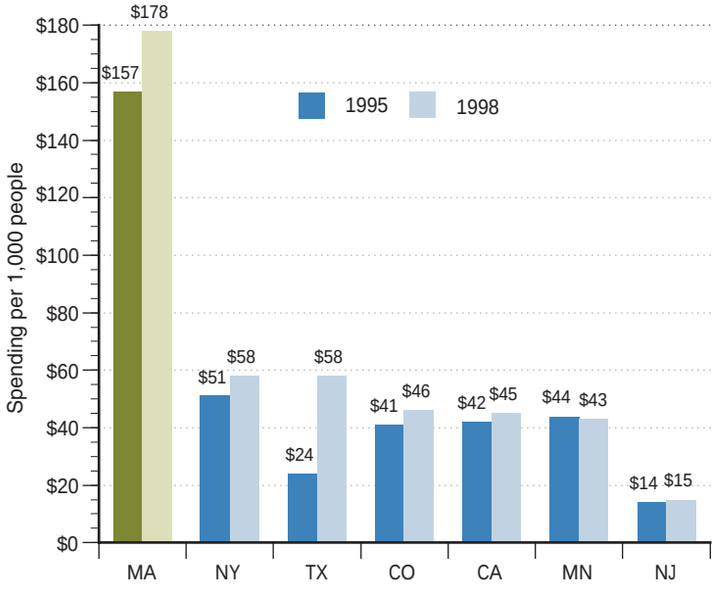
27. Federal R&D Spending and Health R&D Spending

Per Capita Federal R&D Expenditures in Massachusetts Are the Highest of the LTS; New Competitors Emerge in Colorado and Texas

Federal R&D expenditures in academic and nonprofit research institutions, per capita, Massachusetts and other LTS, 1995 and 1998 (1998 $ inflation adjusted)



US Department of Health and Human Services R&D expenditures, per capita, Massachusetts and other LTS, 1995 and 1998 (1998 $ inflation adjusted)



Source of all data for this indicator: National Science Foundation

WHY IS IT SIGNIFICANT?

Research universities and other academic centers are pivotal in the Massachusetts economy, and federal R&D spending is a primary source of their funding. R&D conducted by academic institutions also has a pronounced inducement effect in stimulating private sector R&D investments.

The National Institutes of Health (NIH) is the largest supporter of health-related research in the U.S. It is also the largest source of federal funding for non-defense research. NIH-funded research is a critical driver for the 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 are made through the NIH.

HOW DOES MASSACHUSETTS PERFORM?

Massachusetts universities, hospitals, and nonprofit research institutions have the highest per capita federally funded R&D expenditures ($295) of the LTS, with the next closest LTS, California, at a little less than half that amount ($139). Total federal R&D spending in these Massachusetts institutions was $1.8 billion in 1998, ranking the state second among the LTS in absolute R&D spending (California ranks first in total R&D spending with $4.5 billion).

From 1995 to 1998, per capita federally funded R&D expenditures at Massachusetts academic institutions increased 8%, when adjusted for inflation. Colorado experienced a 36% increase, followed by New York with 12%. California and New Jersey each rose by 6% during this time period, while Texas and Minnesota experienced a decline in comparable funding.

Massachusetts has the highest per capita federally funded R&D expenditures in health ($178) of the LTS. The state's health-related funding is more than three times greater than the closest LTS, New York ($58). Funding for Massachusetts has consistently increased in inflation adjusted terms and relative to the other LTS. Since 1995, HHS funding per capita for Massachusetts increased 19%. New York and Colorado each expanded HHS R&D funding per capita by 18%, but remained considerably behind Massachusetts. Total federal healthcare R&D expenditures in Massachusetts were $1.1 billion in 1998, ranking second among the LTS in total federal healthcare R&D (California ranks first with $1.5 billion).

WHAT DOES THIS TREND MEAN FOR MASSACHUSETTS?

Massachusetts continues to be a leader in federal and health-related R&D. This strong investment bolsters the state's ability to maintain its competitive advantage in several key industry clusters, including Healthcare Technology and Postsecondary Education. The state must continue to be aggressive in its monitoring and advocacy for federal R&D funds. This indicator also highlights the strong links in the chain of innovation: from early stage research and idea generation, in our academic and nonprofit institutions, to later stage product development at local companies.

28. Corporate R&D per Employee

Massachusetts Experiences Strong Increase in Corporate R&D per Employee

WHY IS IT SIGNIFICANT?

Corporate research and development (R&D) spending is an important indicator of how Massachusetts companies are investing in the future. Nationally, the private sector provides about $2 out of every $3 invested in R&D. R&D is essential for developing new products and services that help companies stay on the cutting edge, grow, and produce more jobs.

HOW DOES MASSACHUSETTS PERFORM?

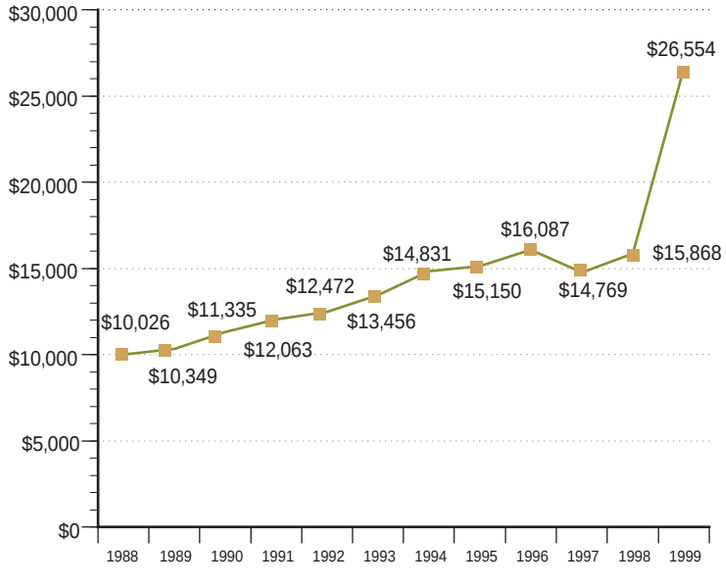
Corporate R&D spending per employee rose significantly in inflation adjusted terms. In 1999, these firms spent $26,554 per employee, a 67.3% increase from 1998 and an all-time high for the state.

Massachusetts key industry clusters posted significant levels of R&D per employee in 1999. The Healthcare Technology cluster had the highest R&D per employee at $69,026. Software & Communications Services ($39,676), Innovation Services ($32,373), and Computers & Communications Hardware ($32,031) also had relatively high levels of R&D investment per employee during this period.

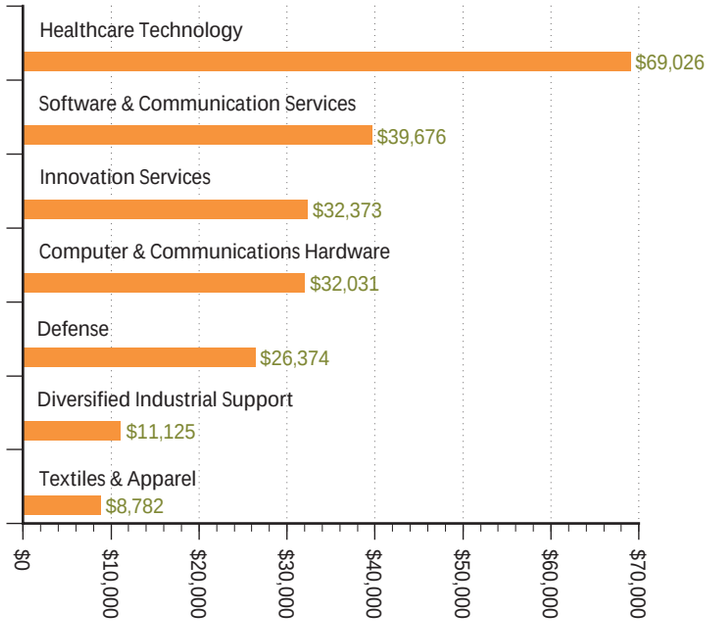
WHAT DOES THIS TREND MEAN FOR MASSACHUSETTS?

R&D fuels the development of new technologies and goods and services that drive company growth in the Innovation Economy. Some industry sectors in Massachusetts tend to be more R&D intensive, as reflected in both the level of corporate investment and the patent statistics. Inter- and intra-industry research joint ventures reflect one strategy for advancing a state's competitive position through collaborative R&D. Corporate and federal R&D keeps Massachusetts at the forefront of the Innovation Economy and the state remains a preferred location for firms with high R&D expenditures. These firms, in turn, employ and require a highly skilled, well-educated workforce.

Corporate R&D expenditure per employee, publicly traded companies with R&D expenditures, Massachusetts, 1988–1999



Corporate R&D expenditure per employee by industry sector, publicly traded companies with R&D expenditures, Massachusetts, 1999

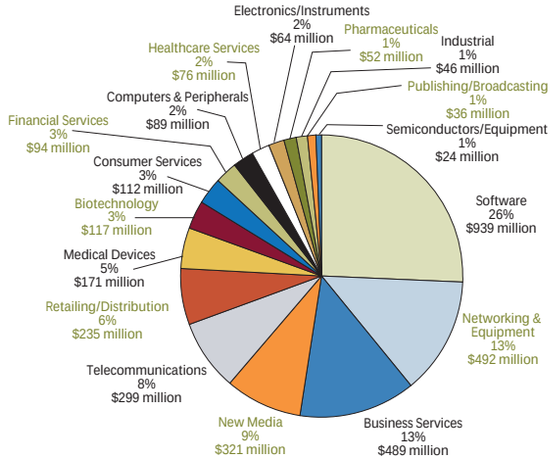


Source of all data for this indicator:
Compustat, Collaborative Economics

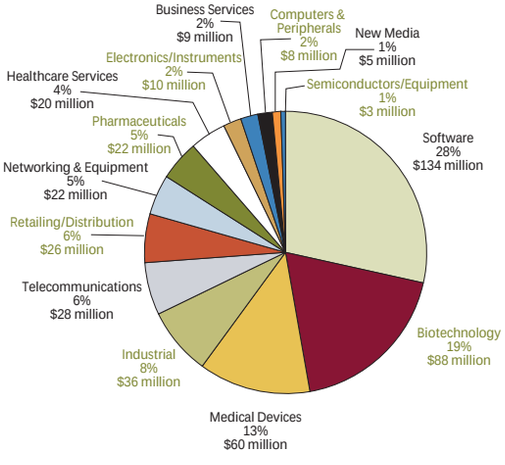
29. Venture Capital

State Achieves Another Record Year in Venture Capital Investment; Continued Growth of E-Commerce Sparks High Investments

Distribution of venture capital investments, Massachusetts, 1999

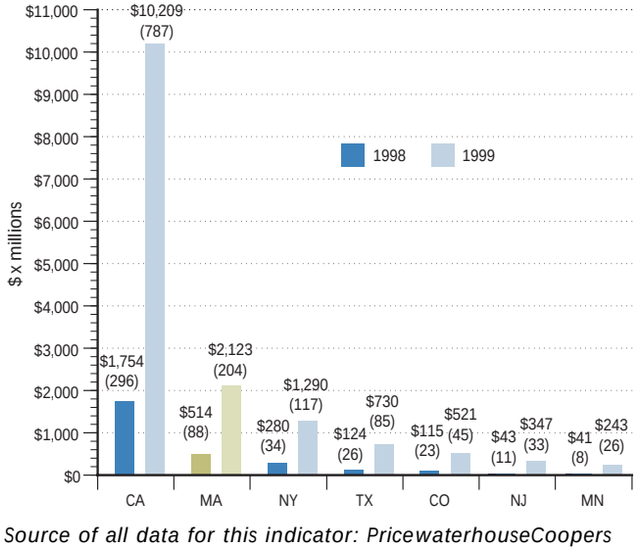


Distribution of venture capital investments, Massachusetts, 1995



Note: Portions may not sum to 100% due to rounding

Value and total number of e-commerce and Internet-related venture capital investments, Massachusetts and LTS, 1998-1999



Source of all data for this indicator: PricewaterhouseCoopers

WHY IS IT SIGNIFICANT?

Venture capital is the dominant source of growth capital for younger companies that have not yet entered the stock markets. While other forms of investment are often utilized to start companies (personal savings, funds from "angel" investors) the venture capital market has become the primary means for raising the large sums necessary for fueling rapid growth. The yearly flow of venture capital funds into a region is thus an important indicator of the region's future chances for new job creation and prosperity.

HOW DOES MASSACHUSETTS PERFORM?

Massachusetts attracted record amounts of venture capital in 1999. Massachusetts firms received $3.6 billion in venture funds, more than double the level of 1998 ($1.7 billion). Despite this increase, the state's share of total U.S. venture capital invested for the year decreased, from 11.9% to 10.3%. The decrease is mostly attributable to the massive venture capital flow into California-based companies.

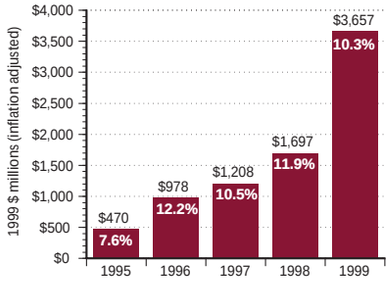
Massachusetts software firms received the largest share of venture funds (26%), followed by networking and communications equipment firms (13%). Firms in the "business services" field received the third highest infusion of venture funds ($489 million or 13%); a number of Web-related firms are, for the time being, classified by analysts as "business service" firms, which accounts for the high valuation in this category. Venture funding for the biotechnology and medical device industries continued to grow, although the substantial influx of funds to software and Internet-related companies is reflected in the fact that biotechnology and medical device firms now account for a decreasing share of the yearly venture capital investment in Massachusetts firms.

The emergence of e-commerce as one of the key drivers of the Massachusetts Innovation Economy has attracted significant venture capital investment in Internet-related and e-commerce companies. In 1999, Massachusetts received more than $2.1 billion in venture capital investment for e-commerce and Internet-related firms (10.7% of the U.S. total), more than four times the 1998 figure ($514 million). California was first among the LTS, receiving more than $10 billion in e-commerce venture capital investment in 1999, an amount almost six times its 1998 investment ($1.7 billion). Among the LTS, Massachusetts continues to rank second to California in the total number of Internet-related venture capital investments. California led the LTS in 1999 with 787 venture capital investments, followed by Massachusetts (204), New York (117), and Texas (85).

WHAT DOES THIS TREND MEAN FOR MASSACHUSETTS?

The Massachusetts share of U.S. venture capital dipped somewhat in 1999. Yet the state continues to rank second only to California in annual investment of venture capital, and has maintained this position during a period of unprecedented and explosive growth in the venture capital industry. Massachusetts outperforms other, much larger LTS, a sign that the venture climate in the state remains very strong. Venture capital in Massachusetts is also targeted towards a wide range of technologies, which will help ensure a diverse economy in the future.

Venture capital investment received by companies and as a percent of total US venture investments, Massachusetts, 1995–1999



30. Massachusetts E-Commerce Companies and E-Commerce Academic Offerings

E-Commerce Companies in Massachusetts Continue to Thrive; Academic Institutions Respond by Increasing E-Commerce Offerings

WHY IS IT SIGNIFICANT?

A critical mass of e-commerce companies is important for maximizing supplier-producer relationships and a shared infrastructure. This cluster also develops a competitive position for the state in the e-commerce marketplace. The growth of e-commerce companies requires a well-educated and highly skilled workforce that can address the challenges and strategies involved in developing and managing e-commerce business.

HOW DOES MASSACHUSETTS PERFORM?

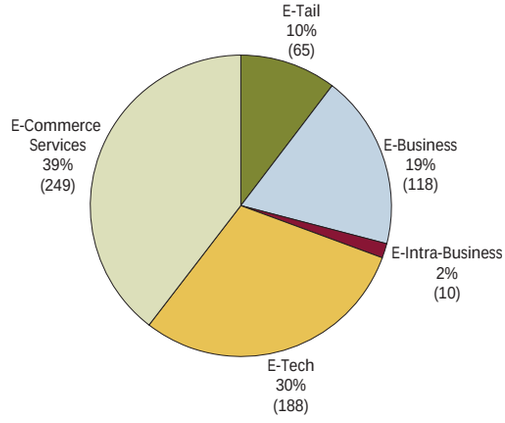
According to the *1999 Massachusetts Directory of High Technology Companies*, published by *Mass High Tech*, 630 companies identified themselves as e-commerce companies, a 28% increase from 1998. These companies employed a total of 30,945 people in 1999 with more than 68% of these people were employed by e-tech companies (which include e-commerce-enabling tools for the Internet, search engines, and security). The reported total annual revenue of e-commerce companies in 1999 indicates that e-tech and e-commerce services (which include e-marketing and web consulting) continue to generate the largest share of e-commerce revenue in Massachusetts.

According to a 2000 Massachusetts Technology Collaborative survey, major academic institutions in Massachusetts have been steadily increasing their number of e-commerce courses and programs. Of the 31 academic institutions surveyed by MTC, 24% offered undergraduate course work, 32% offered graduate course work, and 12% offered degrees or certificate programs in e-commerce.

WHAT DOES THIS TREND MEAN FOR MASSACHUSETTS?

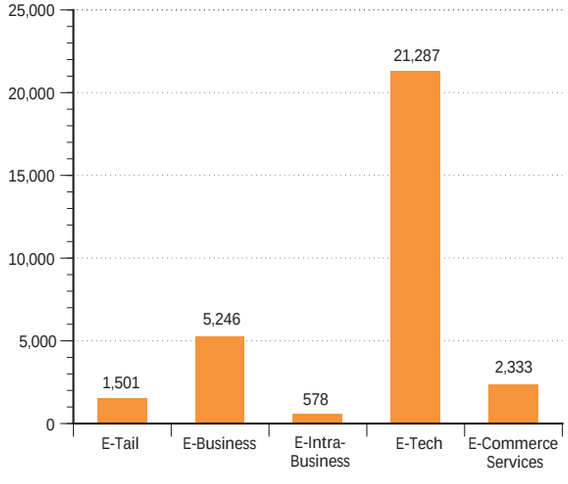
The e-commerce sector continues to be an important driver of growth in the Massachusetts Innovation Economy. The strengths of the e-tech and e-commerce services industries in particular have fueled intense market activity and the development of new technologies, such as optical networking and data storage. The state should continue its support of e-commerce as a new and exciting way to conduct business, as well as continue to adopt e-commerce capabilities within government. Massachusetts academic institutions should continue to integrate e-commerce into courses and degree programs, so that the state can generate a workforce that is knowledgeable about e-commerce, the Internet and other information technologies.

Distribution and number of e-commerce companies, Massachusetts, 1999

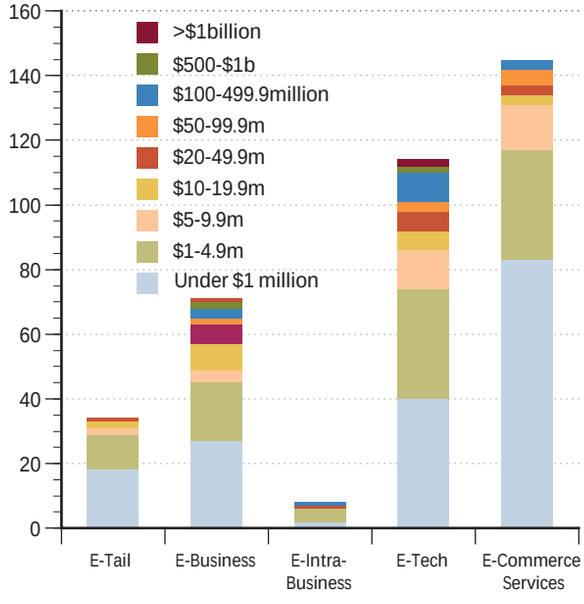


Note: Portions may not sum to 100% due to rounding

Number of employees, select e-commerce companies, Massachusetts, 1999



Annual revenue of select e-commerce companies, Massachusetts, 1999



Source of all data for this indicator: Mass High Tech

APPENDICES

Data Sources for Implications for Action and Roadmap

1998 Digest of Education Statistics,
National Center for Education Statistics

1999 Digest of Education Statistics,
National Center for Education Statistics

America's New Deficit: The Shortage of Information Technology Workers,
U.S. Department of Commerce, Office of Technology Policy, 1997

New England's Educational Advantage: Past Success and Future Prospects,
New England Economic Review, January/February 2000

Older Workers: An Essential Resource for Massachusetts,
Commonwealth of Massachusetts Blue Ribbon Commission on Older Workers, April 2000
(A full copy of the Commission's report is available at
http://www.geront.umb.edu/_documents/massrprt.pdf)

Opportunity Knocks: Training the Commonwealth's Workers for the New Economy,
Massachusetts Institute for a New Commonwealth, March 2000

The Road Ahead, Emerging Threats to Workers, Families and the Massachusetts Economy,
Heinz Foundation and Massachusetts Institute for a New Commonwealth, 1998

Threats to Sustained Economic Growth: Science, Engineering and Information Technology Labor Shortages in the Massachusetts Economy,
Center for Labor Market Studies, Northeastern University Press, September 2000

Up and Over the Bar,
Mass Insight Education, April 2000

Appendix B

Data Availability

For the 2000 *Index*, most indicators are developed from existing secondary sources. The exceptions are primary data gathered by MTC on the retention of engineering graduates within the state (Indicator #24); an occupational needs survey developed by MTC and Northeastern University and distributed by Massachusetts industry councils to their members (Indicator #6); and a survey of academic institutions on e-commerce course work and degree programs (Indicator #30). In most cases, indicators from secondary sources required the reconfiguration of existing datasets. These groupings of data were 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.

We intend to continue updating and refining the *Index* in future years, so that it can serve as an effective monitoring system. In some key areas, however, the team found that data are simply not available or are cost-prohibitive. The team searched for measures that could serve as effective proxies for unavailable data.

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 set of Leading Technology States (LTS) includes California, Colorado, Minnesota, New Jersey, New York and Texas.

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

On several indicators in the document Massachusetts is compared to an LTS average. This average is the mean of each state's reported data, 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 corporations filings with State Employment Securities Agencies (SESA) and the Bureau of Labor Statistics (BLS). Data from RFA was 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 included in Appendix C.

Employment Concentration

State	Software	Computer/ Electronics	Healthcare Technology	Innovation Services	Financial Services	State	1999 LTS	2000 LTS	No. of clusters above 1.0
CA	1.29	2.25	1.40	1.23	0.95	CA	x	x	6
CO	2.23	1.85	0.98	1.24	0.97	CO	x	x	4
MA	1.37	2.30	1.74	1.53	1.62	MA	-	-	
MN	1.01	2.06	1.36	0.66	1.22	MN	x	x	5
NJ	1.64	0.45	2.97	1.38	1.48	NJ	x	x	5
NY	0.93	0.83	1.11	1.93	1.72	NY	x	x	4
TX	1.15	1.62	0.59	1.04	0.85	TX	x	x	3

2. Employment Diversification

This indicator was developed from RFA state-level data of unemployment insurance filings between 1994 and 1999. 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 2.9 is almost 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 1994 to 1999. The size of each circle on the chart reflects the relative size of employment in Massachusetts.

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 1999 current dollars.

4. Pay Per Worker

Data for Massachusetts and the LTS are from the Bureau of Labor Statistics.

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/Northeastern University workforce needs survey conducted in May 2000 in conjunction with the Massachusetts Biotechnology Council, Massachusetts High Technology Council, Massachusetts Medical Device Industry Council, Massachusetts Software & Internet Council, and the Massachusetts Telecommunications Council.

Surveys were sent to approximately 1,200 Massachusetts companies; of these, 301 (25%) 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 H-1B visa workers.

7. High-Tech CEO Rating of Massachusetts

Data are from the Massachusetts High Technology Council's annual business climate survey, 1987-2000.

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.

Destination of Massachusetts exports for 1999 was derived from the Massachusetts Institute for Social and Economic Research (MISER).

Innovation Process Indicators

9. Patents per Capita

Patents per capita data for Massachusetts and other LTS are provided by the U.S. Patent and Trademark Office. Patent distribution and patent citation of scientific literature data are from CHI Research.

The expected rate of patent citations is based upon the level of research and patents occurring within a state. Patent distribution data by industry sectors is provided by CHI Research, Inc.

10. 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. For this analysis the Massachusetts universities that provided information for the AUTM survey include Massachusetts Institute of Technology, Harvard University, Boston University, Brandeis University and the University of Massachusetts. 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, Beth Israel Deaconess Medical Center. St. Elizabeth's Medical Center of Boston and Schepens Eye Research Institute.

11. Technology Licenses and Royalties

Data on licensing agreements involving Massachusetts institutions are also from AUTM. These data are from the same institutions providing patent and invention disclosure information in Indicator number 10.

12. 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) approvals are required of less sophisticated instruments or small product modifications and improvements.

13. New Business Starts

All data are provided by Dun & Bradstreet.

Dun & Bradstreet defines new business starts as businesses actively involved in real commercial activity. Dun & Bradstreet identifies new businesses in their database through a weekly analysis of changes in their files, indicating which enterprises are new, or have been recently introduced. This indicates the beginning of commercial activity. New enterprises with a start date ("birth date") in the current year or in the previous two years are classified as new business starts for the current year. Therefore, the interval between concept and actual commercial activity is compressed into the current year. It should be noted that few new entrants in the first half of the year identify a "birth date" in the current year, demonstrating the delay between the birth of an idea versus the birth of a business.

Dun & Bradstreet's industry categorization for new business starts is based upon the four-digit Standard Industrial Classification (SIC) code level.

14. SBIR Awards

Data are provided by the Small Business Administration 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.

15. Initial Public Offerings

The numbers of initial public offerings (IPOs) by state are provided by Arthur Andersen.

Data on the total value and distribution of IPOs by industry sector are provided by Arthur Andersen. Arthur Andersen's industry classifications for IPOs are based upon the four-digit Standard Industrial Classification (SIC) code level.

16. Mergers & Acquisitions

The number of mergers and acquisitions (M&As) by state are provided by Arthur Andersen Corporate Finance. M&A data represent all entities that have been acquired by another for all years presented in the indicator.

Data on the market share and total number of deals by industry sector of M&As are provided by Arthur Andersen Corporate Finance. Arthur Andersen's industry classifications for M&As are based upon the four-digit Standard Industrial Classification (SIC) code level.

For context, the distribution of market share represents the total dollar value of all M&As in each industry sector. The distribution of total number of deals represents the number of M&As (those firms that have been acquired) in each industry sector. For example, Commercial Banks & Bank Holding Companies was 1% of the total number of deals in Massachusetts in 1999, but 32% of the total market share (total dollar value of the transactions) during the same period.

17. NASDAQ Firms' Market Value

The dataset contains the market capitalization/value of all publicly traded firms listed on the NASDAQ Exchange on the March 31 of each year from 1995-2000. 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) from between 1986 and 1999. This dataset has been updated for 1999 using information from corporate 10K filings as reported by Compustat, Global Researcher, and the SEC.

19. Corporate Headquarters

Data on total number of corporate headquarters by state are provided by American Business Information.

Data on location of Fortune 500 Companies in Massachusetts and the LTS was derived from the annual Fortune 500 List, 1999.

Resource Indicators

20. Population Growth Rate and Unemployment Rate

Data on population growth rate by state are derived from the U.S. Census Bureau.

Data on the unemployment rate by state are derived from the Bureau of Labor Statistics.

21. Migration

Total foreign and domestic immigration data are provided by the U.S. Census Bureau.

Survey data on the percent of new staff hires that are H-1B visa hires by occupation is derived from the MTC/Northeastern University Workforce Needs Survey, April 2000 (for further details, please see Indicator 6).

22. Workforce Education

Data on percentage changes in the adult population without a high school diploma and with a college degree from 1970 to 1998 are provided by the U.S. Census Bureau.

Data on Massachusetts students planning to attend college by race/ethnicity are provided by the Massachusetts Department of Education.

23. Dropout Rates

Data are provided by the Massachusetts Department of Education.

24. Engineering and Computer Science Degrees

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

Information on the number of engineering degrees retained in Massachusetts is compiled by MTC in partnership with the major engineering degree granting institutions in Massachusetts. Data for this indicator are based upon information provided by Boston University, Harvard University, Massachusetts Institute of Technology, University of Massachusetts-Amherst, University of Massachusetts-Dartmouth, University of Massachusetts-Lowell, Tufts University, and Wentworth Institute of Technology.

25. Computers in Education

Data for computer usage by fourth and eighth graders are provided by *Education Week's, Technology Counts 1998 and 1999 Reports*. Data for percentages of fourth and eighth grade students who have access to computers in the classroom, for Massachusetts and five LTS, are provided by *Education Week's, Technology Counts 1999 Report*. New Jersey did not participate in the survey.

26. Student Interest in Technical Careers

Data for intended majors of students taking the SAT in Massachusetts and the LTS are provided by The College Board Online, Profile of College Bound Seniors, 1999. The Profile of College-Bound Seniors presents data for 1999 high school graduates who participated in the SAT Program during their high school years. Students are counted once no matter how often they tested, and only their latest scores and most recent Student Descriptive Questionnaire (SDQ) responses are summarized. The college-bound senior population is relatively stable from year to year; moreover, since studies have documented the accuracy of self-reported information, SDQ information for these students can be considered a highly accurate description of the group. Advanced Placement (AP) data are derived from The College Board's AP Summary Reports.

27. Federal R&D Spending and Health R&D Spending

Data are provided by the NSF for all academic institutions. This includes its university-associated federally funded research and development centers.

Data are provided by the NSF. Data are for all R&D expenditures by the U.S. Department of Health and Human Services. More than 95% of these expenditures occur 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 the Global Researcher database. Industry R&D per employee was calculated for all companies that reported any R&D expenditures.

29. Venture Capital

Data for total venture capital investments in Massachusetts and venture capital investments by industry activity, including e-commerce and Internet-related, are provided by PricewaterhouseCoopers, LLP (PWC). Industry category designations are determined by PWC.

30. Massachusetts E-Commerce

Data on total number, type, and revenues of e-commerce companies located in Massachusetts are derived from *Mass High Tech*, The Massachusetts Directory of High Technology Companies, 1999.

Data on the e-commerce offerings of Massachusetts institutions are derived from a special MTC survey conducted in July 2000. Colleges and universities were chosen based on the Carnegie Foundation Classification of Institutions. These institutions were asked to provide information on their current academic course offerings in e-commerce, as well as academic degree/certificate offerings in e-commerce.

Appendix C

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
3575 Computer Terminals
3661 Telephone and telegraph apparatus
3663 Radio & 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
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 & controlling devices, nec

Diversified Industrial Support

2992 Lubricating oils and greases
3061 Mechanical rubber goods
3069 Fabricated rubber products, nec
3081 Unsupported plastics film & sheet
3082 Unsupported plastics profile shapes
3087 Custom compound purchased resins
3291 Abrasive products
3357 Nonferrous wiredrawing & insulating
3398 Metal heat treating
3399 Primary metal products, nec
3462 Iron and steel 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 Metalworking machinery, nec
3554 Paper industries machinery
3555 Printing trades machinery
3559 Special industry machinery, nec
3561 Pumps and pumping equipment
3562 Air and gas compressors
3567 Industrial furnaces and ovens
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
7322 Adjustment and collection 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
8712 Architectural services
8731 Commercial physical research
8732 Commercial nonphysical research
8734 Testing laboratories
8741 Management services
8742 Management consulting services
8743 Public relations 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
7376 Computer facilities management
4812 Radiotelephone communications
4813 Telephone communications, exc. radio
4841 Cable and other pay television services
7372 Prepackaged software
7373 Computer integrated systems design
7374 Data processing and preparation
7375 Information retrieval services
7377 Computer rental & leasing
7378 Computer maintenance & repair
7379 Computer related services, nec

Textiles and Apparel

2221 Broadwoven fabric mills, manmade
2231 Broadwoven fabric mills, wool
2253 Knit outerwear mills
2257 Weft knit fabric mills
2261 Finishing plants, cotton
2262 Finishing plants, manmade
2269 Finishing plants, nec
2295 Coated fabrics, not rubberized
2297 Nonwoven fabrics
2298 Cordage and twine
2299 Textile goods, nec
2337 Women's and misses' suits and coats
2386 Leather and sheep-lined clothing
2389 Apparel and accessories, nec
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 & lapidary work
3961 Costume jewelry
5131 Piece goods and notions
5136 Men's and boys' clothing
5137 Women's and children's clothing
5139 Footwear

nec - not elsewhere classified

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

American Association of Engineering Societies
Association of University Technology Managers
Bentley College
Boston University, Analytical Services
Bureau of the Census, U.S. Department of Commerce
Bureau of Labor Statistics, U.S. Department of Labor
CHI Research, Inc.
Collaborative Economics
College Board Online
Dun & Bradstreet, Inc.
Education Week
Federal Reserve Bank of Boston
Fortune Magazine
Harvard University
InfoUSA
International Data Corporation
International Trade Administration, U.S. Department of Commerce
Massachusetts Biotechnology Council
Massachusetts Department of Education
Massachusetts High Technology Council
Mass High Tech Journal
Massachusetts Institute of Technology
Massachusetts Software & Internet Council
Massachusetts Telecommunications Council
MassMEDIC
MISER
National Center for Education Statistics, U.S. Department of Education
National Association of Securities Dealers, Inc. (NASDAQ)
National Science Foundation
Northeastern University, Labor Market Studies and Institutional Research Centers
Regional Financial Associates, Inc.
Small Business Administration
Standard & Poor's Compustat
Tufts University, Institutional Research
University of Massachusetts, Amherst
University of Massachusetts, Dartmouth
University of Massachusetts, Lowell
U.S. Census Bureau
U.S. Department of Commerce
U.S. Food and Drug Administration
U.S. Patent and Trademark Office
Wentworth Institute of Technology

INDEX PROJECT STAFF

Director: **Thomas Hubbard**, *MTC Vice President*, *Technology Development & Analysis*
Manager: **Jennifer Banks**, *MTC Project Manager*
Facilitator: **Jeff Lockwood**, *MTC Director, Cluster Program Development*
Contributor: **Robert Kispert**, *MTC Director, Federal Programs*
Contributor: **Conrad Crawford**, *MTC Research Associate*
Communications: **Jean Fleischman**, *MTC Vice President, Communications and Public Affairs*
Graphic Design and Production: **Christine Raisig**, *MTC Publications Manager*
Proofreading: **Nancy Falvey**, *MTC Executive Administrator* and **Ticia Allain-Martin,** *MTC Administrative Assistant*

ADDITIONAL COPIES

Additional copies of the ***Index of the Massachusetts Innovation Economy*** are available for $20.00 per copy for individuals and corporations ($15.00 per copy for quantities over 20), and for $10.00 per copy for nonprofit organizations and educational institutions ($7.50 per copy for quantities over 20).

Orders may be placed through the MTC web site at www.mtpc.org, or by telephone.
To order additional copies or for additional information call 508-870-0312.

The Index is available at no cost by downloading from www.mtpc.org.