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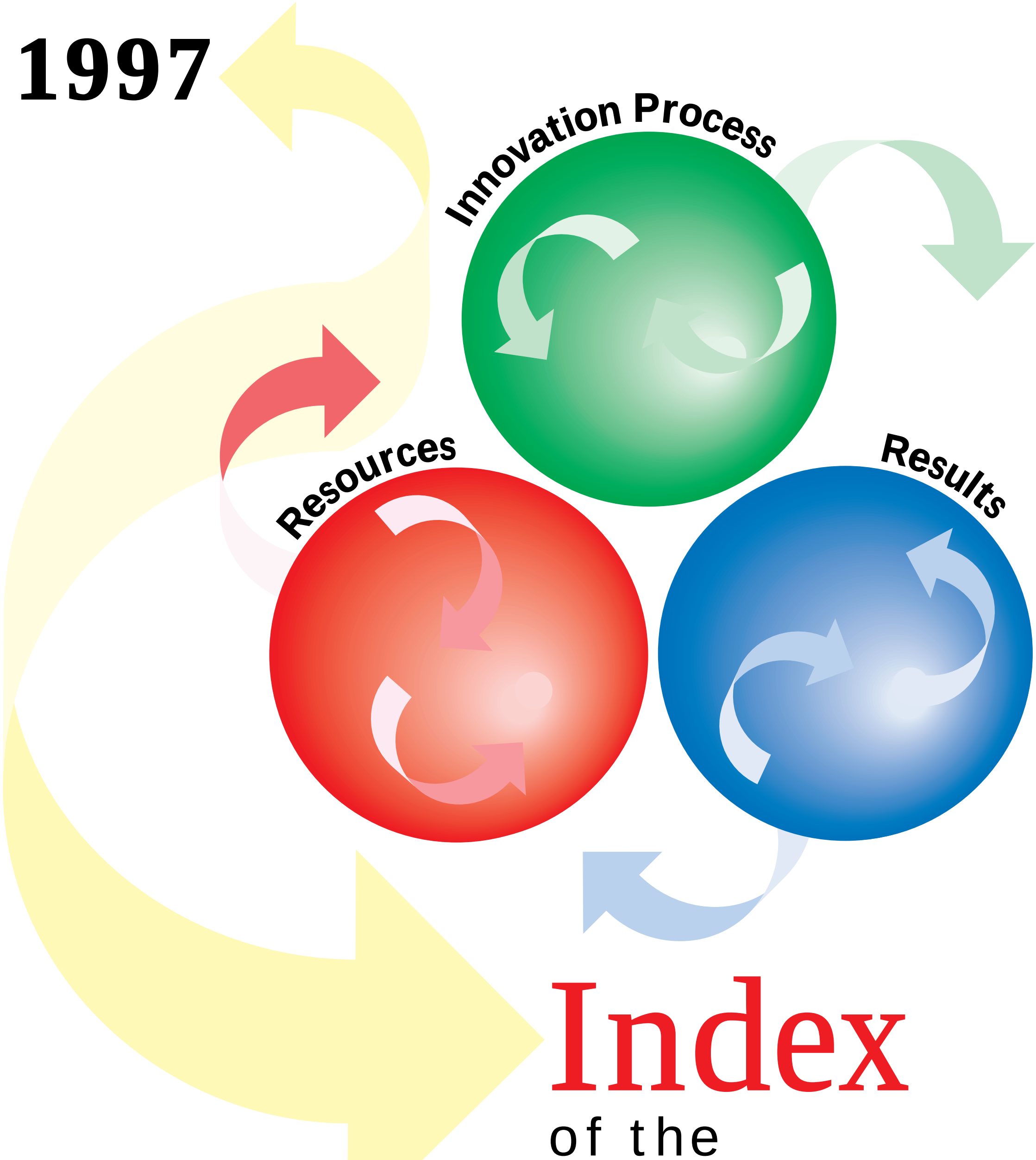

Index of the Massachusetts INNOVATION Economy

Massachusetts TECHNOLOGY Collaborative

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Massachusetts TECHNOLOGY Collaborative

The Massachusetts Technology Collaborative (MTC) is a public-private economic development organization established by the state to foster a more favorable and responsive environment for the formation, retention and expansion of technology-intensive enterprises in Massachusetts. It pursues its mission by facilitating greater collaboration among and between industry, academia and government and by serving as a public laboratory for testing new approaches to economic development.

MTC was established in 1994 by the Board of Directors of the Massachusetts Technology Park Corporation, a publicly chartered independent authority of the Commonwealth, created in 1982 to advance the growth of the technology sector of the Massachusetts economy. MTC is directed by a 23-member Board of Directors appointed by the Governor, representing senior officials from public and private colleges and universities, technology companies and state government.

Board of Directors

Special thanks and acknowledgment to MTC Senior Policy Analyst Jennifer Montana, PhD, who directs the *Index of the Massachusetts Innovation Economy* project.

DEAR READER:

We are pleased to present the *Index of the Massachusetts Innovation Economy*, a set of quantitative indicators that tracks the results of the emerging Innovation Economy, the processes that stimulate these results, and the resources that provide its foundation.

WHY INNOVATION IS IMPORTANT TO THE MASSACHUSETTS ECONOMY

Innovation is the competitive advantage of Massachusetts. Competitive companies, leading-edge research institutions, and universities translate knowledge and ideas into new products, processes, and services, creating increasing productivity, quality jobs, and rising incomes for Massachusetts citizens. This "Innovation Economy" is based on a set of essential resources, dynamic processes, and competitive results.

The Massachusetts Technology Collaborative (MTC) believes that fostering the development of the Innovation Economy is the most prudent and effective strategy for promoting sustainable economic growth and weathering economic cycles. Underpinning this belief is the conviction that Massachusetts can achieve and maintain a higher standard of living only through continuous innovation and increased productivity.

WHY THE *INDEX OF THE MASSACHUSETTS INNOVATION ECONOMY*

MTC recognizes the importance of anticipating and responding effectively to significant changes in the economy. It also acknowledges the need to pioneer new ways to develop and analyze data about the emerging economy. The *Index* is the logical outgrowth of three previous MTC studies that laid the groundwork for identifying key resources and some of the linkages between these resources and the innovation process (see Appendix A).

Understanding the innovation process and developing measures to track its performance are essential for sustaining the key drivers of the Commonwealth's economic vitality and quality of life.

The purposes of the *Index of the Massachusetts Innovation Economy* are to:

- Establish a reliable source of understandable information about the Massachusetts Innovation Economy that can be updated annually
- Inform opinion leaders about the performance of the Innovation Economy and the resources and processes that support its development
- Stimulate discussion about how best to foster the development of the Innovation Economy

This inaugural *Index* includes 33 indicators. Our goal has been to identify a select number of indicators that together tell the story of innovation in Massachusetts, rather than to present all relevant data. The indicators will be updated and refined annually.

While the *Index* provides a state-wide perspective, Massachusetts consists of diverse regional and local economies. We encourage special analyses at the substate level to indicate how different communities fit into overall state trends.

We welcome your insights and suggestions.

John T. Preston
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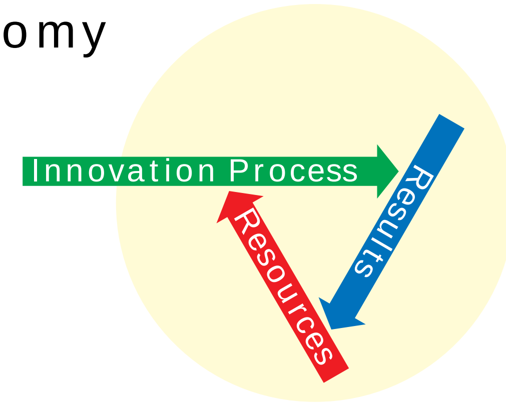
Massachusetts INNOVATION Economy



A FRAMEWORK FOR INNOVATION

Innovation drives economic vitality throughout the state economy. Traditional theories of economic growth identify two principal drivers of productivity: labor and capital. Pioneering research by Robert Solow of the Massachusetts Institute of Technology challenges this model and demonstrates that "technology" is a third major driver of productivity. Building on Solow's work, new growth theorists such as Paul Romer of Stanford University show that economic growth derives from the innovation process inherent in this technology driver. These economists suggest that sustainable economic growth arises from "ideas" that are the basis for "new recipes that transform products and services from low to high value."

With this new understanding, growth is no longer limited by capital or labor but is sustained by people's ability to generate new ideas and translate them into highly valued, marketable products and services. Innovation—the continuous process of generating and applying new ideas to the creation and upgrading of products, processes, and services—has become the primary source of wealth creation in the information age and continues to be essential for the resilience needed to weather economic cycles.

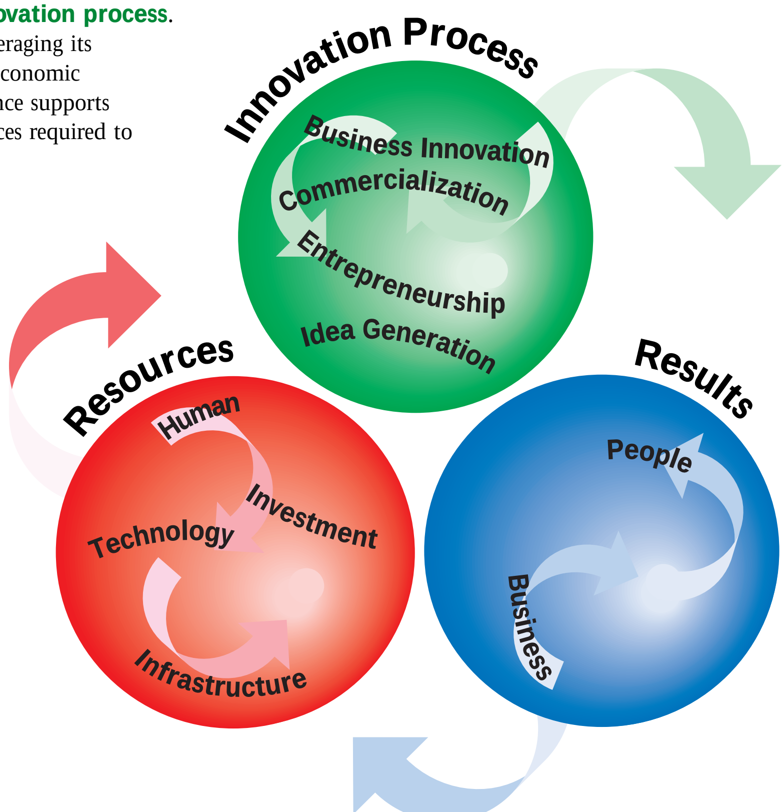
Just as there has been progress in better understanding economic growth and innovation, so too can there be significant improvement in the frameworks and tools used to analyze and measure the Innovation Economy. New ways of defining important economic data are needed as are novel ways to integrate traditional economic indicators into new frameworks that yield important insights about the emerging Innovation Economy.

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

The Massachusetts Innovation Economy has three interrelated and interactive components:

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

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



The inaugural *Index* includes 33 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.

The conceptual framework and indicators were developed by a team composed of the Massachusetts Technology Collaborative, the *Index* Advisory Committee, and Collaborative Economics.

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

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

Each indicator was developed from existing secondary sources with the exception of primary data gathered by MTC on the retention of engineering graduates within the state. In many cases, these indicators 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 update and further refine the *Index* in future years, so that it can serve as an effective monitoring system. In the research for the inaugural *Index*, the team found it challenging to identify data sources to track the Innovation Economy. In key areas, data were simply not available to construct an indicator or the data were cost-prohibitive. The team searched for measures that could serve as effective proxies for unavailable data. Exhibit A: Critical Indicators for Future Investment (page 32) identifies research areas that the team views as high priorities for analysis and investment in future editions of the *Index*.

BENCHMARK COMPARISONS

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 this report are California, Florida, Illinois, New Jersey, New York, and Texas. (See Appendix A for selection methodology.)

NINE KEY INDUSTRY CLUSTERS

In addition to benchmarking Massachusetts' performance, the team believes it is important to monitor the impact of innovation through key industry clusters critical to the state's economy. We have identified nine industry clusters that significantly affect the state and are uniquely linked to the Innovation Economy (see Appendix B for definitions of these clusters). Together, these nine clusters account for 24% of non-government employment in Massachusetts and 35% of total private sector payroll. At $47,600, the average wage paid by the nine key industry clusters is 48% higher than that of the rest of the Massachusetts economy.

OTHER NOTES

Appendix A provides detailed information about definitions and sources for each indicator. Throughout the document, numbers are presented in current dollars unless noted as real, inflation-adjusted values (see Appendix A).

A new economy is emerging in Massachusetts driven by innovation. The structure of this economy has shifted toward higher-end services. Performance still lags, however, in a few key areas such as manufacturing exports. Although the innovation process shows considerable strength, the most fundamental long-term vulnerabilities lie in sustaining Massachusetts' advantages in human and technology resources.

A NEW ECONOMY EMERGES

The structure of the Massachusetts economy has changed dramatically since the early 1990s. A new economy with more diversity, more employment in high-end services, and higher wages is emerging. However, this new economy also shows widening income inequality and relatively low growth in export sales.

- Of the nine key industry clusters that drive the Massachusetts economy, the software and communications services cluster is the biggest gainer, growing by more than 20,000 jobs since 1992. This industry cluster also pays the highest wages, averaging $56,000 per employee.
- Massachusetts has become less reliant on defense and computer/communications hardware, each of which has contracted by nearly 15,000 jobs since 1992.
- The attractiveness of Massachusetts to its high-technology businesses is at an all-time high, with 88% rating the state positively as a place to operate.
- Inflation-adjusted pay per worker in Massachusetts increased 6% from 1990 to 1996, compared with a 2.3% average in the other Leading Technology States (LTS).
- Household income inequality is widening. Average income for the poorest 20% of Massachusetts households declined from 1988 to 1995.
- With 21% real growth since 1991, growth in Massachusetts manufacturing exports trails the U.S. average (31% growth) and the average of other technology states such as California (47%). (Note: Export data on services are not available and, therefore, are not included in manufacturing exports analysis.)

INNOVATION DRIVES THE NEW ECONOMY

The Massachusetts innovation process is driving the new economy through idea generation, technology commercialization, and entrepreneurship, as well as innovation in established businesses.

- Massachusetts leads other LTS in patents per capita, an important measure of idea generation.
- Technology license royalties earned by universities, hospitals, and research institutions in Massachusetts more than doubled from 1991 to 1995.
- The number of fast-growth "gazelle" companies in Massachusetts increased to 99 in 1996, compared with 38 in 1992.
- The value of a firm's intangible assets, on a per employee basis, serves as a proxy for "intellectual capital." For Massachusetts publicly traded companies, this measure exceeds the national average by 40%.
- Key manufacturing industry clusters in Massachusetts such as computers, healthcare technology, defense, and diversified industrial support trail the national average significantly in value added per employee.

PEOPLE AND TECHNOLOGY PROVIDE THE FOUNDATION FOR SUSTAINED INNOVATION

Massachusetts remains a leader in the education of its workforce and the maintenance of strong technology assets, but it faces challenges to sustaining this skills and technology advantage.

- Although federal R&D spending per capita at Massachusetts universities has been relatively constant since 1989, when adjusted for inflation, it is significantly higher than in the other LTS. Federally funded health R&D has consistently increased since 1985.

- Massachusetts eighth graders excel on math and science tests compared with eighth graders in the other LTS. SAT scores and SAT participation rates are high and continue to rise.

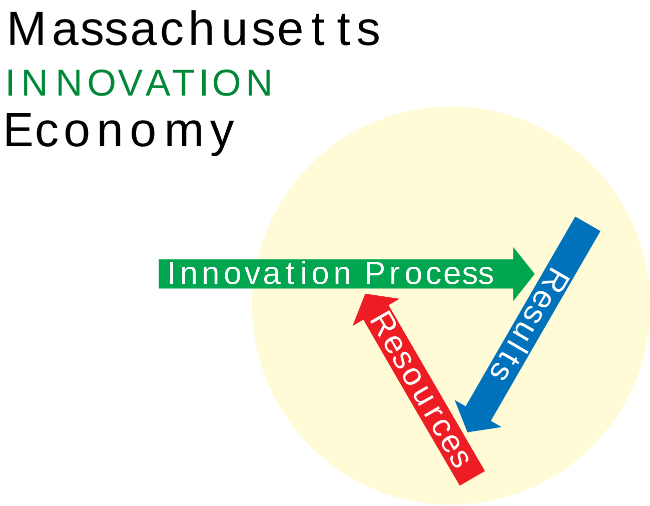
- Of all the LTS in January 1997, Massachusetts had the second highest number of internet hosts per capita (67.9 per 1,000 people), a close runner-up to the top-ranked California (69.2 per 1,000 people).

- Massachusetts continues to experience domestic out-migration. International immigration explains why overall net migration turned positive in 1995 and 1996.

- In 1996, venture capital investment in Massachusetts companies reached an all-time high of $831.5 million, though its share of the national total of venture investment decreased from the early 1990s. This number compares with $1.8 billion received by Silicon Valley companies in 1996.

- The number of undergraduate engineering degrees awarded by Massachusetts institutions has declined by 35% from 1987 to 1996, compared with a 14% decline nationally.

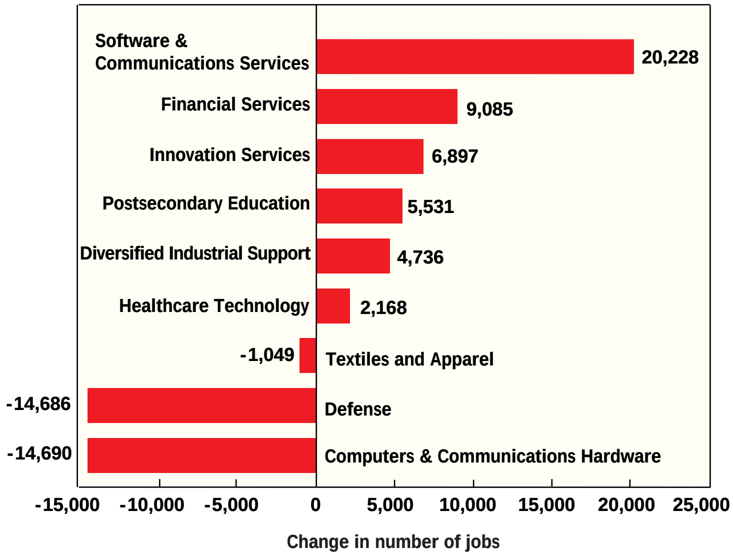
- Although the average high school drop-out rates have declined statewide since 1991, 24% of Massachusetts public high schools have annual drop-out rates in excess of 7%.



I. Results Indicators

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

1. Cluster Employment Shifts Dramatically; Software and Communications Services Is Biggest Gainer



Net employment change, nine key industry clusters, Massachusetts, 1992-1996

Source: Collaborative Economics, Massachusetts Department of Employment and Training, Minnesota IMPLAN Group

WHY IS IT SIGNIFICANT?

Nine key industry clusters, defined as geographic concentrations of interdependent industries, account for 24% of all non-government employment in Massachusetts. Clusters benefit the economy through their multiplier effect. As cluster companies generate wealth and earnings through national and international sales, they stimulate local suppliers and employment. These healthy outward-oriented clusters lead to healthy local-serving industries.

HOW DOES MASSACHUSETTS PERFORM?

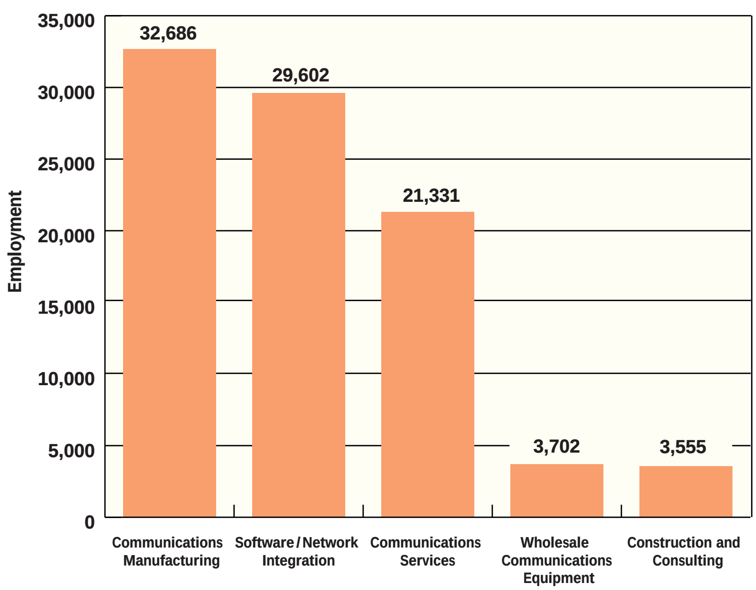
The net increase in new employment in these nine clusters between 1992 and 1996 was 18,220 from a 1992 base of 589,240. Underlying the slight 3% increase in employment are dramatic structural shifts.

Software and communications services registered the strongest absolute job growth between 1992 and 1996: 20,228 new jobs. This cluster is also the highest paying. Other strong gainers in new jobs were innovation services (9,085) and postsecondary education (6,897).

(Innovation services includes a range of outsourced services that support innovative companies, such as engineering services, research and testing services, and consulting services. See Appendix B for definitions of all nine key industry clusters.)

Between 1992 and 1996, computer and communications hardware contracted by 14,686 jobs. Defense also contracted by 14,690 jobs.

2. Telecommunications Industry Emerges with Many Segments



Sectoral employment in the telecommunications industry, Massachusetts, 1996

Source: Massachusetts Telecommunications Council, University of Massachusetts

WHY IS IT SIGNIFICANT?

Often innovation occurs as capabilities from multiple sectors converge. New industries emerge, or traditional ones transform, cutting across multiple industry clusters. In this process, "fusion" industries are formed that combine the strengths of several industries. As they emerge, these fusion industries are often difficult to define and to track over time.

HOW DOES MASSACHUSETTS PERFORM?

A recent study conducted by the Massachusetts Telecommunications Council and the University of Massachusetts identified telecommunications as a fast-growing industry that employed 90,876 people in the state in 1996. Telecommunications includes diverse segments from traditional industry categories: communications hardware manufacturing, telecommunications services, telecommunications software/network integration, consulting and construction, and wholesale sales of communications equipment.

Taken together, employment in these segments grew 61% between 1993 and 1996, adding 34,465 workers. During the same period, sales revenue is estimated to have grown 290%. Telecommunications can be considered a mature industry that has changed dramatically and is experiencing explosive growth.

Because it is a fusion industry, it has proved difficult to develop an historical dataset for telecommunications that allows consistent comparison with other industry clusters. For this reason, data on telecommunications are presented here as a separate chart, and are not provided in other cluster indicators. Rather, the key segments of telecommunications appear in software and communications services and in computer and communications hardware.

WHY IS IT SIGNIFICANT?

Successful economies have specialized employment concentrations but do not rely on just one or two specialized industry clusters. Overreliance on a particular cluster can leave a state vulnerable to economic shifts and reduce its resilience. Areas exhibiting long-term economic growth tend to have a diverse portfolio of industry clusters.

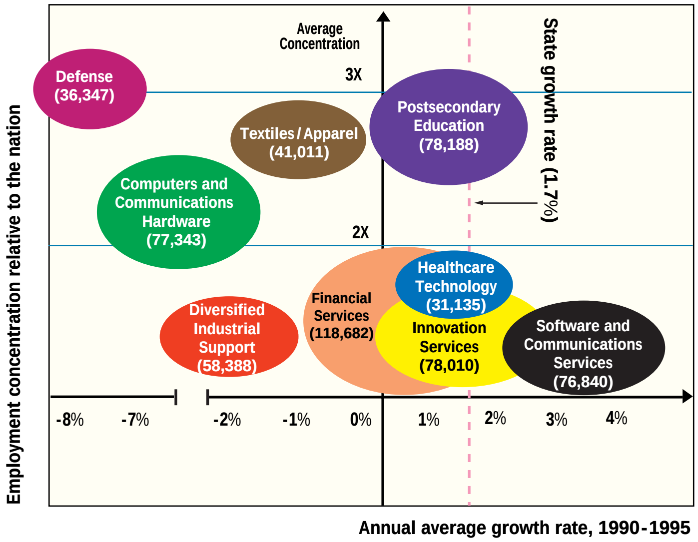
HOW DOES MASSACHUSETTS PERFORM?

Massachusetts has at least nine key industry clusters with employment concentrations greater than the national average. The industry clusters that are most concentrated in Massachusetts relative to the nation are defense (3 times as concentrated), postsecondary education (2.6 times), and textiles/apparel (2.5 times). (On the chart, these clusters are highest on the vertical axis.)

Employment in these nine clusters is changing at different average annual rates. The fastest-growing cluster is software and communications services (3.1% annually). The defense cluster, by contrast, has experienced the greatest contraction since 1990: 8.9% annually. Since 1990, defense has declined from 9% to 6% of industry cluster employment. In general, industry clusters associated with manufacturing contracted through the 1990s, while service-oriented industry clusters experienced positive growth rates.

Of the nine key industry clusters, financial services is the largest employer, with 20% of total employment in the nine clusters. The software and communications services, innovation services, computer and communications hardware, and postsecondary education clusters are roughly comparable in size—each represents 13% of industry cluster employment. (The size of each oval on the chart reflects the relative size of employment in Massachusetts.)

3. Massachusetts Has a Diverse Portfolio of Specialized Clusters



Portfolio of nine key industry clusters by employment concentration and growth, Massachusetts, 1990-1995

Source: Minnesota IMPLAN Group, Collaborative Economics

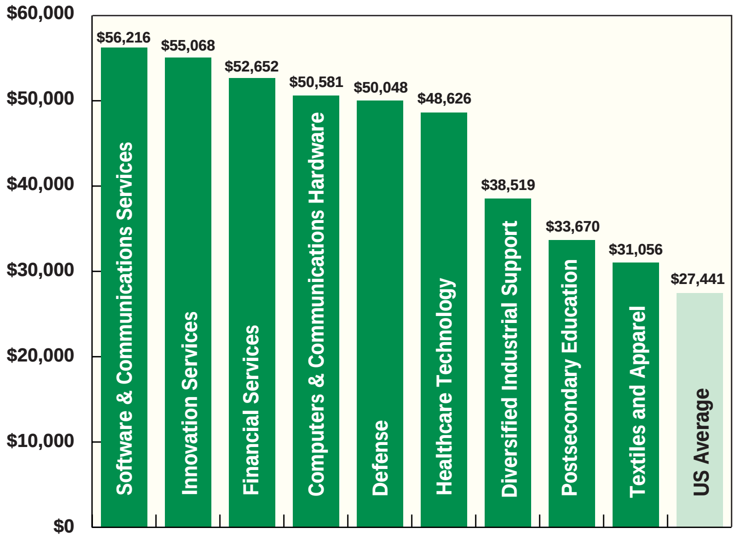
WHY IS IT SIGNIFICANT?

High average pay in key industry clusters reflects the wealth-generating impact that outward-oriented industries have on the state. Such industries generate wealth and earnings through national and international sales.

HOW DOES MASSACHUSETTS PERFORM?

Workers in the software and communications services industry cluster earn the highest average pay, at $56,216 per year. Innovation services ranks a close second, at $55,068, followed by financial services at $52,652 per year. Textiles and apparel has the lowest average pay of the key industry clusters at $31,056 per year.

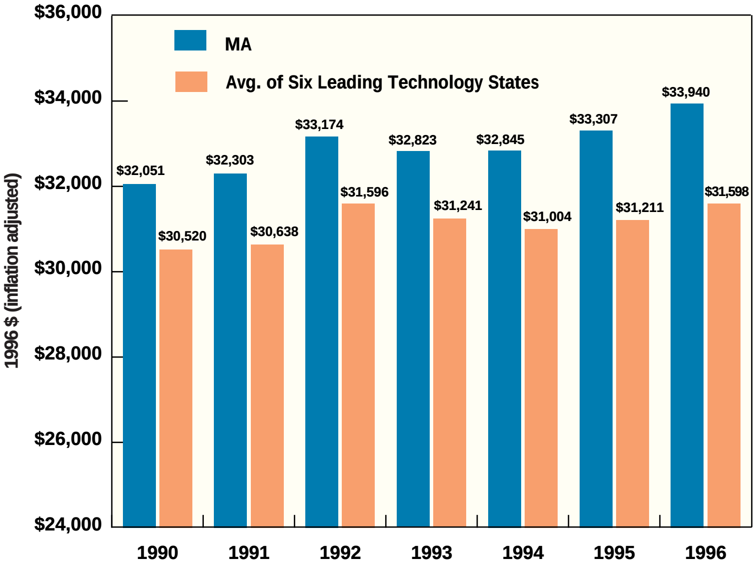
4. Software and Communications Services Industry Cluster Leads in Average Pay



Average annual pay per worker, nine key industry clusters, Massachusetts, 1995

Source: Minnesota IMPLAN Group, Bureau of Labor Statistics

5. Inflation-Adjusted Pay per Worker Rises 6% Since 1990



Average annual pay per worker, Massachusetts and six LTS, 1990-1996

Source: Bureau of Labor Statistics

WHY IS IT SIGNIFICANT?

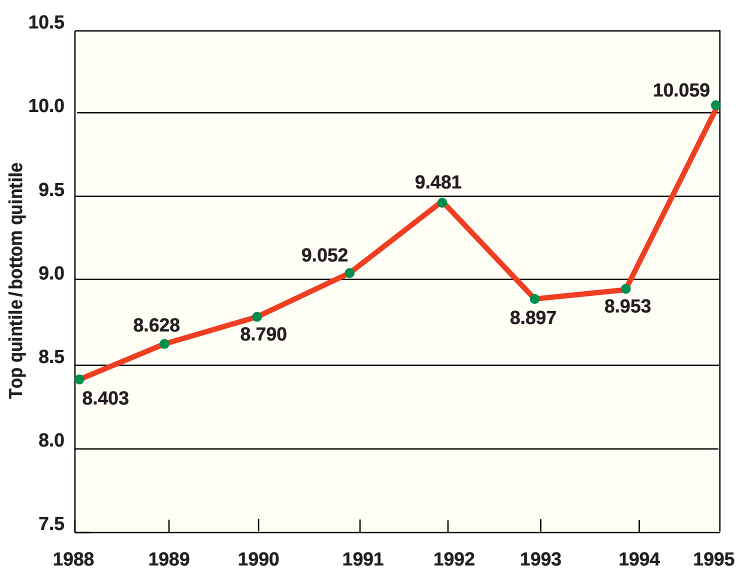
Growth in pay per worker, adjusted for inflation, is a measure of job quality and a key determinant of standard of living.

HOW DOES MASSACHUSETTS PERFORM?

Between 1990 and 1996, average annual pay of Massachusetts workers increased 6% in inflation-adjusted terms, compared with 2.2% nationally and a 2.3% average in the other Leading Technology States (LTS). In comparison with the six LTS, Massachusetts consistently reports the third-highest average annual pay, just behind New York and New Jersey and above California.

In 1996, average annual pay in Massachusetts was $33,940. This figure compares with $28,945 for the nation and $31,598 for the six LTS.

6. Income Distribution Is Widening



Ratio of the mean income of the highest to the lowest 20% of households, Massachusetts, 1988-1995

Source: Purdue University, Bureau of the Census, Current Population Survey

WHY IS IT SIGNIFICANT?

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

Although good data on income mobility in Massachusetts are not available, the *Index* includes the best available information about income distribution. Many factors are associated with rising household income inequality, including the increase in single-parent households and the growing wage premium for college education (see Katherine Bradbury, *New England Economic Review*, July/August 1996).

HOW DOES MASSACHUSETTS PERFORM?

From 1988 to 1995, average income for the poorest 20% of Massachusetts households declined 12%, from $8,921 to $7,869. Average income for the top 20% of households increased 6% from $74,959 to $79,149. As a result, the income ratio of the top fifth to the bottom fifth increased from 8.4 to 10 between 1988 and 1995.

In 1995, Massachusetts ranked fifth nationally on the basis of average income for all households, but thirty-ninth on the basis of income distribution. Only California and Washington, D.C., had a wider gap between their rankings for average income and the ratio between top and bottom fifths.

WHY IS IT SIGNIFICANT?

Exports are an important indicator of global competitiveness. Serving growing global markets bolsters growth in employment, sales, and market share at innovation-based companies.

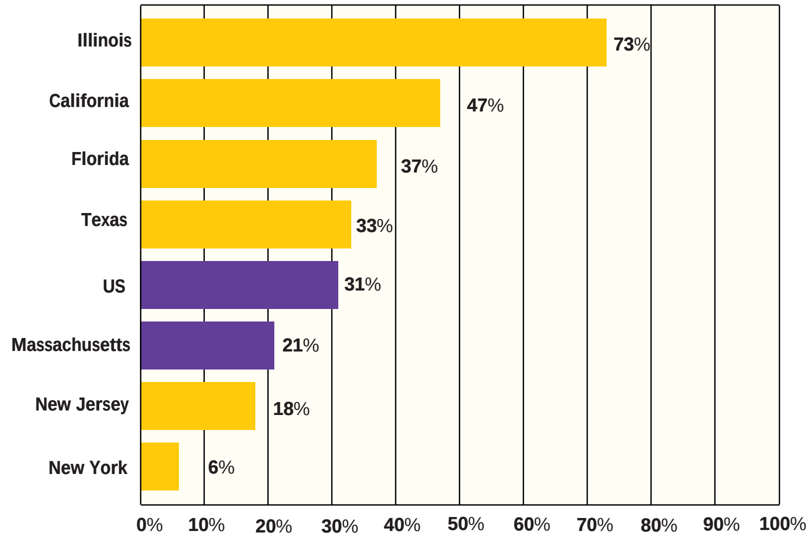
HOW DOES MASSACHUSETTS PERFORM?

Between 1991 and 1996, Massachusetts-manufactured exports increased 21%, in inflation-adjusted terms, from $9.5 billion to $11.5 billion. Massachusetts-manufactured exports have not grown as quickly as those of the nation (31%) and other top-ranking Leading Technology States (LTS), including California (47%) and Illinois (73%).

Three high-tech industries account for more than two-thirds of all Massachusetts exports: industrial machinery and computers, electronic and electric equipment, and instruments and related products. Of these exports, electronic equipment registered the strongest growth, increasing 74%, in inflation-adjusted terms, between 1990 and 1996.

This export measure of manufacturing does not include healthcare technology, software and communications services, and financial services. Unfortunately, service export data are not collected at present. The World Trade Organization estimates that the value of global trade in services grew 14% in 1995 to just under $1.2 trillion, about a quarter of the value of goods traded. Using this benchmark, service trade in Massachusetts would represent approximately $2.9 billion in 1996.

7. Manufacturing Exports Substantially Trail Those of Leading Technology States



Change in value of manufacturing exports, Massachusetts and six LTS, 1991-1996 (inflation-adjusted dollars)

Source: Office of Trade and Economic Analysis, International Trade Administration, U.S. Department of Commerce

WHY IS IT SIGNIFICANT?

Confidence in a region both reflects current conditions and influences its future. Positive or negative perceptions of a state affect investment patterns. The perception by high-technology businesses of how Massachusetts rates as a place in which to create, operate, or expand high-technology businesses is a bottom-line indicator of the overall innovation climate.

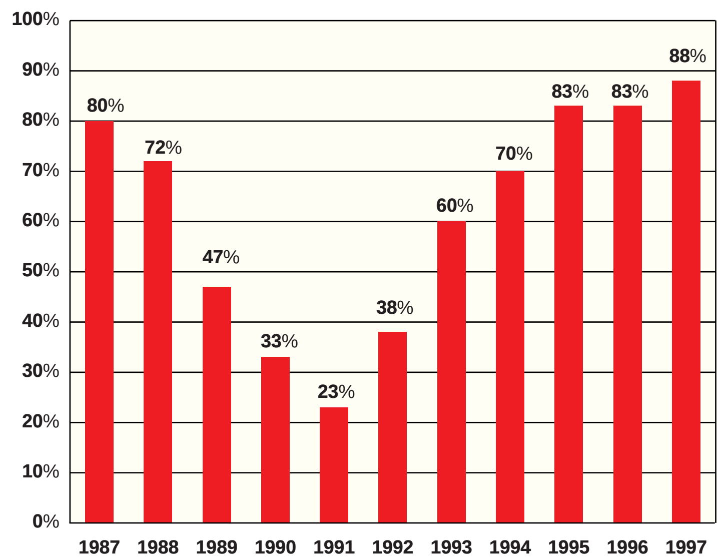
HOW DOES MASSACHUSETTS PERFORM?

The attractiveness of Massachusetts to high-technology business has turned around dramatically over the past decade.

In 1991, only 23% of businesses responding to the Massachusetts High Technology Council Annual Survey rated the Massachusetts business climate "good" or "outstanding." As the economy contracted, the state's positive rating had fallen quickly from its initial 1987 level of 80%.

After bottoming out in 1991, the state's positive rating started increasing significantly. By 1997, 88% of businesses awarded the Massachusetts business climate the "good" or "outstanding" distinction.

8. Perceptions of Business Climate Improve Dramatically



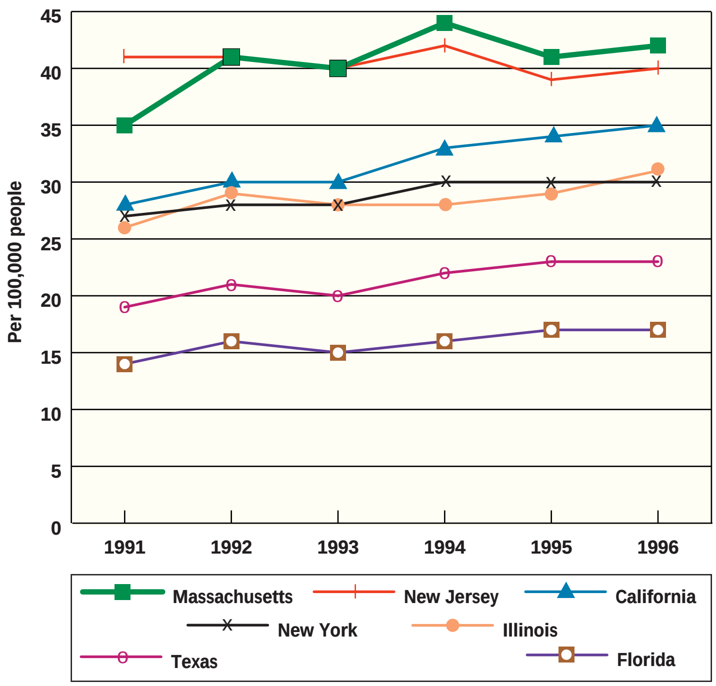
Percentage of high-tech CEOs rating the Massachusetts business climate as "good" or "outstanding," 1987-1997

Source: Massachusetts High-Technology Council

II. Innovation Process Indicators

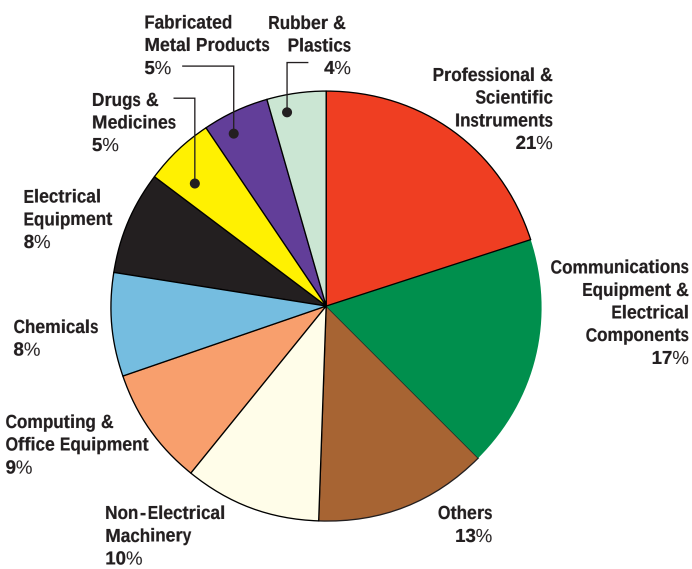
The innovation process is reflected in idea generation, technology commercialization, and entrepreneurship, as well as innovation in established businesses. This dynamic innovation process is an essential component of a competitive economy, because it translates ideas into high-value products and services.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

9. National Leader in Patents; Discoveries Are Diverse



Number of patents issued to state residents, per capita, Massachusetts and six LTS, 1991-1996

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



Distribution of patents issued, Massachusetts, 1992-1996

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

Source: CHI Research

WHY IS IT SIGNIFICANT?

Patents reflect the initial discovery and registry of innovative ideas. A key motivator to get patent protection is its potential relevance to a marketable product or process. Patents reflect important, high-impact discoveries that often lead to new innovations downstream.

HOW DOES MASSACHUSETTS PERFORM?

Massachusetts ranks first in patents per capita among the Leading Technology States (LTS). In 1995, innovators in Massachusetts were granted 42 patents per 100,000 residents. This figure compares with 39 in next-ranking New Jersey and 33 in California. The absolute number of patents in Massachusetts has increased from 2,105 in 1991 to 2,484 in 1995.

From 1992 to 1996, patents in Massachusetts were distributed across a wide range of sectors. The two most active industries were instruments (21%) and communications equipment/electronic components (17%). (See Appendix A for a definition of the diverse “other” category.)

Patents reflect important, high-impact discoveries that often lead to new innovations downstream.

WHY IS IT SIGNIFICANT?

Massachusetts universities, hospitals, and research institutions are important sources of innovative ideas. These institutions disclose inventions, some of which may merit a patent. Patenting then reflects the initial registry of an innovative idea or invention with commercial potential.

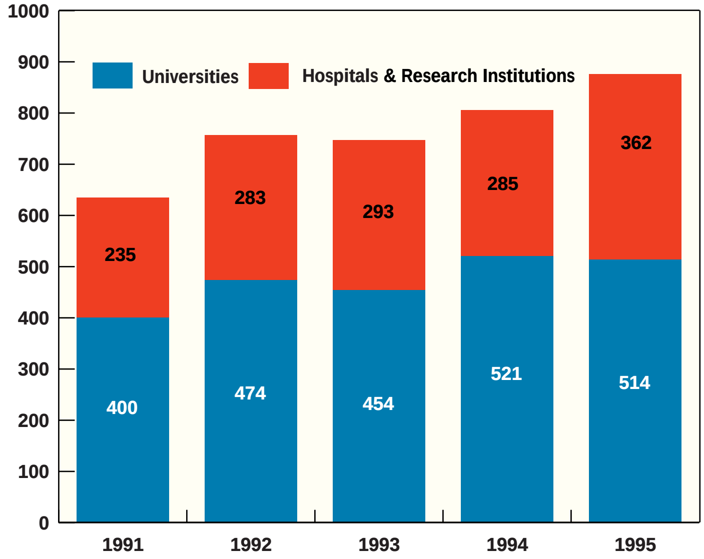
Research conducted by universities, hospitals, and research institutions has a twofold "spillover" effect in the state's economy. First, institutional research induces private research to capitalize on institutional innovations. Later, the new companies, goods, and services created downstream spur economic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

HOW DOES MASSACHUSETTS PERFORM?

The number of invention disclosures received annually by Massachusetts institutions increased 38% from 635 in 1991 to 876 in 1995. During this period, approximately 60% of invention disclosures were received by universities. Of the hospitals and research institutions, Massachusetts General Hospital (MGH) accounted for the most invention disclosures, and Children's Hospital experienced the greatest absolute increase. (See Appendix A for a list of universities, hospitals, and research institutions that participated in the survey.)

The number of new patent applications filed increased from 227 in 1991 to 316 in 1995. The major universities in Massachusetts have been responsible for this growth. Of the universities, MIT and Harvard account for 44% and 29% of patents, respectively, during this period. Of the hospitals and research institutions, MGH accounts for 34% of the total.

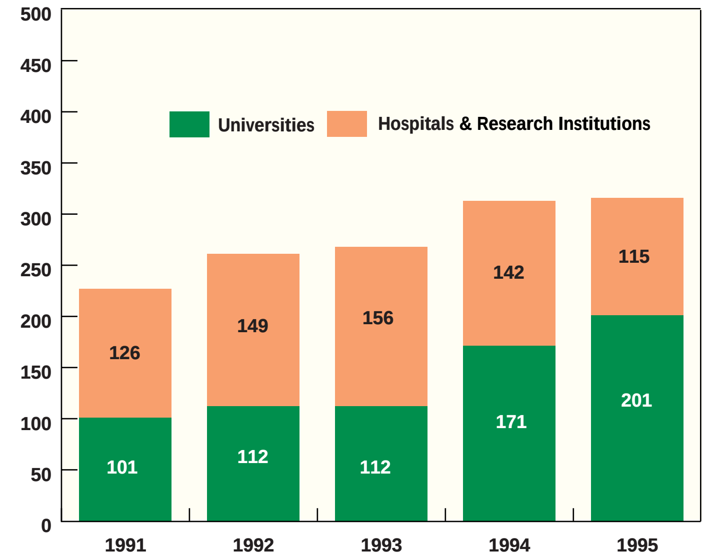
10. Inventions and Patent Applications by Institutions Are Increasing



Number of invention disclosures received by major universities, hospitals and research institutions, Massachusetts, 1991-1995

Source: Association of University Technology Managers

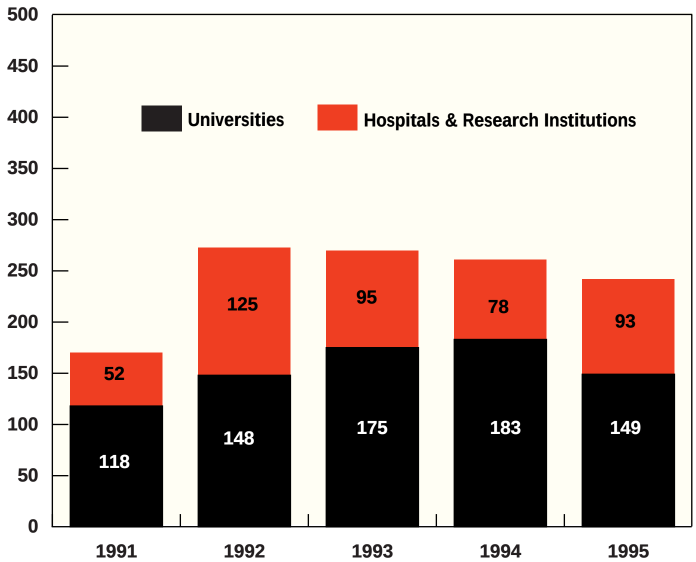
The number of new patent applications filed increased 39% from 1991 to 1995.



Number of new patent applications filed each year by major universities, hospitals and research institutions, Massachusetts, 1991-1995

Source: Association of University Technology Managers

11. License Royalties at Major Institutions More Than Double in Four Years



Number of technology licenses issued by major universities, hospitals and research institutions, Massachusetts, 1991-1995

Source: Association of University Technology Managers

WHY IS IT SIGNIFICANT?

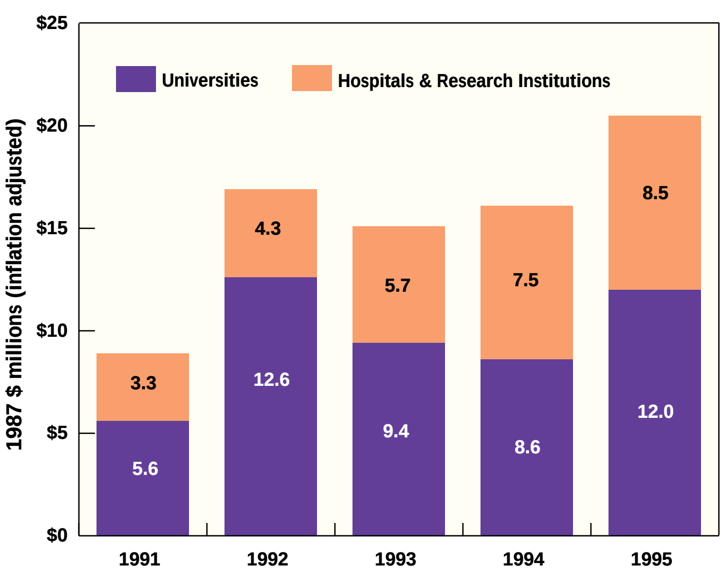
Once a university, hospital, or research institution has a patent, it can enter into a licensing agreement with a company and receive a negotiated fee. This agreement is a step toward commercializing the new idea as a marketable product. (There can be a significant time lag between receipt of a patent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

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

The number of new technology licenses at major universities, hospitals, and research institutions in Massachusetts ranged between 170 and 273 per year during the 1991-1995 period.

Although there has been a modest decline in the number of new technology licenses issued annually since 1992, gross royalties received annually from licensing increased, in inflation-adjusted dollars, from $8.9 million in FY 1991 to $20.5 million in FY 1995. In 1995, the top royalty-receiving institutions in order were Harvard University, Brigham and Women's Hospital, Massachusetts Institute of Technology, Boston University, and the Dana-Farber Cancer Institute. (See Appendix A for a list of institutions surveyed.)



Value of technology licenses outstanding, Massachusetts, 1991-1995

Source: Association of University Technology Managers

Licensing agreements are a step toward commercializing new ideas as marketable products.

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. The most complex, high-risk, and the newest technologies tend to be classified as IDEs or PMAs. Approval rates reflect innovation in medical device manufacturing and important linkages to the teaching hospitals, where many of these instruments undergo clinical investigation.

HOW DOES MASSACHUSETTS PERFORM?

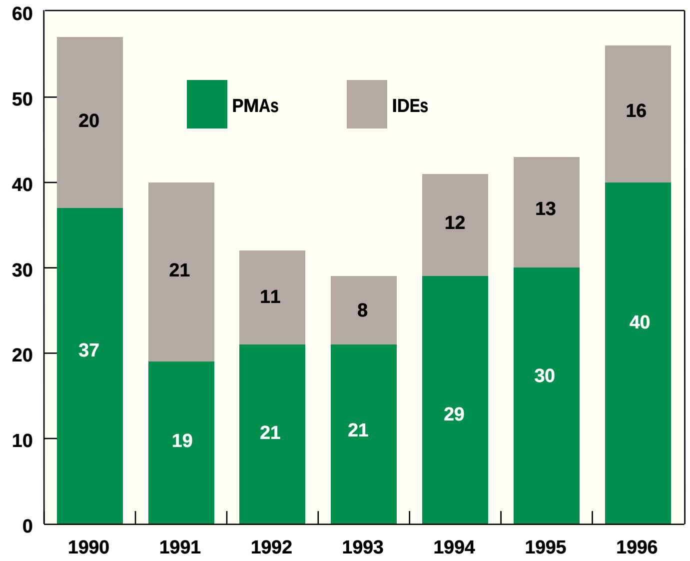
Massachusetts has consistently ranked among the top states in the nation for approval of IDEs. After a decrease in the early 1990s, IDE approvals increased from 8 in 1993 to 16 in 1996.

The number of PMAs in Massachusetts reflects the concentration of high-value-added medical device manufacturing. Since 1991, the number of PMAs has more than doubled from 19 to 40, surpassing the 1990 high of 37.

The Massachusetts medical device industry received 413 approvals for 510(k)s in 1996—9% of all such approvals in the nation.

According to MassMEDIC, the association of medical device manufacturers in the state, more than 200 medical device companies are based in Massachusetts. These firms account for 5% of the state's total manufacturing base and employ more than 18,000 people.

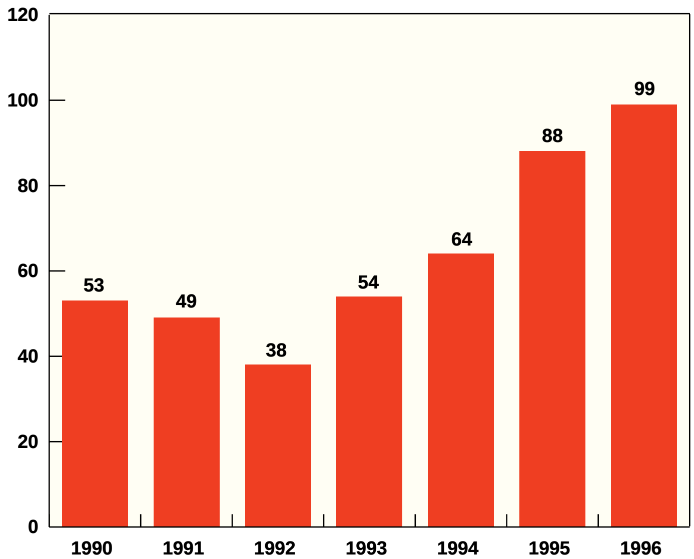
12. FDA Approval of Advanced Medical Devices Is Strong



Number of FDA application approvals for advanced medical devices, Massachusetts, 1989-1995 (fiscal years)

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

13. Number of Fast-Growth "Gazelle" Companies Nears 100



Number of publicly traded "gazelle" companies, Massachusetts, 1990-1996

Source: Compustat, Collaborative Economics

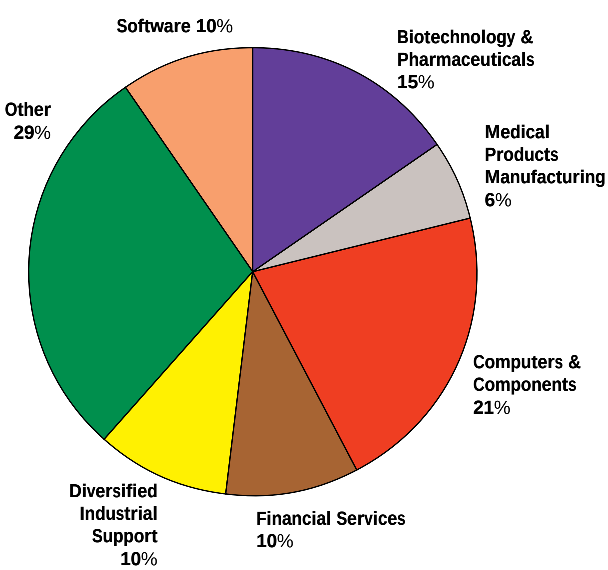
WHY IS IT SIGNIFICANT?

As the United States transitions toward a knowledge-based economy, a new generation of growth-oriented companies is emerging. One benchmark of such growth is the number and distribution of "gazelles," i.e., publicly traded companies 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 growth of other businesses and personal spending. (David Birch of Cognetics, Inc., in Cambridge, coined the term *gazelle*.)

HOW DOES MASSACHUSETTS PERFORM?

The number of gazelles in Massachusetts increased substantially from 38 in 1992 to 99 in 1996. In 1996, 25% of the state's publicly traded companies were gazelles. This figure compares favorably with 3% nationally and 20% in Silicon Valley. (Silicon Valley had 73 gazelles in 1996.)

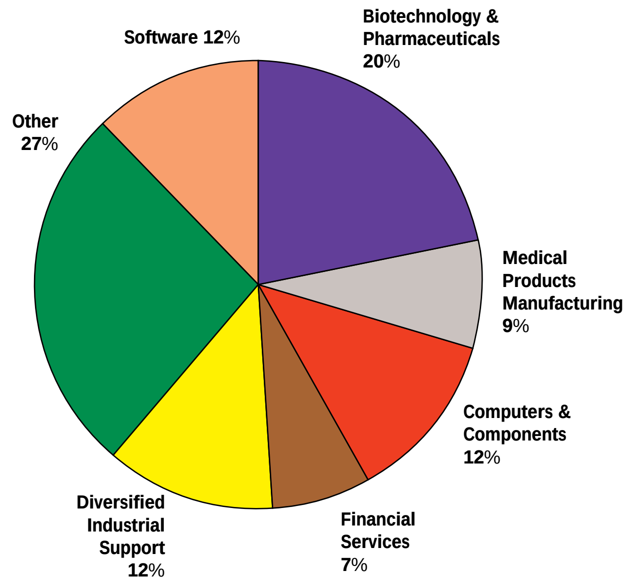
The sector spawning the largest share of gazelles in Massachusetts in 1996 was biotechnology and pharmaceuticals at 20% of the total. Twenty-seven percent of gazelles fall into the "other" category, which spans retail, restaurants, waste management, healthcare, and other diverse services and products.



Distribution of publicly traded "gazelle" companies, Massachusetts, 1990

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

Source: Compustat, Collaborative Economics



Distribution of publicly traded "gazelle" companies, Massachusetts, 1996

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

Source: Compustat, Collaborative Economics

WHY IS IT SIGNIFICANT?

The Small Business Innovation Research (SBIR) Program provides competitive grants to entrepreneurs seeking to do proof-of-concept and commercialization work ("Phase I" and "Phase II," respectively). In 1997, SBIR will grant $1 billion nationwide, compared with $4 billion invested by the venture capital industry.

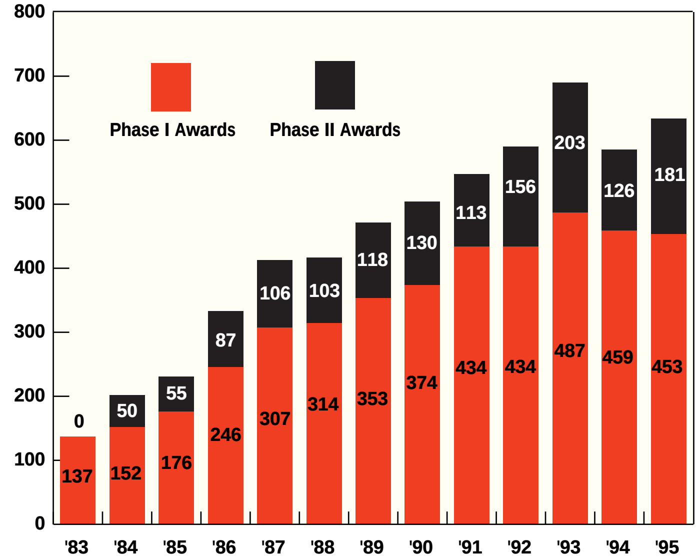
Success in this program is an indicator of entrepreneurship and of state support for entrepreneurs. A study by a Harvard Business School professor found that, from 1985 to 1995, sales at companies that received Phase II awards grew 123%, versus 48% at comparable companies that did not receive Phase II awards (see Josh Lerner, HBS Working Paper #96-038).

HOW DOES MASSACHUSETTS PERFORM?

Between 1983 and 1995, the number of SBIR awards received by Massachusetts companies escalated from 137 to 634. Since the inception of the program, in 1983, Massachusetts has consistently ranked second in the number of SBIR awards received behind California, which had a total of 940 awards in 1995. Generally, more than one-third of the companies that receive Phase I awards subsequently receive Phase II awards.

The total dollar value of SBIR awards to Massachusetts companies reached an all-time peak in 1995, at $142 million. Phase II awards are significantly larger in dollar value than Phase I awards.

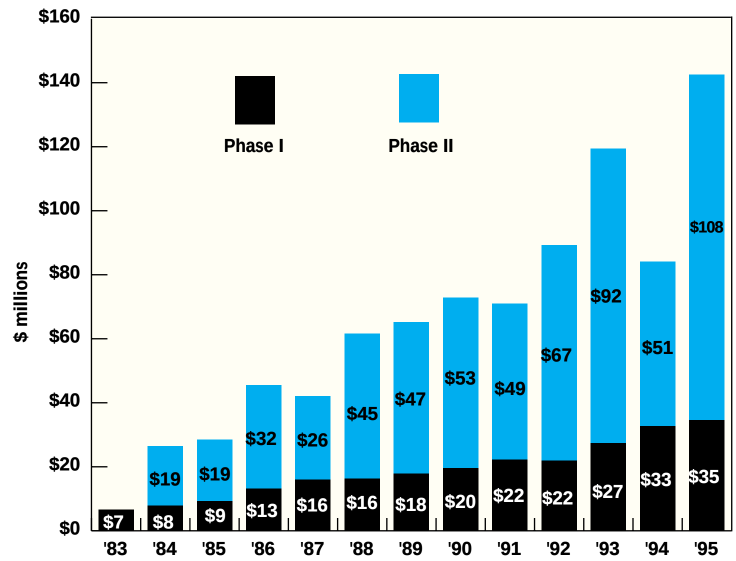
14. Small Business Innovation Research Awards Are Growing



Number of SBIR awards to companies by technology development phase, Massachusetts, 1983-1995

Source: Small Business Administration

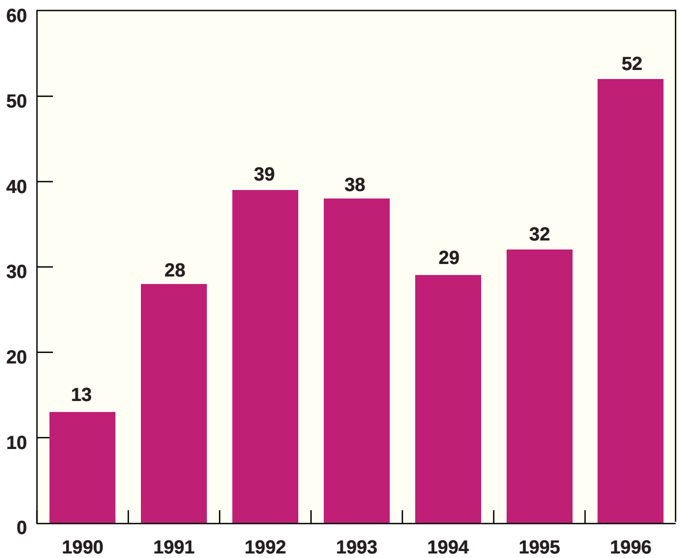
Success in the Small Business Innovation Research Program is an indicator of entrepreneurship and of state support for entrepreneurs.



Dollar value of SBIR awards received by companies, Massachusetts, 1983-1995

Source: Small Business Administration

15. Initial Public Offerings Rebound in 1996



Number of Initial Public Offerings (IPOs), Massachusetts, 1990-1996

Source: Hale and Dorr, LLP

WHY IS IT SIGNIFICANT?

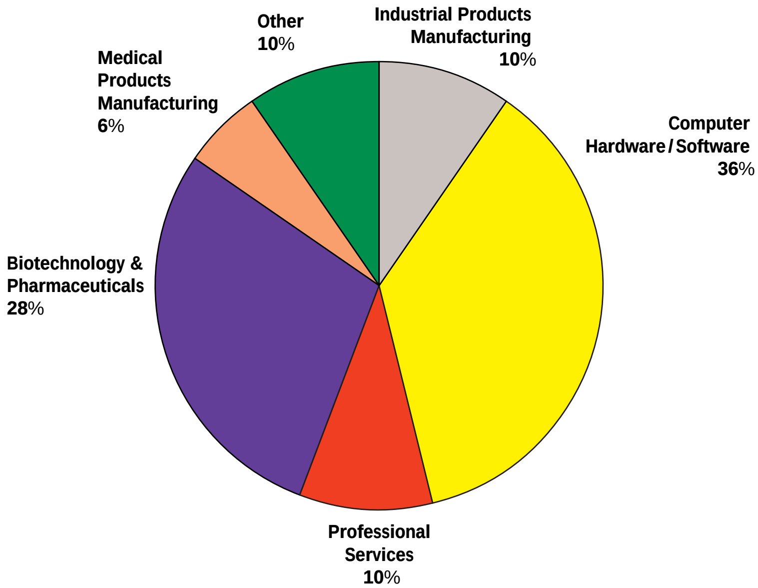
The number of initial public offerings (IPOs) is an indicator of future high-growth companies. "Going public" raises significant revenue to invest and stimulate growth in a company to its next level. A successful IPO reflects confidence by investors that the company can generate increases in value and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

HOW DOES MASSACHUSETTS PERFORM?

The number of Massachusetts IPOs increased sharply from 32 in 1995 to 52 in 1996.

Nineteen IPOs were in the computer hardware and software sectors. Another 15 were in biotechnology and pharmaceuticals.

In the first half of 1997, Massachusetts launched 12 IPOs, 46% of its total for the first half of 1996. During the 1997 period, IPOs across the nation lagged behind their 1996 rate, and Massachusetts trailed further behind the nation, respectively. There were 271 IPOs across the nation in the first half of 1997; this represents 63% of the national total for the first half of 1996.



A successful Initial Public Offering reflects confidence by investors that the company can generate increases in value and sustained growth.

Distribution of IPOs, Massachusetts, 1996

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

Source: Hale and Dorr, LLP

WHY IS IT SIGNIFICANT?

High and increasing value added in companies is a prerequisite for high and increasing income for workers. Value added is derived by subtracting the costs of a company's materials, inputs, and contracted services from the final value of the products it produces. Value added indicates how much economic value is created by the company. Increased innovation—more efficient processes that lead to the development of higher-value goods or cut production costs—is an important factor driving increases in value added.

HOW DOES MASSACHUSETTS PERFORM?

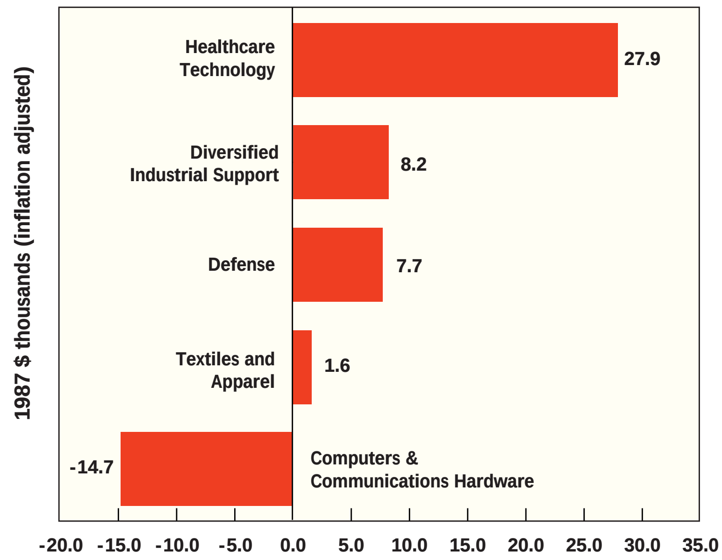
Between 1987 and 1992, manufacturing value added per employee increased for four key manufacturing clusters: health technology, diversified industrial support, defense, and textiles. Value added in health care increased by $27,900 per employee. Value added in the computer hardware cluster, by contrast, declined by $14,700.

When compared with the nation, however, most Massachusetts manufacturing industry clusters fall below their respective industry's average value added. Only the textiles and apparel cluster in Massachusetts operates with value added per employee above the national average for the cluster.

Note: This dataset does not reflect services productivity; services employment and earnings are growing in Massachusetts and nationally.

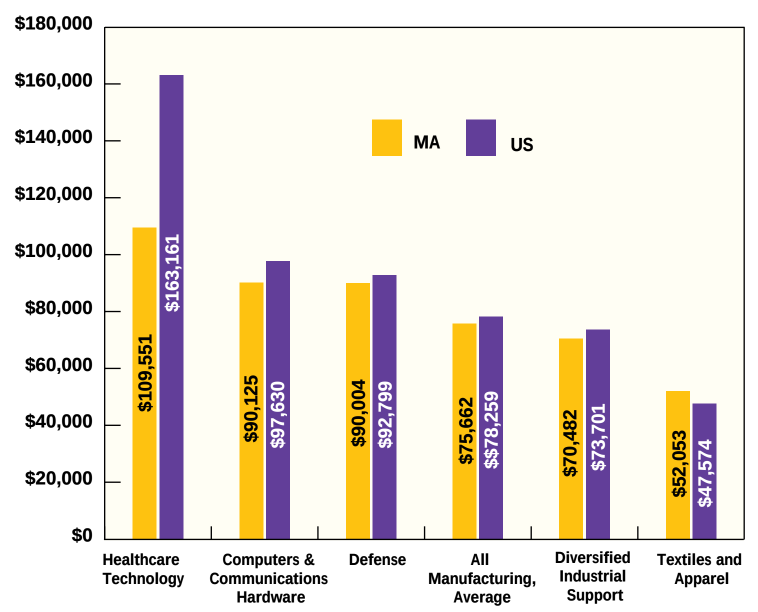
Increased innovation—more efficient processes that lead to the development of higher-value goods or cut production costs—is an important factor driving increases in value added.

16. Several State Industry Clusters in Manufacturing Improve Value Added, but Many Trail U.S. Averages



Change in annual value added per employee, selected manufacturing industry clusters, Massachusetts, 1987-1992

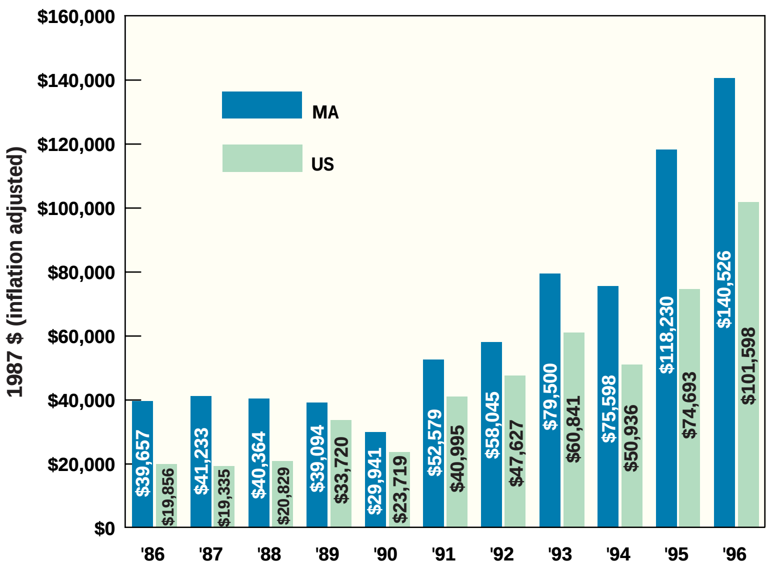
Source: U.S. Department of Commerce, Economic Census of Manufactures



Value added per employee, selected manufacturing industry clusters, Massachusetts and U.S., 1992

Source: U.S. Department of Commerce, Economic Census of Manufactures

17. Value of Intangible Assets Accelerates in the 1990s



Market value minus book value of publicly traded companies, per employee, Massachusetts and U.S., 1986-1996

Source: Compustat, Collaborative Economics

WHY IS IT SIGNIFICANT?

Innovation is central to creating value out of knowledge and physical assets. The difference between market capitalization of a company (perceived value) and its book value (fixed assets) can be considered a basic measure of the company's development of intangible assets—including its acquisition and use of knowledge assets. Although market value can be influenced by a number of factors, tracking this net measure of intangible assets over time can serve as a rough proxy for a company's intellectual capital. (See, for example, Thomas Stewart, *Intellectual Capital: The New Wealth of Organizations*, 1997.)

HOW DOES MASSACHUSETTS PERFORM?

After several years of stability, the market value minus book value per employee of publicly traded companies escalated 370%, in inflation-adjusted terms, in the 1990s. In 1996, the value of intangible assets per employee was 38% higher in Massachusetts than in the nation.

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.

WHY IS IT SIGNIFICANT?

Labor force expansion can help to sustain the economic growth of a region as employers have a larger pool of workers from which to hire. Alternatively, labor shortfalls, particularly in areas of high demand, can constrain economic growth as employers experience staffing shortages, higher wages, or both. The size of the Massachusetts labor force in 1997, 3.20 million, has just topped its 1988 high of 3.13 million people.

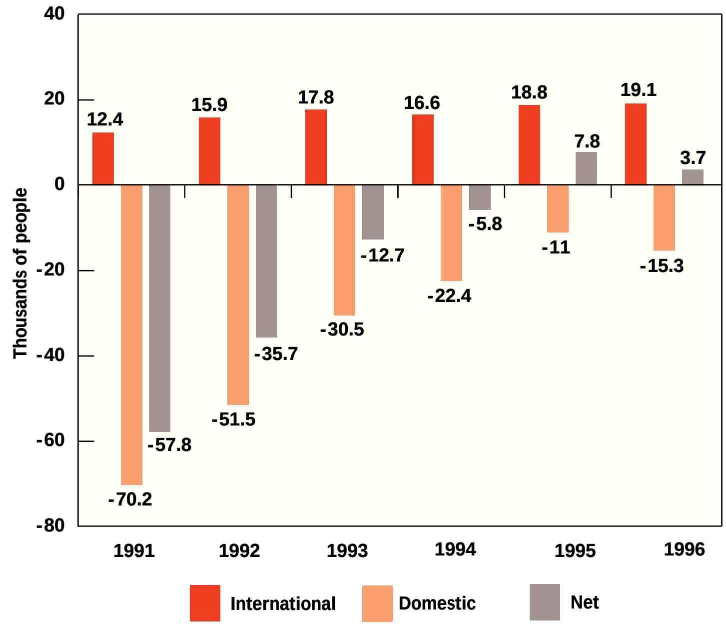
HOW DOES MASSACHUSETTS PERFORM?

This indicator shows the important role that immigration plays in the growth of the Massachusetts population. Every year between 1991 and 1996, Massachusetts experienced domestic out-migration. In 1996, 15,300 more people moved from Massachusetts to other states than from other states to Massachusetts. According to Cognetics, Inc., Massachusetts ranked forty-third of 50 states in net domestic population migration (1980-1994).

International immigration explains why overall net migration turned positive in 1995 (7,800) and remained positive in 1996 (3,700). Without international immigration, the Massachusetts population would have declined by 200,900 between 1991 and 1996, instead of by 100,300.

An often neglected aspect of international immigration is that it supplements the skilled workforce needed in the Massachusetts Innovation Economy. According to the 1990 U.S. Census, 28% of the immigrant workforce in the state had a bachelor's degree or higher, compared with 25% of native Massachusetts workers.

18. Immigration Drives Population Growth



International and domestic migration, Massachusetts, 1991-1996

Source: Mass Insight, Regional Financial Associates, Census Bureau

WHY IS IT SIGNIFICANT?

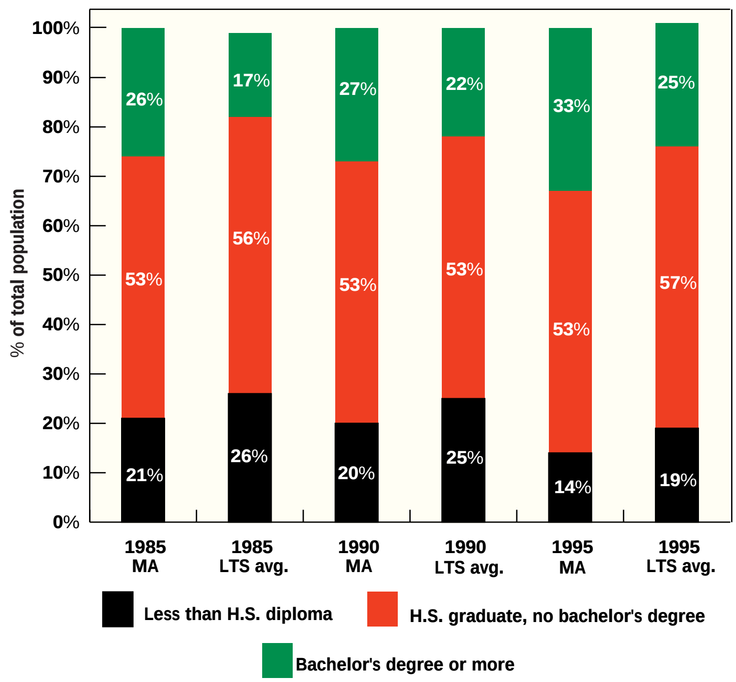
Education and skills of the workforce are keys to competitive advantage in the global economy. The educational attainment of the workforce is an important indicator of the quality of the labor force in Massachusetts relative to other states.

HOW DOES MASSACHUSETTS PERFORM?

Across the board, the Massachusetts population has attained a higher level of education than the six other Leading Technology States (LTS). Since 1985, Massachusetts consistently has had a significantly greater percentage of population with at least a bachelor's degree. In 1995, one-third of Massachusetts residents had at least a bachelor's degree, compared with 25% of people in the six LTS.

In 1995 only 14% of state residents had less than a high school diploma, down from 21% in 1985 and compared with 19% in the other LTS.

19. Advanced Education Level of the Workforce Is an Advantage

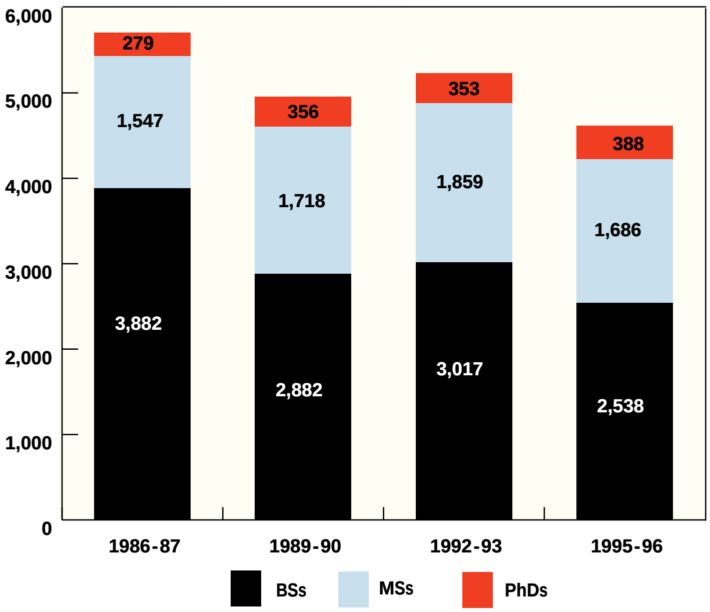


Educational levels of Massachusetts and other LTS populations, 1985, 1990, 1995

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

Source: Bureau of the Census, Current Population Survey, B64

20. Engineering Degrees Awarded Lag National Trends



Number of engineering degrees awarded, by degree level, Massachusetts, 1987, 1990, 1993, 1996

Source: American Association of Engineering Societies

WHY IS IT SIGNIFICANT?

Regions that are well-served by postsecondary engineering programs have a strong workforce advantage in the creation and testing of new products and ideas. This indicator shows a potential pool of new engineers for technology-related industries in Massachusetts.

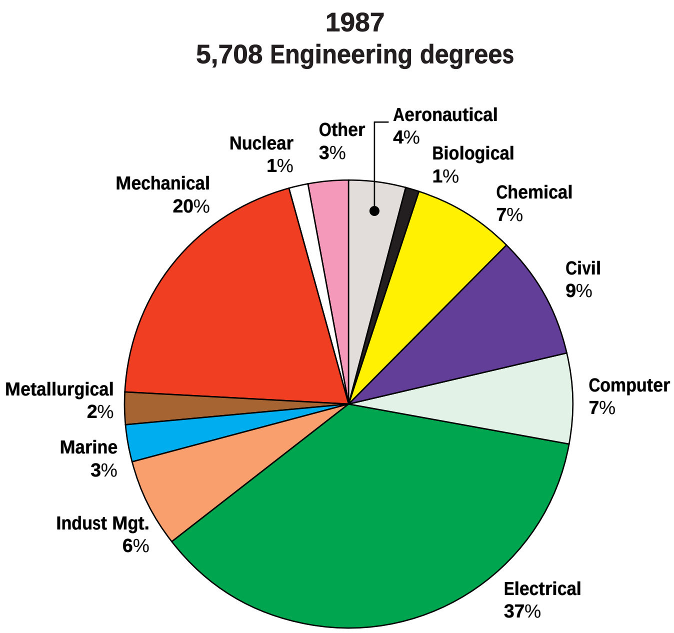
HOW DOES MASSACHUSETTS PERFORM?

The awarding of engineering degrees in Massachusetts has lagged national trends in recent years. At the undergraduate level, the number of degrees awarded by Massachusetts schools decreased 35% from 1987 to 1996 (from 3,882 to 2,538). Nationally, undergraduate engineering degrees decreased only 14% during the same period.

At the graduate level, the number of degrees in engineering awarded from 1987 to 1996 by Massachusetts institutions rose 14% (from 1,826 to 2,074). However, this increase was less than half the national growth rate (33%) at the graduate level.

The most significant shifts in the composition of degrees by engineering field have been the decrease in electrical engineering and the increases in chemical and civil engineering.

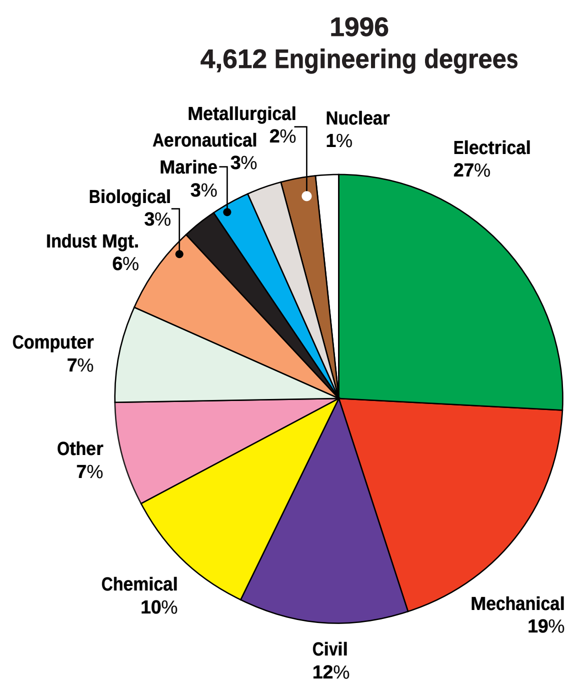
How many engineering graduates stay in Massachusetts? An MTC survey of eight Massachusetts institutions showed that of those students receiving an engineering degree between 1990 and 1996, about 42% were still located in the state in 1997.



Distribution of engineering degrees awarded by field, Massachusetts, 1987

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

Source: American Association of Engineering Societies



Distribution of engineering degrees awarded by field, Massachusetts, 1996

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

Source: American Association of Engineering Societies

WHY IS IT SIGNIFICANT?

People with doctorates represent the most highly educated segment of the workforce available for research, education, and innovation industries. These people are especially important for idea generation and fundamental breakthroughs.

HOW DOES MASSACHUSETTS PERFORM?

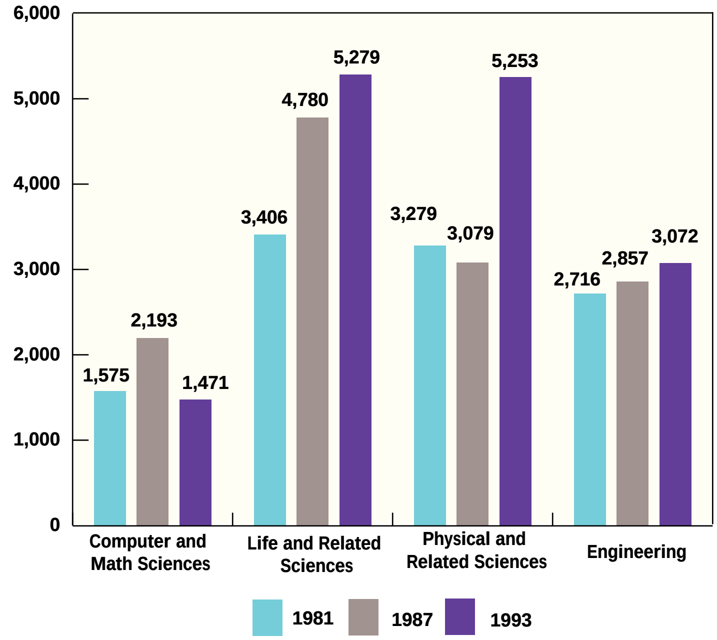
In 1993, more than 15,000 Massachusetts workers had PhDs in the hard sciences. One-third of these degrees are in life sciences; another third are in physical sciences; the remainder are in computer and math sciences and in engineering.

One-third of the people who received a doctoral degree from a Massachusetts educational institution in the last 10 years are working in the state.

The next most popular state for Massachusetts PhDs is California, followed by New York.

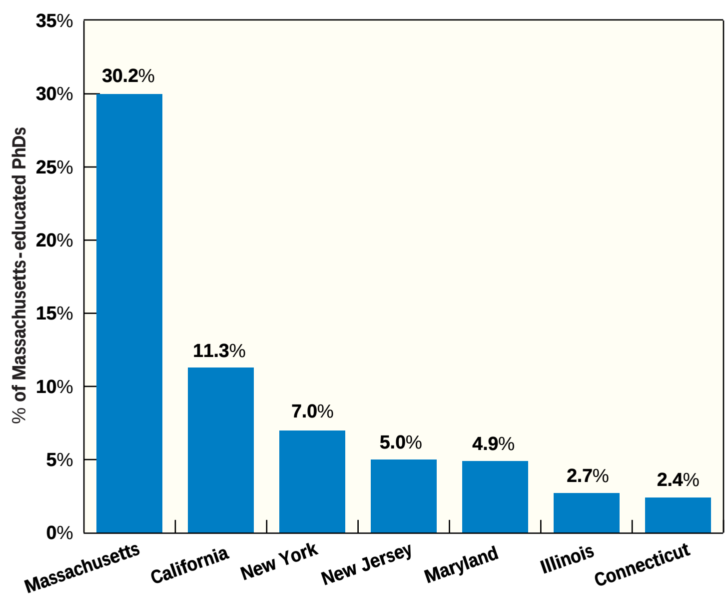
One-third of the people who received a doctoral degree from a Massachusetts university in the last 10 years are working in the state.

21. One-Third of Science and Engineering Doctorates Stay Working in the State



Number of Massachusetts-awarded science-related doctorates working in the state by field, 1981, 1987, 1993

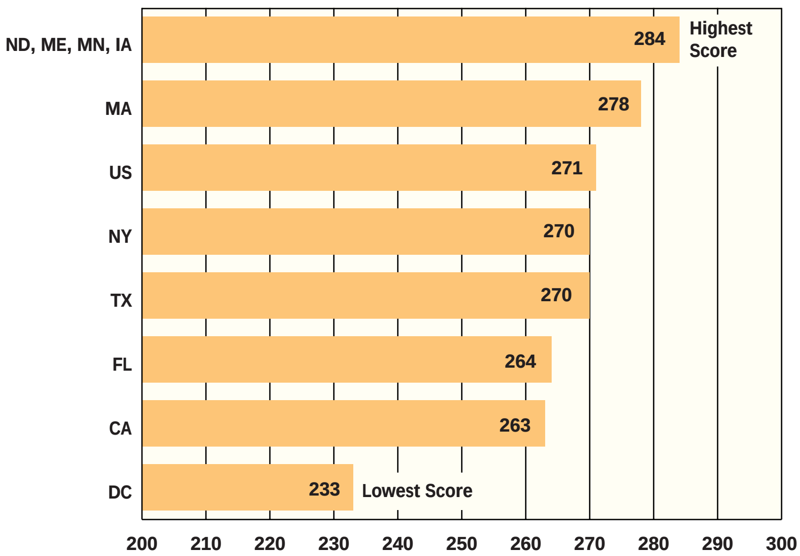
Source: National Science Foundation



Percentage of individuals who received a doctoral degree from a Massachusetts university in the last 10 years, by location of employment, 1995

Source: National Research Council

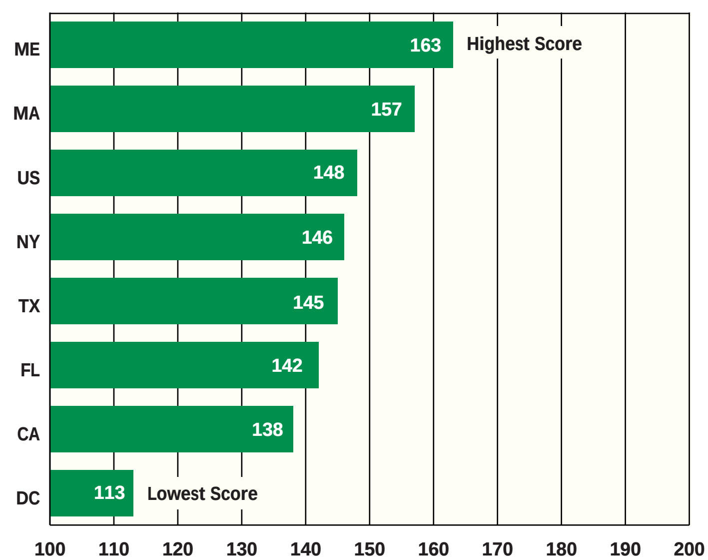
22. Eighth Graders Excel in Math and Science



NAEP mean math scores, grade eight public schools, Massachusetts and other participating LTS, 1996

Note: Scores ranged from 0 to 500. LTS of Illinois and New Jersey did not participate in 1996 NAEP. ND, ME, MN, IA and DC are not LTS.

Source: National Assessment of Educational Progress



NAEP mean science scores, grade eight public schools, Massachusetts and other participating LTS, 1996

Note: Scores ranged from 0 to 300. LTS of Illinois and New Jersey did not participate in 1996 NAEP. ME and DC are not LTS.

Source: National Assessment of Educational Progress

WHY IS IT SIGNIFICANT?

The future vitality of the Massachusetts Innovation Economy depends on the skills and knowledge of the state's next-generation workforce. The academic performance of K-12 students is an indicator of the quality of that future workforce. Strong skills in math and science are the foundation for the acquisition of advanced education, experience, and lifelong learning.

HOW DOES MASSACHUSETTS PERFORM?

Massachusetts public-school eighth graders score well in math and science, relative to the U.S. average and to their Leading Technology State (LTS) counterparts that participate in the National Assessment of Educational Progress (NAEP). In 1996, Massachusetts eighth graders scored an average of 278 in math, with eighth graders in all other LTS scoring below the U.S. average of 271. A similar pattern prevailed in science, with Massachusetts students scoring 157—above the U.S. average of 148 and well above other LTS.

The academic performance of K-12 students is an indicator of the quality of the Massachusetts Innovation Economy's future workforce.

WHY IS IT SIGNIFICANT?

Most quality jobs require a high-school degree, at a minimum. The high school drop-out rate is a risk indicator that warns of lost potential and future societal costs. The need to fully develop our human resources is especially critical in a Massachusetts environment of slow labor-force growth.

HOW DOES MASSACHUSETTS PERFORM?

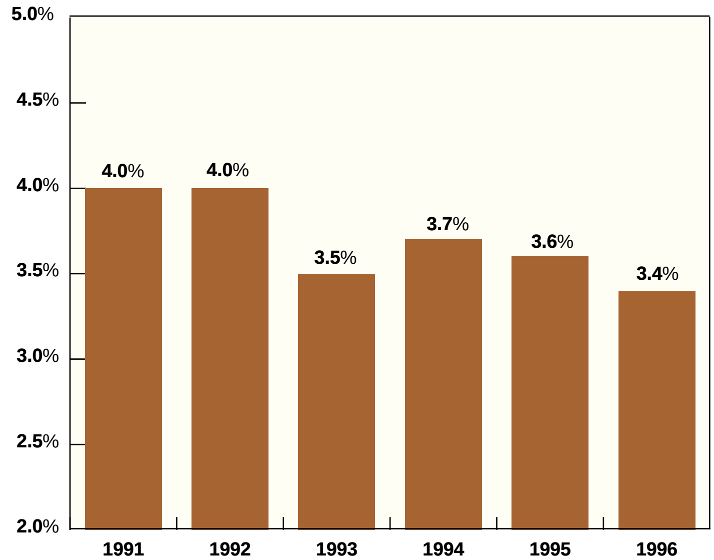
The 1996 annual drop-out rate was 3.4%—the lowest rate this decade. (This means that 3.4% of the ninth to twelfth graders enrolled in the state's public schools in the fall of 1995 did not return in 1996 for reasons other than transfer.) Based on the 3.4% annual rate, it is projected that, over the course of a four-year high school degree program, about 14% of the Class of 1999 may not graduate.

Wide disparity exists by school and ethnicity. Ten schools in the state report a 0% drop-out rate in 1996, whereas 12 schools in central Boston report annual drop-out rates of 10% to 39%.

In 1993 (the most current year that state-to-state comparisons are available), the Massachusetts annual drop-out rate of 3.5% compared favorably with 5.1% for California and 4.3% for Texas.

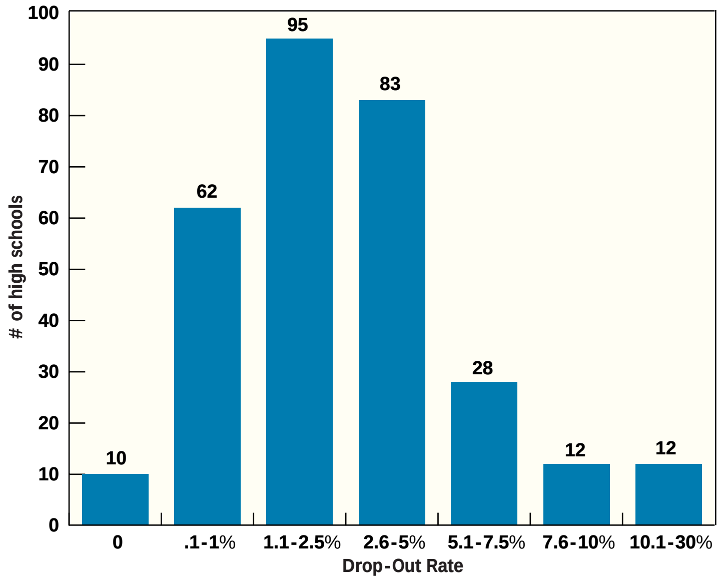
The drop-out rate is a risk indicator that warns of lost potential and future societal costs.

23. Drop-Out Rates Continue to Decline, but Vary Widely



Percentage of high school students who drop out each year, Massachusetts, 1991-1996

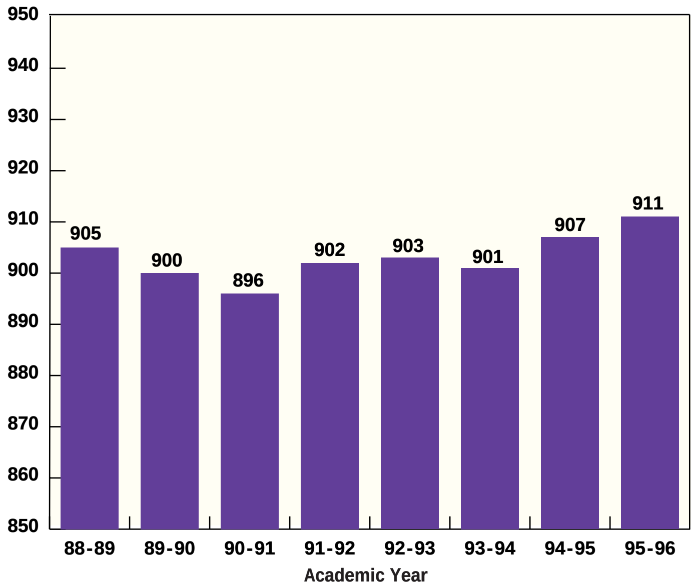
Source: Massachusetts Department of Education



Distribution of high schools by annual drop-out rate, Massachusetts, 1996

Source: Massachusetts Department of Education

24. SAT Scores Are at a High; Strongest Participation Rate in Country



Combined math and verbal scores of students taking the SAT, Massachusetts, 1988/89 - 1995/96

Source: The College Board, Massachusetts Department of Education

WHY IS IT SIGNIFICANT?

Postsecondary education is a basic requirement for a growing share of jobs in innovation-based companies. Most colleges and universities require the Scholastic Aptitude Test (SAT) as part of the admission requirement. SAT scores and the share of students taking the SAT reflect the readiness of the future workforce for the Innovation Economy.

HOW DOES MASSACHUSETTS PERFORM?

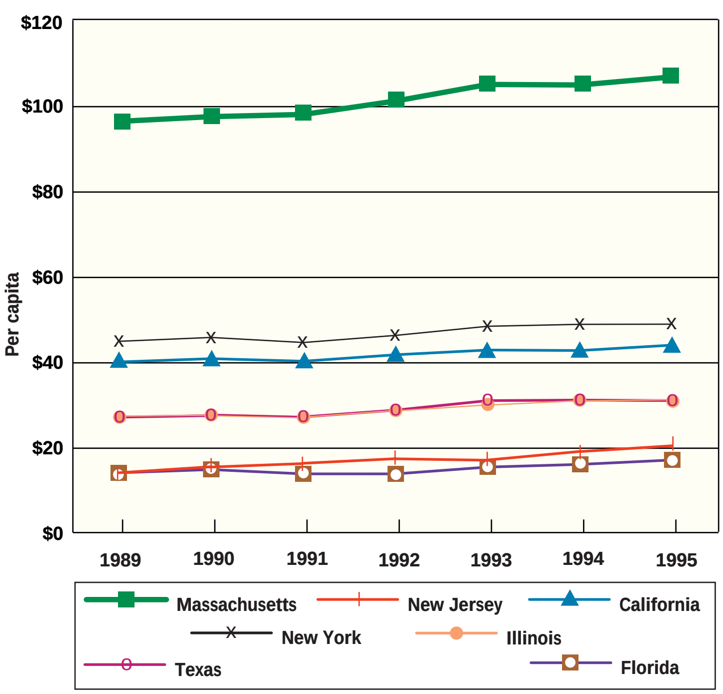
Math and verbal SAT scores by Massachusetts test takers (public, private, and parochial) have been increasing since 1990. The 1996 math score is at a 10-year high, and the verbal score is at a seven-year high.

The SAT is a measure of student aptitude, but its participation rate also reflects the expectations held by parents, students, and teachers. At 80% in 1996, the participation rate in Massachusetts is the highest in the country. The rate has risen steadily from 64% in 1986. The Massachusetts participation rate is nearly double the national average of 41%, and above that of its East Coast neighbors (New York at 73%, New Hampshire at 70%, Vermont at 70%, and Rhode Island at 69%). (Note: Midwestern states tend to favor the American College Testing Program [ACT] over the SAT.)

The fact that so many Massachusetts students choose to take the SAT or are being encouraged by their parents and teachers to do so indicates that expectations are generally high for Massachusetts high school graduates.

RESOURCE INDICATORS Technology Resources

25. Per Capita Federal R&D Spending at Academic Institutions Remains Relatively Constant



Federal R&D expenditures in academic institutions, per capita, Massachusetts and six LTS, 1989-1995 (inflation-adjusted 1987 dollars)

Source: National Science Foundation

WHY IS IT SIGNIFICANT?

Research universities and academic health centers play a distinctive role in the Massachusetts economy, and federal R&D spending is a key source of funding. R&D conducted by academic institutions also has a pronounced inducement effect in stimulating private sector R&D.

HOW DOES MASSACHUSETTS PERFORM?

Per capita federally funded R&D expenditures at Massachusetts academic institutions have remained relatively constant from 1989 through 1995, when adjusted for inflation. Consistently, federal R&D expenditures to academic institutions in Massachusetts have been more than double those of the six Leading Technology States (LTS).

However, Massachusetts has trailed other LTS in growth of federally funded academic R&D. Annual average funding in the six LTS has increased 2.5% since 1989, compared with 1.6% in Massachusetts.

Massachusetts academic institutions are more dependent on federally funded R&D than those in any other state. Federally funded R&D constitutes 72% of academic research in Massachusetts.

WHY IS IT SIGNIFICANT?

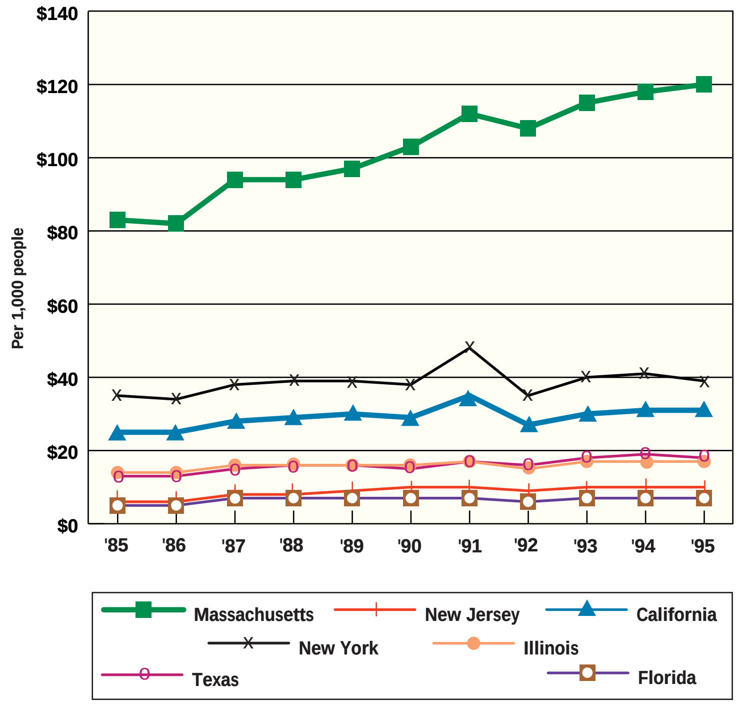
The National Institutes of Health (NIH) is the major funder of health-related research in the United States. It is the largest source of federal funding for civilian research. NIH-funded research is a critical driver for Massachusetts biotechnology, medical device, and health services industries.

HOW DOES MASSACHUSETTS PERFORM?

Over the past decade, NIH funding for Massachusetts has consistently increased in inflation-adjusted terms and relative to the other Leading Technology States (LTS). Since 1985, NIH funding for Massachusetts has increased 104% compared with 89% for the six LTS.

Historically, approximately 58% of all NIH R&D funding awarded to teaching hospitals across the nation has been awarded to Massachusetts institutions.

26. Per Capita Health R&D Funding Increases in Absolute and Relative Terms



U.S. Department of Health and Human Services R&D expenditures, per capita, Massachusetts and six LTS, 1985-1995 (inflation-adjusted 1987 dollars)

Source: National Science Foundation

WHY IS IT SIGNIFICANT?

Corporate research and development (R&D) spending is an important indicator of how companies are investing in their future. R&D is essential for developing new products and services that help companies stay on the cutting edge, grow, and produce more jobs.

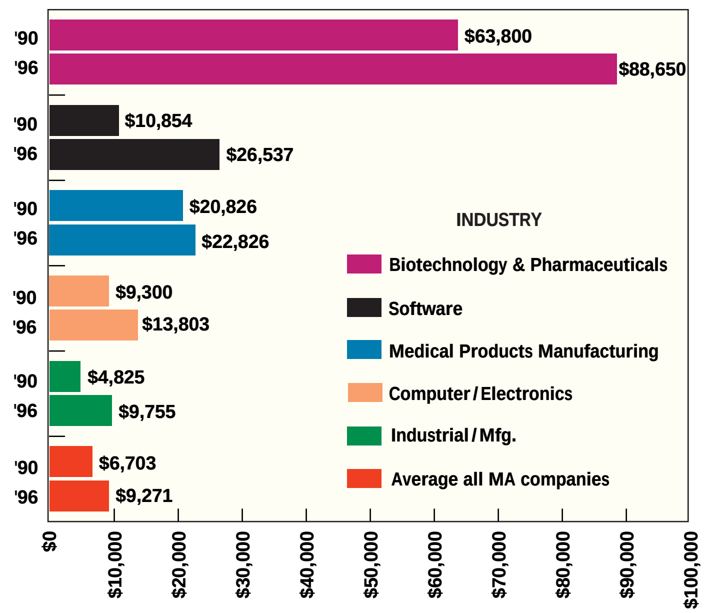
HOW DOES MASSACHUSETTS PERFORM?

The biotechnology and pharmaceuticals industry in Massachusetts has the highest R&D expenditure per employee, and it increased the most, in absolute terms, from 1990 to 1996.

The software industry saw its R&D expenditure per employee more than double between 1990 to 1996—from $10,854 to $26,537. In 1996, the more mature computer/electronics industry had lower R&D expenditure per employee at $13,803.

Overall, Massachusetts publicly traded companies invest 35% to 40% more in R&D per employee than the national average for such companies.

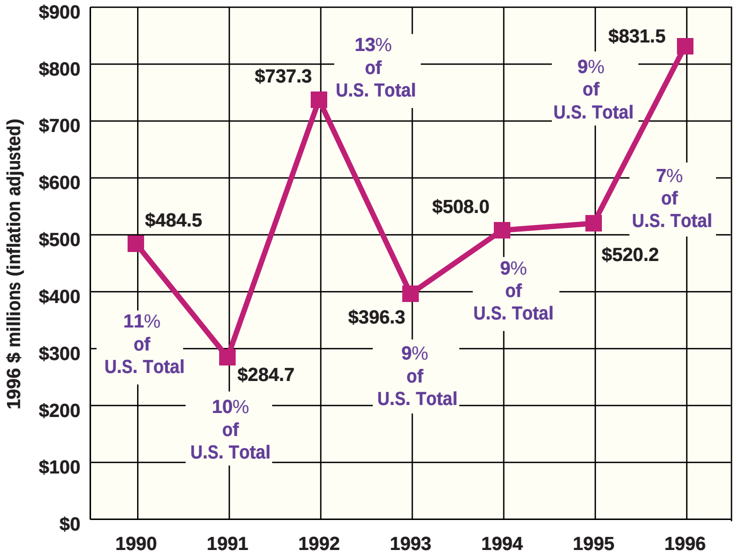
27. Corporate R&D per Employee Varies Widely by Sector



Corporate R&D expenditure per employee, publicly traded companies, Massachusetts, 1990, 1996

Source: Compustat, Collaborative Economics

28. Venture Capital Reaches All-Time High, but Overall Share of National Total Decreases from the Early 1990s



Venture capital investment received by companies and as a percent of total U.S. venture investments, Massachusetts, 1990-1996

Source: Venture Economics

WHY IS IT SIGNIFICANT?

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

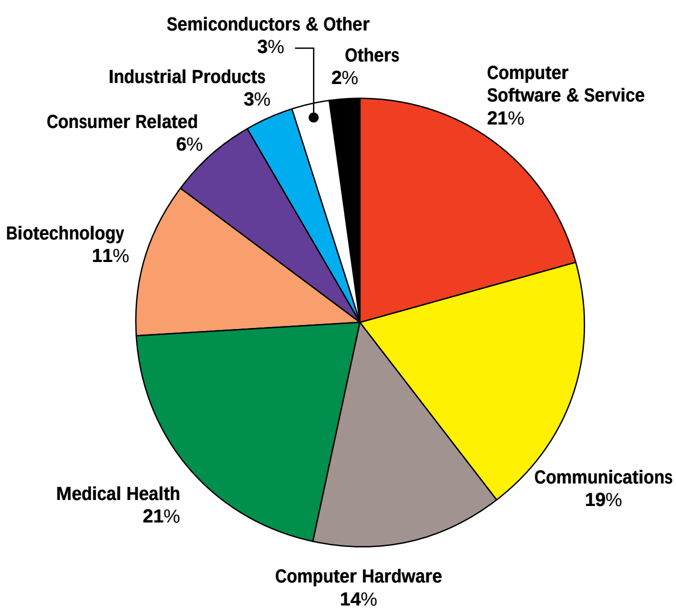
HOW DOES MASSACHUSETTS PERFORM?

The amount of venture capital received by Massachusetts companies reached an all-time high in 1996 at $831.5 million.

The sectors that received the most venture capital funding in 1996 were computer software and services (32%) and medical health (22%). Since 1990, venture capital investment in computer hardware declined from 14% to 4%; investment in communications declined from 19% to 10%. Since 1990, computer software and services enjoyed the most significant increase in share of venture capital funding, from 21% to 32%.

The $831.5 million invested in Massachusetts compares with $1.8 billion received by companies in Silicon Valley in 1996 (population 2.2 million).

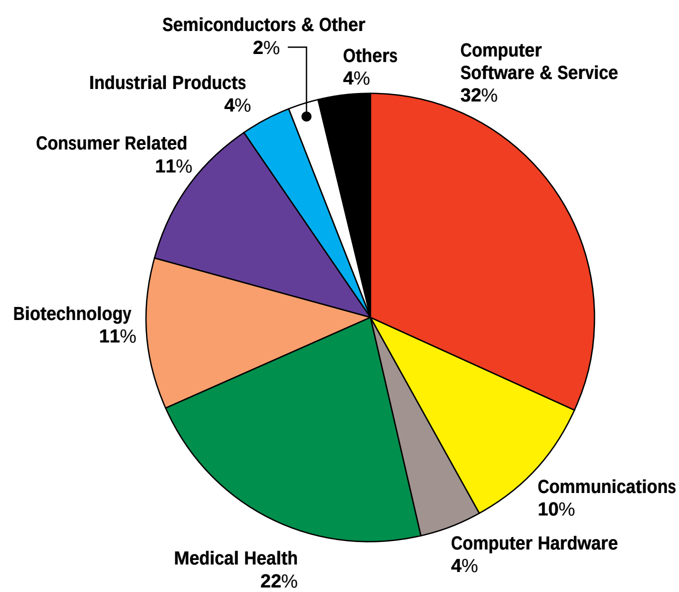
The Massachusetts share of national venture capital funding has remained at approximately 9% in recent years; this is below the proportion it garnered in the early 1990s.



Distribution of venture capital investments, Massachusetts, 1990

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

Source: Venture Economics



Distribution of venture capital investments, Massachusetts, 1996

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

Source: Venture Economics

WHY IS IT SIGNIFICANT?

The Massachusetts research tax credit is a state tool to encourage businesses to invest in research—research being an important underpinning of higher-value-added activities. The tax credit can be taken for qualified research expenses incurred by a company or for grants to in-state research institutions. In 1995, the Office of Technology Assessment (OTA) found that similar tax credits, at the federal level, result in at least one dollar in new R&D spending for each dollar lost in tax revenue (see *The Effectiveness of Research and Experimentation Tax Credits,* OTA, 1995).

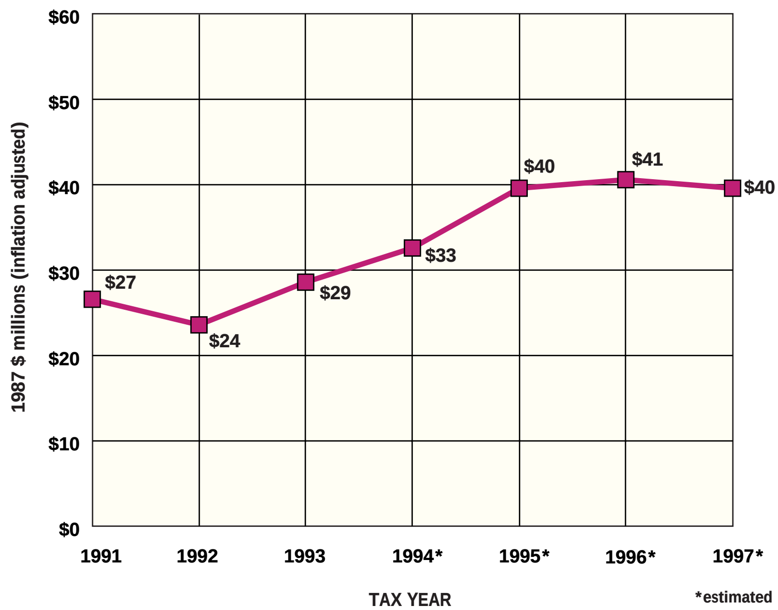
Thirty-five states have a research tax credit. In Massachusetts, the state credit is 10% on qualified company research expenditures and 15% on research payments made for basic university research.

HOW DOES MASSACHUSETTS PERFORM?

Use of the tax credit increased significantly through the first half of the 1990s. Since its inception in 1991 to its projected use in 1997, the dollar value of the credit to Massachusetts companies has increased 48% in real, inflation-adjusted, terms.

In 1993, the number of Massachusetts organizations that benefited from the credit was 733.

29. Use of Research Tax Credit Increases 48% since 1991



Dollar value of research credit awarded to companies, Massachusetts, 1991-1997

Source: Massachusetts Department of Revenue

WHY IS IT SIGNIFICANT?

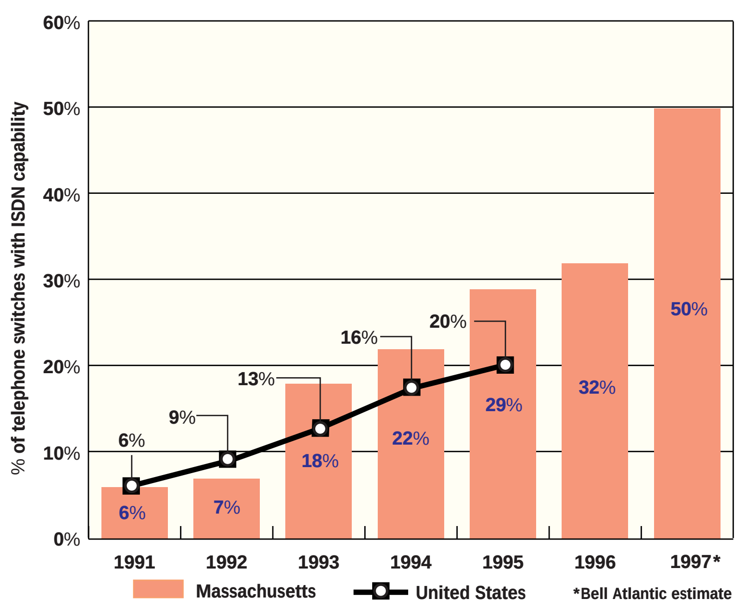
The Integrated Services Digital Network (ISDN) is a digital communications technology that is replacing analog Plain Old Telephone Service (POTS) in some business applications, as second lines for homes, and for data services. Digital communications have several advantages over analog. Voice, video, and data information can be compressed to make better use of network capacity, and data quality is preserved. ISDN is less expensive to deploy than many other new technologies, because it works on the twisted-pair copper lines that are already in place, connecting homes and offices to the central switching offices.

ISDN is popular in many homes, because it allows people to work at home by connecting their computers to their offices and the Internet. ISDN operates up to 4.4 times faster than the typical 28.8-kilobit analog modem. Higher-speed technologies, such as cable modems and the Advanced Digital Services Network (ADSL), are just entering the market. These technologies operate 300 times faster than today's modems at prices that should be affordable to many more small businesses and homes.

HOW DOES MASSACHUSETTS PERFORM?

Bell Atlantic, the primary telecommunications company in the state, is upgrading the Massachusetts infrastructure more rapidly than areas elsewhere in the nation are being similarly improved. At the end of 1995, 29% of central office switches had been upgraded to support ISDN, versus 20% across the United States. Bell Atlantic plans to equip 50% of Massachusetts switches with ISDN by the end of 1997. This high build-out rate gives Massachusetts a competitive advantage in both urban and rural areas.

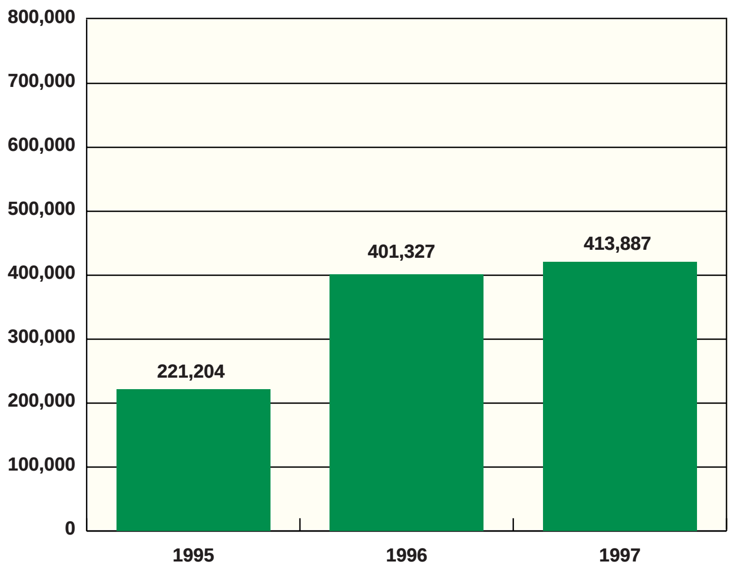
30. Availability of ISDN Increases Significantly



Portion of telephone switches with ISDN capability, Massachusetts and United States, 1991-1997

Source: Bell Atlantic, Federal Communications Commission

31. Massachusetts Leads in Internet Connectivity



Number of Internet host computers, Massachusetts, 1995-1997

Source: Matrix Information and Directory Services

WHY IS IT SIGNIFICANT?

An Internet host reflects any computer system physically connected to the Internet, either full- or part-time, directly, or by dial-up. A high number of Internet hosts relative to the population provides the potential for widespread adoption of Internet-based communications and use of the information infrastructure.

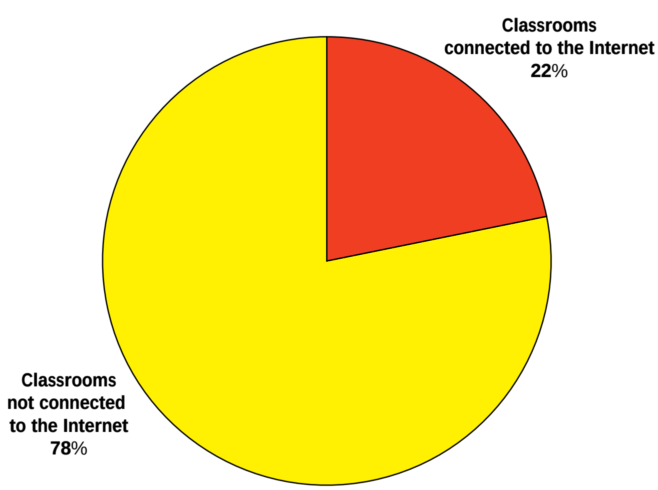
Adding up Internet hosts is not equivalent to counting users. Some Internet host numbers are unused, being kept in reserve for future growth; others support multiple individual users; and others connect vending machines and other equipment to the Internet. Because such practices are applied consistently across the country, many groups use Internet host counts to compare regions and broad trends.

HOW DOES MASSACHUSETTS PERFORM?

From January 1995 to January 1997, the number of Internet hosts in Massachusetts jumped from 221,204 to 413,887.

Massachusetts has the second highest number of Internet hosts per capita of the Leading Technology States (LTS). In 1997, Massachusetts had 67.9 Internet hosts per 1,000 people. This number compares with 69.2 hosts per 1,000 people in California, the highest, and 35 hosts per 1,000 people for the U.S. average.

32. Classroom Access to the Internet Outpaces the Nation



Percentage of public-school classrooms connected to the Internet, Massachusetts, 1997

Source: Communica, Inc., Massachusetts Department of Education

WHY IS IT SIGNIFICANT?

Internet access through high-speed networks allows students and teachers to access, create, and share information with images, sound, and animation. Participation in local-area networks links students, teachers, and administrators to each other.

HOW DOES MASSACHUSETTS PERFORM?

Massachusetts has a substantial number of classrooms connected to the Internet. In 1997, more than 10,000 classrooms have some level of Internet access—about 22% of all public-school classrooms in the state. This first-time survey conducted on behalf of the Massachusetts Department of Education can serve as a useful benchmark for future progress.

The United States Department of Education estimates that 9% of public-school classrooms in the nation are connected to the Internet.

In addition to having Internet access, just over one-quarter of Massachusetts public-school classrooms are connected to a local-area network.

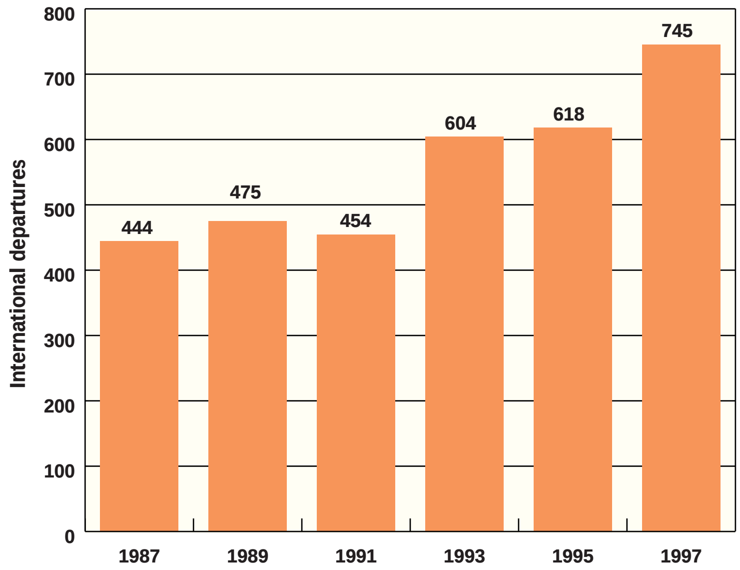
WHY IS IT SIGNIFICANT?

Increasingly, companies grow through serving international markets. *Choosing to Compete* (Commonwealth of Massachusetts, Office of Economic Affairs, May 1993) identified access to international flights as important in encouraging foreign business transactions. Access to a major airport, preferably a hub and preferably international, is a key feature of the most entrepreneurial environments (see Cognetics, Inc., *Entrepreneurial Hotspots 1996)*.

HOW DOES MASSACHUSETTS PERFORM?

The number of direct and nonstop international flights to and from Logan Airport increased 68% from 1987 to 1997, from 444 to 745 flights per month. The number of international destinations served has remained constant at 14 (see Appendix A). Twenty percent of international flights are to London, and another 20% to France. Congested ground access into Logan Airport and flight delays are increasingly important obstacles to business expansion and competitiveness. For the last two years, interviews by Mass Insight of high-tech executives found that Logan Airport improvements are a top priority.

33. Number of International Cities Served by Logan Airport Remains Constant, though Foreign Flights Increase



Number of nonstop flights from Logan Airport to international destinations besides Canada, per month, 1987-1997

Source: BACK Information Services

EXHIBIT A: CRITICAL INDICATORS FOR FUTURE INVESTMENT

Creating appropriate measures of the Innovation Economy is central for tracking and understanding the competitive advantage of Massachusetts. As we develop the *Index of the Massachusetts Innovation Economy* in future years, we would like to access new data sources to monitor better the key components of the Innovation Economy: resources, innovation processes, and results.

This effort will require the support of various private and public organizations to collect new kinds of data and to organize existing data in new ways. With collaboration in future years, we can create even more precise monitoring tools for the Innovation Economy.

The following questions identify areas for additional research on the Innovation Economy. Some respond to known gaps in available information; others highlight questions raised by indicators in this year's *Index*. We welcome suggestions about how to define and refine the indicators, so that we can better understand the emerging Innovation Economy, and provide data and analysis for use by public and private sector decisionmakers in generating and sustaining an environment in which innovation thrives.

POTENTIAL NEW INDICATORS

Desired Results Indicators

Additional results indicators will help us measure with increased precision the nature and share of economic activity and job growth attributable to the Innovation Economy.

1. *What kinds of jobs are different industries creating?*
   Indicator: Occupations by industry

2. *What is the value of services exports?*
   Indicator: Measure of services exports

3. *Where are jobs growing now?*
   Indicator: Current quarterly employment data by industry

Desired Indicators of the Innovation Process

The innovation process—the dynamic translator of resources into valuable results—is the core of the Innovation Economy's success. This analytic component fills a major gap in understanding how to identify and accurately track the economy. Additional indicators will help us better monitor and improve the Massachusetts innovation process.

4. *How productive are service industries?*
   Indicator: Measure of productivity or value added of service industries

5. *How does innovation occur in established businesses?*
   Indicator: Survey of how innovation occurs in established businesses

6. *Are large companies continuing to focus on new products and ideas?*
   Indicator: Share of corporate revenue from products developed in the prior three years

7. *In what industries are new businesses being created?*
   Indicator: New business starts by industry

8. *What role do collaborative practices play in the Massachusetts Innovation Economy?*
   Indicator: Number of strategic alliances/partnerships between industry, universities, and other research institutions

Desired Resource Indicators

Additional resource indicators will deepen our understanding of the nature of the base that supports innovation in Massachusetts.

9. *What is the level of corporate investment in information technology?*
   Indicator: Percentage of corporate investment in information systems development

10. *What are the impacts of shifts and reductions in federal funding of R&D on the quality of Massachusetts universities?*
    Indicator: Distributional effects of funding changes on research
    Indicator: Private funding variations in relation to public funding
    Indicator: Quality of applicant pools at undergraduate and graduate levels

11. *Does Massachusetts have a continuous learning mechanism to meet the rapidly changing needs of its Innovation Economy?*
    Indicator: Number and types of professional continuing education and management development programs
    Indicator: Enrollment in professional continuing education and certificate programs

12. *How is Massachusetts investing in its technical labor force?*
    Indicator: Public and private investment in two-year technical degrees

13. *How fast is decision making in the regulatory process?*
    Indicator: Measure of speed of the state regulatory process

14. *How can we best measure quality of life as it relates to the Innovation Economy?*
    Indicator: Components of quality of life most important to the knowledge worker
    Indicator: Measures of traffic, congestion, and environmental impact

SAMPLE INDICATOR UNDER DEVELOPMENT

Traditional indicators do not reflect the variety of ways in which Massachusetts companies use innovation to better compete in the marketplace. To capture one component of innovation, we are developing an indicator that measures innovation as the share of corporate revenue derived from products/services that were introduced in the prior three years. This measure is often cited in business literature and used by companies such as 3M. We hope that you will complete and return the survey (page 43) so that we can add this measure to next year's *Index*.

MTC has already surveyed a very small sample of large established businesses in Massachusetts to look at preliminary trends in this area.

INNOVATION PROCESS INDICATORS

Percentage of sales revenue derived from products and services introduced in the prior three years.

WHY IS IT SIGNIFICANT?

Continuous innovation in established firms is essential to maintain competitiveness in a world of ever-quickening product life cycles. Increasingly, companies are tracking the percentage of sales generated by new products as a revealing measure of innovation.

HOW DOES MASSACHUSETTS PERFORM (PRELIMINARY)?

In a very small sample of some of Massachusetts' larger companies, data suggested that revenue generated from new products and services has increased 35% as a portion of the corporation's total annual sales. In recent years, it appears that sales revenue from new products and services has increased 11% faster than total corporate sales.

Innovation in Large Established Firms

APPENDIX A: DATA SOURCES

I. Introduction
MTC released *Technology Development in Massachusetts* in 1995, *Planning for Change/Preparing for Growth* in 1996, and *Preliminary Analysis of the Impact of the FY 97 Federal R&D Budgets on the Massachusetts Economy* in 1997. These reports examine the structure and performance of technology-based industries in Massachusetts, the distinctive role of research universities and academic health centers in the State's economic vitality, and the projected impact of likely reductions in federal R&D spending on these institutions and the economy. These studies underscore the importance and magnitude of a dynamic knowledge-based, innovation-driven sector to the economic health and competitiveness of the Commonwealth. The studies also confirm the great degree to which nonprofit research institutions underlie the structural integrity and resilience of the Innovation Economy.

II. 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. Using County Business Patterns (CBP) data from the U.S. Census Bureau, we examined 13 well-known technology states. Our first step was to rank the states by their share of employment in those key industries identified in Massachusetts' industry clusters (see Appendix B for definitions of the nine key industry clusters).

To refine the selection process further, we examined the 1995 state rankings of high-tech employment, wages, exports, and concentration compiled by the *American Electronics Association* (AEA). The AEA's definition of the high-tech industry includes 45 Standard Industrial Code (SIC) classifications in three broad areas: high-tech manufacturing, software and computer-related services, and telecommunications services. This definition does not include industry activity in biotechnology and innovation services. The AEA's rankings of employment, wages, and employment concentrations are derived from the same unemployment insurance data that CBP uses. (For discussion of employment concentrations, see indicator number three below.) Export data are from the Origin of Movement state export series compiled by the Census Bureau.

Comparing the ranking results for all five measures, we chose six states with the best representation across all measures: California, Florida, Illinois, New Jersey, New York, and Texas.

	CBP 1994	AEA High-Tech Rankings 1995				
State	Share of emp. in key technology industries	Employment	Wage	Export	Concen-tration	Selected
MA	21.3%	4	4	5	3	
NY	15.5%	3	7	3		X
NJ	15.1%	7	2		5	X
CA	14.0%	1	3	1	4	X
PA	13.3%	8		9		
MN	12.2%				6	
IL	12.1%	5		4		X
CO	12.0%				2	
NC	11.2%					
TX	10.6%	2		2		X
AZ	10.2%			8	7	
FL	9.4%	6		6		X
WA	8.8%		1			

III. Inflation-Adjusted Values

Except for wages, which are adjusted using the Consumer Price Index (CPI), all inflation-adjusted indicators use the calendar-year-based Gross Domestic Product (GDP) implicit price deflator (1987 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. The National Science Foundation refers to its own use of the deflator as follows:

In keeping with U.S. Government and international standards, R&D trend data usually are deflated to 1987 constant dollars using the Gross Domestic Product (GDP) implicit price deflator. Since GDP deflators are calculated on an economy-wide rather than R&D-specific basis, their use more accurately reflects an "opportunity cost" criterion, rather than a measure of cost changes in doing research.

IV. Notes on Data Sources for Individual Indicators

Results Indicators

1. Cluster Employment Shifts Dramatically; Software and Communications Services Is Biggest Gainer

The Massachusetts Department of Employment and Training (DET) and the Minnesota Implan Group, Inc. (MIG, Inc.), track industry employment via employers' unemployment insurance filings. This data series is commonly known as the ES202 dataset. Datasets from both organizations were analyzed 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 B.

2. Telecommunications Industry Emerges with Many Segments

Data were derived from the recent report, *Connection to the Future: An Analysis of the Telecommunications Industry in Massachusetts,* produced by the Massachusetts Telecommunications Council and the University of Massachusetts (1997). This was an analysis of telecommunications activities in 19 different industry segments.

3. Massachusetts Has a Diverse Portfolio of Specialized Clusters

This indicator was developed from MIG, Inc., state-level data of unemployment insurance filings between 1990 and 1995. Employment concentration is measured as the relative amount of employment in a cluster as a portion of total state employment compared with the same clusters' employment nationally as a portion of total U.S. employment. For each cluster, the level of national employment is indexed at 100. Therefore, defense employment at 303 is three times more concentrated in Massachusetts than at the national level. The annual average growth rate is the rate of change in industry cluster employment over the five periods from 1990 to 1995. The size of each oval on the chart reflects the relative size of employment in Massachusetts. The largest oval, financial services, employed 118,700 people in 1995.

4. Software and Communications Services Industry Cluster Leads in Average Pay

Data are from MIG, Inc., and the Bureau of Labor Statistics and are derived from payroll data reported as part of unemployment insurance filings. The wage estimate for each cluster is the mean payroll per employee in 1995 current dollars.

5. Inflation-Adjusted Pay per Worker Rises 6% since 1990

Wage data for Massachusetts and the six LTS are from the Bureau of Labor Statistics, *Average annual pay by state and industry*. These data, like those of the DET and MIG, Inc., are derived from employers' unemployment insurance filings. This source represents 96.7% of all wage salary workers in the nation. All years shown in the chart have been adjusted into 1996 dollars using the CPI.

6. Income Distribution Is Widening

Data on mean household incomes in Massachusetts are derived from the Census Bureau's *Current Population Survey* by Professor Jon Haveman of Purdue University. Household income is calculated as a three-year rolling average for each year.

7. Manufacturing Exports Substantially Trail Those of Leading Technology States
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 calendar year price deflator from the Bureau of Economic Analysis.

Services have commonly been treated as "untradable" because of their intangible qualities. At present, we lack good measures to help us understand Massachusetts' significant amount of service industry exports.

8. Perceptions of Business Climate Improve Dramatically
Data are from the Massachusetts High Technology Council's annual business climate survey, 1987-1997.

Innovation Process Indicators

9. National Leader in Patents; Discoveries Are Diverse
Data on the diversity of patent activity in Massachusetts are from a special analysis of patent activity by CHI Research of Haddon Heights, New Jersey. The "Other" category included minor industries such as Food & Kindred Products (<1%), Textile Mill Products (<1%), Petroleum & Natural Gas Extractives (<1%), Stone-Clay-Glass-Concrete (1.9%), Primary Metals, Transportation Equipment (2%), Other Industries (7.2%), and Not Classified (<1%).

10. Inventions and Patent Applications by Institutions Are Increasing
For an in-depth discussion of the spillover effect and its impact on Massachusetts, see MTC's *Planning for Change/Preparing for Growth* prepared by Adam Jaffe, PhD, of The Economic Resources Group, Inc.

Indicator data are from the Association of University Technology Managers (AUTM), which has annually surveyed its member population since 1991 (279 institutions). Survey follow-up efforts are concentrated on the top 100 universities as identified in the National Science Foundation's (NSF) *Federal Support to Universities, Colleges, and Nonprofit Institutions*. The survey had an 87% response rate among these institutions and an overall response rate of 62%, or 173 institutions. Time series data are from the 104 institutions that have participated each year.

Massachusetts universities include Massachusetts Institute of Technology, Harvard University, Boston University, Tufts University, Brandeis University, University of Massachusetts-Amherst, University of Massachusetts Medical Center, and Northeastern University. Massachusetts hospitals/ research institutions included are Massachusetts General Hospital, Children's Hospital Boston, Brigham and Women's Hospital, Woods Hole Oceanographic Institute, Dana-Farber Cancer Institute, New England Medical Center, New England Deaconess Hospital.

11. License Royalties at Major Institutions More Than Double in Four Years
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 of Advanced Medical Devices Is Strong
Information provided by MassMEDIC is based on its analysis of U.S. Food and Drug Administration (FDA) data.

13. Number of Fast-Growth "Gazelle" Companies Nears 100
The number of gazelle companies is derived from a special data run conducted by Standard & Poor's Compustat of Englewood, Colorado, 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 1996. In 1996, there were 408 Massachusetts companies filing data with the SEC.

14. Small Business Innovation Research Awards Are Growing

Data are provided by the Small Business Administration (SBA) and U.S. Department of Commerce. Data are for the number and dollar value of awards distributed in each fiscal year. Phase I awards are for companies to research the technical merit and feasibility of their idea; Phase II awards build on these findings and further develop the proposal idea.

15. Initial Public Offerings Increase Sharply

Data are provided by Hale & Dorr, LLP of Boston, Massachusetts, from a special data run of its tracking of IPOs throughout New England.

16. Several State Industry Clusters in Manufacturing Improve Value Added, but Many Trail U.S. Averages

This indicator reflects annual value added per employee in manufacturing industry clusters. Data come from the 1987 and 1992 U.S. Census of Manufactures. Value added per employee is the total value added by manufacturing companies divided by these companies' total number of employees. Total value added per company is derived by subtracting the total cost of inputs, other than direct labor costs, from the stated value of the final goods produced. These estimates are adjusted by the addition of value by merchandising operations plus the net change in finished goods and work-in-process between the beginning and end-of-year inventories.

17. Intangible Assets Accelerate in the 1990s

This indicator is derived from the Standard & Poor's Compustat dataset of publicly traded companies in Massachusetts. Both market capitalization and book value are aggregated for all publicly traded companies in Massachusetts.

Market capitalization is the sum value of a company's outstanding shares. The book value of a company is the value of its fixed assets, such as equipment and inventory. The difference between these two values is considered the company's intangible assets. This measure, when examined over time and controlled on a per employee basis, serves as an indicator of a company's acquisition and use-of-knowledge assets.

Resource Indicators

18. Immigration Drives Population Growth

Data are provided by Mass Insight, Cambridge, Massachusetts. This measure is based on analysis by Regional Financial Associates, Westchester, Pennsylvania, and data from the Census Bureau and the Internal Revenue Service.

19. Advanced Educational Level of the Workforce Is an Advantage

State-level data on educational attainment are maintained by the National Center for Education Statistics in the U.S. Department of Education. See the *Digest of Educational Statistics* for the most current data. Data on all 50 states are gathered every five years by the Census Bureau in conjunction with the Current Population Survey.

20. Engineering Degrees Awarded Lag National Trends

Data are provided by the American Association of Engineering Societies (AAES), Washington, DC. The AAES tracks the number of engineering degrees awarded from accredited institutions throughout the United States each year.

MTC surveyed Boston University, Massachusetts Institute of Technology, Northeastern University, Tufts University, University of Massachusetts-Amherst, Western New England College, Woods Hole Oceanographic Institution, and Worcester Polytechnic Institute.

21. One-Third of Science and Engineering Doctorates Stay Working in the State

Data are provided by the National Research Council, Office of Scientific and Engineering Personnel, from a special run of its 1995 doctorate survey data. The survey population of PhDs from Massachusetts institutions was 12,009.

22. Eighth Graders Excel in Math and Science

Sciences and Mathematics assessment test scores are from the National Assessment of Educational Progress (NAEP), 1996, U.S. Department of Education, Office of Educational Research and Improvement, National Center for Education Statistics. A few states, including Illinois and New Jersey, did not participate in 1996 NAEP.

23. Drop-Out Rates Continue to Decline, but Vary Widely

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

24. SAT Scores Are at a High; Strongest Participation Rate in Country

SAT scores are combined mathematics and verbal scores, obtained from the SAT Program Summary Reporting Service, College Board; Annual Profiles of SAT & Achievement Test Takers, Massachusetts, 1989 to 1995.

25. Per Capita Federal R&D Spending at Universities Remains Relatively Constant

Data are provided by the National Science Foundation for all academic institutions. This includes its university-associated federally funded research and development centers. Population data are from the Census Bureau.

26. Per Capita Health R&D Funding Increases in Absolute and Relative Terms

Data are provided by the National Science Foundation. 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.

27. Corporate R&D per Employee Varies Widely by Sector

Data are derived from Standard & Poor's Compustat. Compustat provided information on all publicly traded companies headquartered in Massachusetts between 1986 and 1996. For both 1990 and 1996, industry R&D per employee was calculated for all companies that reported any R&D expenditures. All publicly traded companies reporting R&D expenditures were used for the calculation of the Massachusetts average. Some report zero expenditures on R&D.

28. Venture Capital Reaches All-Time High, but Overall Share of National Total Decreases from the Early 1990s

Data are provided by Venture Economics of Boston, Massachusetts. This measure is of all venture capital funding received by Massachusetts-based companies. Industry designations are also determined by Venture Economics.

29. Use of Research Tax Credit Increases 48% since 1991

Data are provided by the Massachusetts Department of Revenue. The value of the research credit is estimated for tax years 1994, 1995, 1996, 1997.

30. Availability of ISDN Increases Significantly

Data are provided by Bell Atlantic and the Federal Communications Commission's Common Carrier Bureau. Data are derived from required reporting of local exchange companies subject to mandatory price cap regulation (report name: Armis 43-07). Together, these local exchange companies provide service to 90% of the nation's telephone lines.

31. Massachusetts Leads in Internet Connectivity

The number of Internet host computers is from Matrix Information and Directory Services (MIDS), Austin, Texas. Data are derived from estimates of Internet protocol addresses from Network Wizards' annual Domain Survey.

32. Classroom Access to the Internet Outpaces the Nation

Data are provided by Communica, Inc., from a survey done for the Massachusetts Department of Education (DOE) as part of a statewide assessment of each district's current technology level and training needs for implementation of the Massachusetts DOE Information Management System. This survey, the District Technology Profile, received a response rate of 80%.

33. Number of International Cities Served by Logan Airport Remains Constant, though Foreign Flights Increase

Data are provided by BACK Information Services, Newport Beach, California. Data are for all international destinations except those in Canada. Logan International Airport is among the top 30 airports in the world as measured by both the volume passenger and cargo traffic. Destinations include:

Amsterdam, Netherlands
Athens, Greece
Bermuda, Atlantic Ocean
Brussels, Belgium
Dublin, Republic of Ireland
Rome, Italy
Frankfurt, Germany
Reykjavik, Iceland
London (Gatwick), England, UK
London (Heathrow), England, UK
Paris, France
Ponta Delgada, Portugal (Azores)
Shannon, Republic of Ireland
Zurich, Switzerland

APPENDIX B: INDUSTRY CLUSTER DEFINITIONS

I. Defining Key Industry Clusters in Massachusetts

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

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

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

Computers & Communications Hardware

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

Defense

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

Diversified Industrial Support

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

Financial Services

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

Healthcare Technology

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

Innovation Services

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

Postsecondary Education

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

Software & Communications Services

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

Textiles and Apparel

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

nec – not elsewhere classified

MEASURING INNOVATION IN ESTABLISHED BUSINESSES

Traditional indicators do not reflect the variety of ways in which Massachusetts companies use innovation to better compete in the marketplace. To capture one component of innovation, MTC is developing an indicator that measures innovation in established businesses.

The questions below will be used to measure the percentage of corporate revenue derived from products/services that were introduced in the three years immediately prior to each of the years being surveyed. We would like to add your company to our database and share results with you on an annual basis. All responses will be kept confidential; data will be presented in aggregate form only.

The survey can also be completed at MTC's website http://www.mtpc.org/research/indica.htm. Thank you.

1. Company name ______________________________

2. Company address ______________________________

3. Contact person, if follow-up is required ______________________________

Telephone ______________________________

	1996	1995	1994	1993
4. Total number of employees	_____	_____	_____	_____
5. What were your company's total sales revenues for each of the following years?	_____	_____	_____	_____
6. What were your company's total sales revenues for each year from those new products/services that were introduced in the three years immediately prior to each of the following years?	_____	_____	_____	_____

Note: For questions five and six, please specify whether dollar amounts indicated are in hundreds, thousands, or millions.

Please copy and mail or fax to:

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