EXECUTIVE REPORT

The IT Industry:

Hub of the Massachusetts Technology Economy

UNIVERSITY OF MASSACHUSETTS • DONAHUE INSTITUTE
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Contents

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Letter from the Consortium

Dear Colleague,

From its earliest days, Massachusetts has always been recognized for its spirit of innovation. The Information Technology (IT) industry in Massachusetts, borne out of the minds and hard work of some of the best and brightest scientists and engineers in history, is no exception. From the birth of the telephone to computing and networking, and from the creation of the Internet to the earliest of video games, some of the most transformative technologies of our time were born right here. These and many other innovations have emanated from an industry that has contributed to the economic success of our region — and continues to revolutionize how societies live, work and play.

Inspired by these innovations, a consortium of leaders from corporations, industry associations, and government came together last year to better understand the nature of the IT industry and its contributions to the Massachusetts economy. This group commissioned the University of Massachusetts' Donahue Institute to study the current composition of the industry. The findings of the Donahue Institute's study entitled, "The IT Industry: Hub of the Massachusetts Technology Economy," speaks volumes. **As one of the state's largest sectors, Massachusetts' IT industry is home to 10,300 firms and over 178,000 workers. The IT industry directly expended $65 billion in Massachusetts in 2008, a figure that is comparable in scale to nearly 18 percent of state GDP.**

The figures are impressive, but what is truly inspiring are the possibilities ahead. From robotics, to video gaming, to mobile applications, the revolutionary scientists, inventors, and entrepreneurs among us are upending the status quo as they create new technologies and whole new industries. Digital technology is enabling our key industries to reach into the future by transforming work, learning, and discovery. Computing, science, engineering, business, and art are converging in unexpected and previously unimaginable ways to revolutionize how cures for disease are discovered, healthcare is delivered, finance is managed, entertainment captivates, and research advances the frontiers of knowledge. Massachusetts is at the hub of the new digital revolution.

Now it's time to build off of what we've created. Last January, Governor Patrick called on industry and academic leaders to come together in the Massachusetts IT Collaborative. In close collaboration with existing technology councils, the Collaborative is working to improve the competitiveness of the sector and enhance the state's economy by nurturing the spirit of innovation and entrepreneurship, building the talent pipeline, and mentoring young entrepreneurs. Join us in cultivating the next generation of the IT industry — the "Mass Tech Hub." Let us work together to maintain its dynamism and help propel our state's industries to move faster into the future. Visit innovate.masstech.org.

Sincerely,

Secretary Gregory Bialecki
Massachusetts Executive Office of Housing and Economic Development

Paul Bosco
Vice President and General Manager, Video and Wireless Products
Cisco

Donna Cupelo
Region President of New England
Verizon

Summary of Key Findings

The Information Technology (IT) industry is widely recognized as a driving force of Massachusetts' innovation economy. In 2008, a consortium of corporate, industry association, and government leaders formed to discuss the evolving identity of today's Massachusetts IT industry and to better understand the substantial contributions the IT sector makes to the Massachusetts economy. The consortium includes AT&T, Cisco Systems, Comcast, EMC, IBM, Massachusetts Executive Office of Housing and Economic Development, Massachusetts Network Communications Council, Massachusetts Technology Collaborative John Adams Innovation Institute, Massachusetts Technology Leadership Council, Microsoft, TechAmerica, and Verizon Communications. The consortium selected the University of Massachusetts Donahue Institute (UMDI) to conduct in-depth research on the IT industry in the state.

Massachusetts continues to be at the forefront of the modern information economy. Today, this economy is diverse and includes "home-grown" companies as well as thousands of other U.S. and international companies that have opened regional offices, divisions, or subsidiaries in the Commonwealth. Although this study organizes the IT industry into four distinct sectors, the Massachusetts IT industry is highly interconnected, continuously developing linkages between the traditional sectors of Hardware, Software, Network Communications, and IT Services, as well as sectors outside of the industry. New enterprises, along with established businesses, leverage ever-expanding technology developments in telecommunications, mobile, media, robotics, and other fields to develop products for global markets and provide services for regional customers.

The Massachusetts IT industry, particularly the Software sector, continues to add employees and new firms, despite the recent lagging national economy and the major shocks to the industry over the past ten years. The ultimate impact of the extended global recession on the IT industry still remains unclear. The industry as a whole appears resilient, however, and Massachusetts firms remain entrepreneurial and ready to compete. Sectoral shifts, along with linkages to other industries like health care and financial services, have resulted in a stronger and more diverse industry. Its workforce is highly educated and well-trained, and the institutional capacity to contribute to innovation and growth remains high, as evidenced by the availability of research dollars, corporate partnerships, and other factors. While industry growth may continue to be volatile in some sectors and stagnant in others, the industry's capacity for transformation and innovation should help it navigate through difficult economic conditions.

The Massachusetts IT industry is an economic engine for the Commonwealth and a leading source of global innovation.

The IT industry is a major contributor to the Massachusetts economy.

- The IT industry directly expended $65 billion in Massachusetts in 2008, a figure that is comparable in scale to nearly 18 percent of state GDP.
- The cumulative effects of spending by the Massachusetts IT industry, its suppliers, and all related employees is estimated to result in an additional $14.7 billion in taxes and fees to federal, state, and local governments.
- The Massachusetts IT industry employs 5.5 percent of Massachusetts workers.

Massachusetts is a magnet for IT investment.

- Massachusetts' regions draw top levels of investment: venture capital financing levels in the Route 128 subregion are second only to the Silicon Valley.
- Between 2006 and 2008, half of all venture capital investment in Massachusetts went to the IT industry with security/firewalls/encryption software, wireless communication services, and database management software attracting the most investment dollars.
- When compared to California, Massachusetts is particularly strong in backup and disaster recovery and internet security and transaction services, outperforming investment in California dollar for dollar.
- In several major federal funding programs, Massachusetts draws the most IT grant dollars per IT worker in the nation and far outpaces that received by California on a per-IT worker basis.

Massachusetts is a compelling business location.

- Industry focus groups highlighted the importance of higher educational institutions in Massachusetts as a critical source of talent and research capabilities.

- Seventy percent of respondents to a comprehensive survey of Massachusetts IT firms identified the Commonwealth's cultural amenities as a regional strength and advantage for IT businesses when compared to all other regions.

- Sixty-four percent of respondents cited "access to world-class research partners" as a significant regional strength.

- Both focus groups and survey respondents recognized "the presence of world class business networks and colleagues," both inside and outside the industry, as a regional strength. With global powerhouses in industries like biotechnology and health care firmly planted in Massachusetts, focus group participants felt that the Commonwealth's IT industry is uniquely positioned to partner with leaders in other like-minded innovation sectors.

The IT industry is one of the most significant employers in the Commonwealth.

- Total employment in the IT industry ranks second among key industry clusters and outpaces other industry clusters in the Commonwealth, including leading industries such as financial services and life sciences.

- Massachusetts' IT industry is home to 10,300 IT firms and over 178,000 workers.

- Additionally, there are more than 50,000 workers employed in IT technical occupations in diverse industries outside of the core IT sectors.

- Massachusetts' IT industry employment and investment levels have been growing since the dot-com bust, denoting recovery, but overall, have not returned to all-time highs.

    - Though Hardware is still Massachusetts' largest IT employment sector (32 percent of all IT employment), mirroring national trends, it continues to shed jobs. This sector had 34,746 fewer jobs in 2008 than it did in 1998.

    - Software, however, is growing strongly. Software sector growth has driven overall IT employment growth in recent years with new jobs, new firms and new investments, particularly in custom computer programming.

    - By 2008, IT industry employment in the IT Services sector returned to 1998 employment levels.

    - The Network Communications sector has gained firms since 1998 in spite of losing jobs.

The Massachusetts IT workforce is large, diverse and growing.

The IT industry employs workers at every level of educational attainment, from those without a high school diploma to PhDs, and these workers are well compensated.

- Although there is a wide range of opportunity for workers with different levels of educational attainment, workers in the IT industry are significantly more likely to have Bachelor's and Master's degrees than workers in other industries.

- Nevertheless, it is estimated that nearly 60,000 workers in the Massachusetts IT industry have an Associate's degree or less.

- The average pay of nearly all occupations in the Massachusetts IT industry consistently exceeds that of comparable workers in other industries.

- The largest occupational groups of non-technical workers in the IT industry include business management analysts, managers and executives, and sales representatives.

IT technical professionals in Massachusetts (those workers contributing specific computer and mathematical expertise) are exceptionally well compensated, highly educated, and their occupations are projected to grow more than three times the state average by 2016.

- Twelve of thirteen IT technical professional occupations are projected to grow between 2006 and 2016, with the majority outpacing the statewide average growth rate for all occupations.

- Over 80 percent of the IT technical professionals in Massachusetts work in positions that require at least a Bachelor's degree and earn $75,000 or more annually.

- Four percent of the Massachusetts workforce is employed in an IT technical occupation, more than the national average of 2.7 percent and above California (3.0 percent).

- Massachusetts IT technical professionals are more heavily concentrated in the best-paid IT occupations than in California, Texas, North Carolina, and nationwide. IT worker pay is on par with California IT workers, the most well paid in the nation, at $87,784, and well above the Massachusetts state average of $49,070.

- IT technical professional jobs appear to be more resilient in times of economic crisis than average. Although rising slightly, as of June 2009, unemployment rates for IT technical professionals were about one half the rate when compared to all occupations in the Commonwealth.

To maximize the future growth of the IT industry in Massachusetts, industry leaders and policymakers must address a variety of competitiveness issues.

Policy priorities for IT businesses include reducing the cost of doing business, improving information infrastructure, and growing the pipeline of science, technology, engineering and math (STEM) workers.

- IT firms overwhelmingly identified the need to reduce business costs as high priority for their business. In particular, consistency and predictability in tax policy was cited as essential for business decision-making.

- Surveyed firms identified the improvement of information infrastructure (broadband, wireless access, connectivity, etc.) as imperative.

- Both survey respondents and focus group participants expressed concerns about the pipeline of STEM workers. They noted the need to develop better opportunities for students in higher education to gain real-world experience and to bolster interest in technology in K-12 education. Others cited concerns about finding senior-level talent in Massachusetts.

Massachusetts needs to strengthen its climate for IT innovation.

- Nearly half of survey respondents found "access to venture capital and funding" to be a major obstacle when compared to California.

- Respondents also identified the need to create a more supportive environment for entrepreneurs and startups in the Commonwealth.

Growing companies to scale, encouraging an environment of collaboration and utilizing the state's varied regions remain challenges.

- It is widely known that Massachusetts has a knack for producing startups. However, focus group participants felt that the industry should focus on growing companies to scale and fostering an environment with a robust social and business network in order to grow jobs long-term and attract and retain a critical mass of anchor companies.

- Many firms further expressed support for increased efforts to foster more collaboration in the state.

- Over 70 percent of venture capital funding was directed to firms within the Greater Boston region. Outside of this region, the IT industry is considerably less developed. While other regions in the state can offer resources, infrastructure issues and the nature of the industry in Massachusetts have, to date, prevented a significant number of IT industry firms from moving beyond I-495.

Preface

The **Information Technology (IT) industry** is widely recognized as a driving force of Massachusetts' innovation economy. In 2008, a consortium of corporate, industry association, and government leaders formed to investigate the evolving identity of today's Massachusetts IT industry and to better understand the substantial contributions it makes to the Massachusetts economy.

The executive report that follows is driven by the following research components:

Defining the IT industry

Major components of the effort to develop an up-to-date definition of the IT industry include a rigorous review of relevant local, regional, and national literature along with in-depth interviews with industry leaders and relevant stakeholders. The analysis includes a current description of the industry's major subsectors as they exist in Massachusetts today and an identification of essential IT occupations.

Surveying IT businesses

Informed by interviews with firms and discussions with industry leaders and the IT industry study group, a detailed survey identified major policy concerns and challenges and their relative importance. The survey instrument was designed to systematically capture the policy priorities of Massachusetts IT businesses in an effort to guide elected officials and public policymakers in the development of policies and programs that support the IT industry.

Analyzing the economic contribution of the IT industry in Massachusetts

The study explores and documents economic conditions, discusses workforce dynamics, and identifies sources of innovation and growth in the Massachusetts IT industry and its **four core sectors**. The analysis included a variety of data sources including firm-level employment, payroll and revenue data, occupational and workforce data, and funding and investment data.

Exploring the IT industry as an economic catalyst

The research team analyzed the extent to which the IT industry serves as a catalyst for growth and innovation in the Commonwealth. This assessment was informed by discussions with industry leaders in IT sectors as well as with representatives from outside of the IT industry.

In addition, an economic impact analysis allowed researchers to illustrate the monetary value of IT industry output. An econometric model was used to estimate direct, indirect, and induced economic impacts, tax revenue paid to the state, as well as employment impacts (direct jobs, as well as those generated by the spending of the industry and its employees and contractors).

A NOTE ABOUT TERMS:
This report contains many terms that are specific to the IT industry or are technical in nature. These terms appear in **bold** throughout the report, and are defined in Appendix A: Glossary of Terms.

Copies of the report are available from the UMass Donahue Institute at www.massbenchmarks.org.

1 The IT Industry: Setting the Context

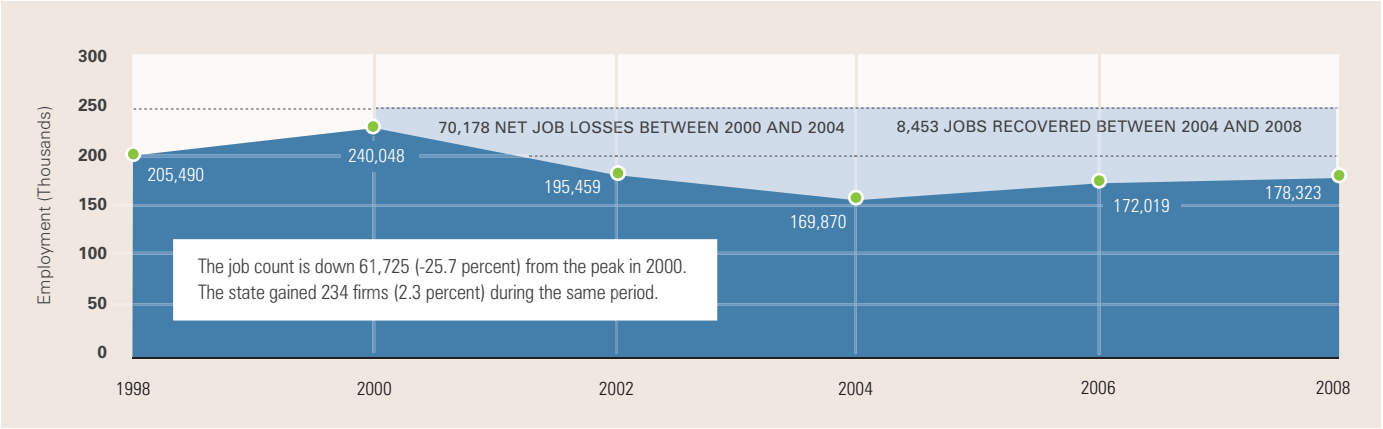
A legacy of innovation

Massachusetts is consistently at the forefront of the modern information economy, remaining on the cutting edge as technological demands shift over time. Through contributions of both research institutions and firms, the Commonwealth has fostered the development of numerous crucial technologies, including the telegraph, telephone, the first automatic programmable computer, early internet (ARPANET), electronic mail, the first spreadsheet software, the first cable modem, early video games, and multiple memory storage breakthroughs. Massachusetts is the source of many of the core components of today's information and technology-based world.

The legacy of innovation is evident throughout the state, in large corporations and small firms that design and market computing equipment and devices, and in the cadre of consultants and independent applications developers, programmers, and others who provide information technology services to the state's many established and emerging businesses and industries. The Massachusetts IT industry is diverse and includes "home-grown" companies as well as thousands of other U.S. and international companies that have opened regional offices, divisions, and subsidiaries in the Commonwealth. Although this study organizes the IT industry into four distinct sectors, the Massachusetts IT industry is highly interconnected, continuously developing linkages between the sectors of **Hardware, Software, Network Communications**, and **IT Services**, as well as with sectors outside of the industry. New enterprises, along with established businesses, leverage ever-expanding technology developments in telecommunications, mobile, media, robotics, and other fields to develop products for global markets and provide services for regional customers.

Because of the changing dynamics of this industry and the speed at which it moves, businesses in the state must continually innovate in order to grow. The state maintains a solid foundation in its traditional strength in computer hardware production, but software, semiconductors/chips, mobile technologies and online

Figure 1: Information Technology Industry Employment in Massachusetts, 1998–2008



Source: Minnesota IMPLAN Group (MIG), Inc; Massachusetts Executive Office of Labor and Workforce Development (EOLWD), ES-202 Series; Calculations by UMass Donahue Institute (UMDI).

application service providers (OASPs) are driving economic growth in today's Massachusetts IT industry. Massachusetts IT firms face competition globally and, if they fail to invest in research and development, they fail to succeed as their technologies become obsolete in just a few years. A strong foundation of supporting institutions in the state—academic and technical resources, financing institutions, industry groups, and a highly skilled and able workforce—have helped to bolster technology development and the growth of firms in the industry.

Resilience

The Commonwealth is set apart from other states in its ability to harness technological innovation, intellectual capacity, and entrepreneurism to sustain its information-based economy. Despite the **dot-com** bust in 2000, Massachusetts IT firms grew by 15.8 percent between 1998 and 2007. In contrast, California saw only a modest 2.7 percent increase in firms during that time frame.[1] Jobs are still in the process of recovering. These signs of recovery from the shock to the Massachusetts IT industry illustrate its resilience.

Current trends

Today, the IT industry remains one of the most significant employers in the Commonwealth;[2] IT firms employ one in every twenty workers in the state, or approximately 5.5 percent.[3] With over 178,000 workers, total employment in the IT industry is second, among key industry clusters, to healthcare delivery and outpaces other industry clusters in the Commonwealth, including leaders such as financial services and life sciences.[4]

Increasingly, Massachusetts' other leading industries rely on IT to move their businesses forward. Many skilled IT professionals work outside of the IT industry in Massachusetts. More than 50,000 **IT technical professionals** (technical workers contributing specific computer or mathematical expertise) are dispersed throughout other industries. Overall, IT technical professionals earn higher average annual salaries than typical workers in the state and those employed by firms within the IT industry earn substantially more than their counterparts in other industries.

The Massachusetts IT industry is diversified, with the Hardware sector leading with 32 percent of total employment, followed closely by the IT Services (28 percent) and Software (27 percent) sectors. Network Communications, the smallest sector, makes up just shy of 14 percent of total IT employment. With a rich manufacturing history, it is not surprising that many of the state's IT employees are employed by Hardware firms. Despite national declines in manufacturing activity over the past several decades, that sector, in 2008, maintained more than 6,500 more jobs than IT Services (the second largest of the four core sectors).

During the study period, which includes the dramatic dot-com boom and bust cycle in the late 1990s and early 2000s, some sectors remained relatively sluggish with minimal percentage changes in the number of firms or jobs between reference years. Other sectors were more volatile and experienced strong growth or decline. Since 1998, the share of Software firms in the Massachusetts IT industry expanded from 26 to 33 percent. Remarkably, employment in this sector also grew steadily through the end of 2008, particularly in custom computer programming firms, and was up over 3,000 jobs from its peak in 2000.

Figure 2: Massachusetts Employment in Selected Industry Clusters, 2008

	Employment 2008
Healthcare Delivery	315,465
Information Technology	178,323
Financial Services	168,220
Business Services	155,729
Postsecondary Education	105,778
Biopharmaceuticals, Medical Devices and Hardware	60,412
Defense Manufacturing and Instrumentation	41,133

Source: U.S. Bureau of Labor Statistics (BLS), Quarterly Census of Employment and Wages (QCEW); Massachusetts Technology Collaborative.

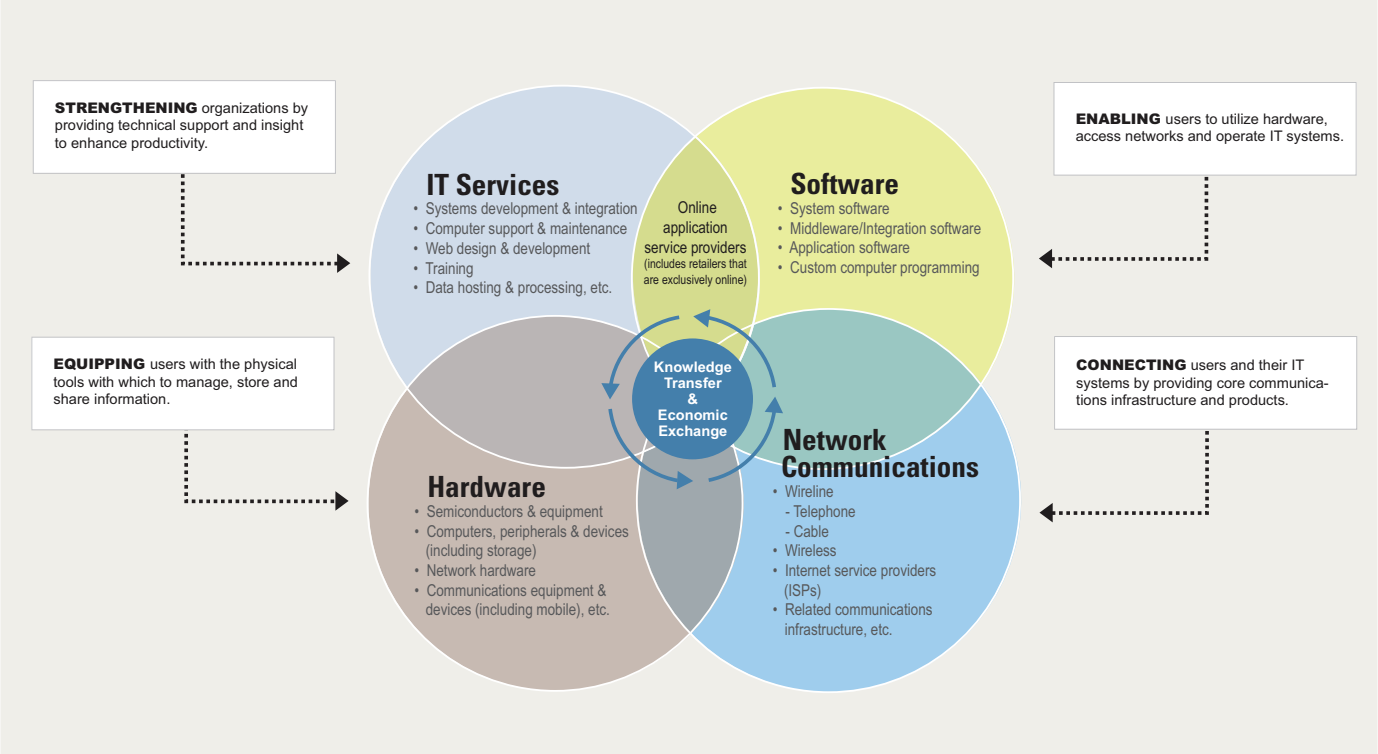
Despite the recent lagging national economy and the major shocks to the industry over the past ten years, the Massachusetts IT industry, particularly the Software sector, continues to add employees and new firms. The ultimate impact of the extended global recession on the IT industry and its sectors still remain unclear. However, it appears that the industry as a whole is resilient and Massachusetts firms remain entrepreneurial and ready to compete. Sectoral shifts, along with linkages to other industries, like health care and financial services, have resulted in a stronger and more diverse industry. Its workforce is highly educated and well trained and the institutional capacity to contribute to innovation and growth remains high, as evidenced by the availability of research dollars, corporate partnerships, and other factors. While industry growth may continue to be volatile in some sectors and stagnant in others, the industry's capacity for transformation and innovation should help it navigate through difficult economic conditions.

2 Characteristics of the Massachusetts IT Industry

Over the past several decades, IT firms throughout the U.S. have evolved in response to consumer demand, business needs, globalization, and technology innovation. In Massachusetts, the IT industry includes a diverse group of firms and workers that support existing key industries and enable new industry growth by providing valuable consumer and commercial services to workers and firms throughout the Commonwealth.

Although the impact of the IT industry is vast, and exists within a larger economic system,[5] for the purposes of this study, the industry is divided into four core sectors: Hardware, Network Communications, Software, and IT Services. Each of these is further divided into multiple subsectors, based on the range of industrial activities in the sector. Industry-wide data and findings are complemented by sector and subsector analyses that reveal patterns and trends unique to Massachusetts.

Figure 3: Massachusetts Core Information Technology Sectors and Subsectors



Source: UMDI.

The sector definitions are founded on a functional analysis of the strategic role played by each sector; firms are differentiated according to the way in which they contribute to the industry as a whole. The diagram reveals interaction and overlap between the industry's sectors. Overlap is fostered by ongoing knowledge transfer and economic exchange, made possible by the workforce and firm characteristics found in Massachusetts.

An analysis of industry, labor, and other data reveals that IT firms sort into groups that perform four distinct functions:

1.) Equip users with the physical tools needed to manage, store, and share information (Hardware);

2.) Connect users and their systems by providing core communications infrastructure and products (Network Communications);

3.) Enable users to utilize hardware, access networks, and operate IT systems and programs (Software); and

4.) Strengthen organizations by customizing products and services, and providing technical strategy and support services that enhance productivity (IT Services).

Although some firms specialize in a core sector such as Software, many firms—especially in Massachusetts—cut across more than one sector. This is characteristic of many large IT firms, which offer complementary products and services to different types of customers.

Employment in the core sectors continues to shift, mirroring national trends and pointing to major structural changes taking place in the IT industry. Despite the traditional strength of the Hardware sector in the state, the Software sector has been the main driver of new growth over the past ten years. Now accounting for about 27 percent of employment in the Massachusetts IT industry, the Software sector has grown by nearly 12,160 jobs (34.5 percent) over the ten-year period since 1998. The sector shows strong growth since 2004, and has now surpassed 2000 peak employment levels by more than 3,000 jobs.

In contrast, employment in the other sectors has either markedly declined or stayed level over the ten-year period from 1998 to 2008. The Hardware sector remains the largest, accounting for about 32 percent of industry employment in 2008. However, employment in the sector has decreased by 36.8 percent, more than 34,700 jobs, since 1998. This tremendous shift reflects ongoing consolidation of manufacturing operations in the Hardware sector and ongoing realignments to maintain productivity in the face of global competition.

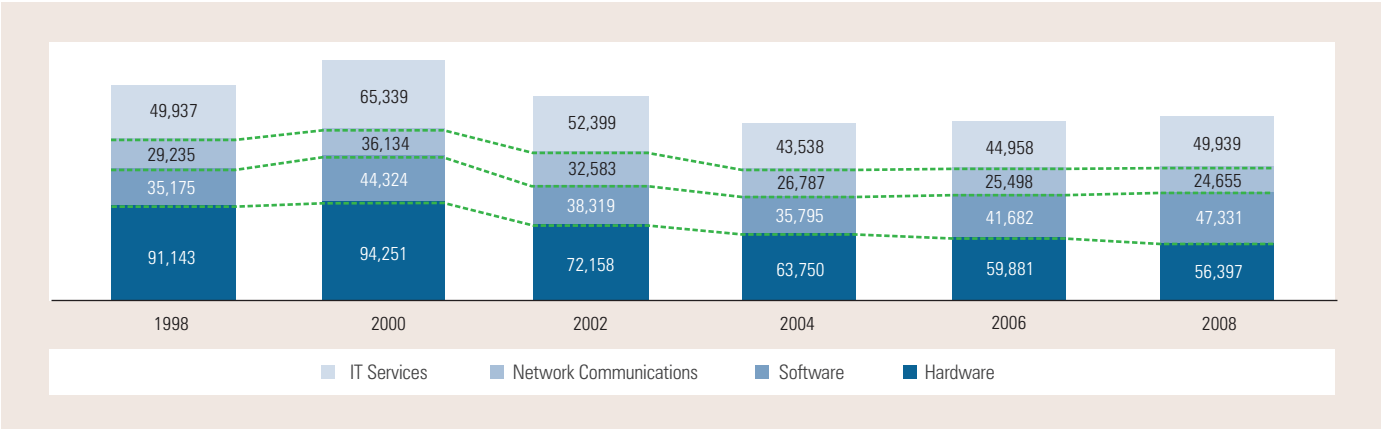
The remaining two sectors have stayed fairly level since 1998. IT Services, the second largest employer in the state's IT industry, accounts for about 49,900 jobs in the industry, more than 28 percent of total Massachusetts IT employment. In spite of much stronger growth nationally, this sector has not grown significantly over the ten-year period: 2008 employment numbers are on point with 1998 levels but remain 24 percent lower than the sector's employment peak in 2000. Network Communications has remained the smallest of Massachusetts' core IT sectors, hovering at 14 percent of total IT employment. Employment in the sector in 2008 is slightly lower than it was in 1998 and remains 32 percent lower than peak employment levels reached in 2000.

The section that follows provides a detailed discussion of current conditions in each of the four core sectors.

Hardware: Equipping users with physical equipment and IT tools

Hardware firms contribute in the most material and tangible way to the proliferation of IT in both the workplace and the consumer environment. These businesses produce, test, market, and distribute the components of computer and information systems;

Figure 4: Massachusetts IT Industry Employment by Sector



Source: MIG, Inc; EOLWD, ES-202 Series; Calculations by UMDI.

computers, devices and equipment; network hardware systems; and semiconductors, the core components of communications equipment and systems. These firms provide the material infrastructure, equipping users with the physical tools needed to operate computer and information systems. In conjunction with hardware products, many of these firms provide systems integration and other services.

The Hardware sector includes firms that offer products and services in four subsectors:

- Semiconductors and Equipment:
  Firms in this subsector provide the essential ingredients of the hardware devices that form the backbone of IT products and services. These firms manufacture microchips, circuit boards, wafers, and all of the other materials that together create computers, routers, printers, and other pieces of IT equipment.

- Computers, Peripherals, and Devices, Including Storage:
  Businesses in this subsector produce larger units that are assembled from the outputs of the semiconductors and equipment subsector. These firms manufacture personal computers, business servers, and other computing devices, as well as hard drives and other storage solutions for both personal and business use.

- Communications Equipment and Devices, Including Mobile:
  Firms in this subsector provide communications hardware, such as telephones (landlines and mobile) and the equipment necessary to test these devices, as well as products that transmit voice and video information over television and radio.

- Network Hardware:
  Companies in this subsector produce hardware that enables data communications over short and long distances. These firms manufacture and install short-run cables that are necessary for building local-area networks, as well as switches and routers that enable wider-area network communications. This subsector does not include telecommunications infrastructure (such as large-scale fiber-optic installations).

Employment and firm growth patterns in the Hardware sector

Over the past ten years, Hardware has remained the predominant sector for employment in the Massachusetts IT industry, despite its steady decline throughout the decade. From its peak of 94,047 employees in 2000, the sector has lost jobs every year, falling by 40 percent to 56,397 employees in 2008. In 1998, Hardware maintained a 44.3 percent share of total IT employment, but has since decreased to 31.6 percent in 2008. The sector's dominance is likely to continue to fade, reflecting major structural shifts in the IT industry (i.e., globalization and outsourcing). Large-scale manufacturing operations appear to be less feasible as a result of higher labor, energy, and resource costs.

Although the Hardware sector's share of employment remains the largest in IT, it has the smallest number of firms of all Massachusetts IT sectors. Hardware firms once accounted for 15 percent of all IT firms in the state, but as of 2008 that portion had shrunk to 9.0 percent, with a total of 940 establishments. Thus, the Hardware sector has a much higher concentration of employees per firm, relative to the other three core sectors. In 2008, Hardware firms employed an average of 60 workers, a significant drop from an average of 74 workers per firm in 2000. This decrease could be linked to an increase in worker productivity levels or to the scaling back of Massachusetts workers by a few large employers during the study period.

Although this data does not account for large outliers, such as a 1,000-employee manufacturing plant, it is plain to see the relative concentration of jobs in a smaller number of Hardware firms. As a result, the loss or gain of firms in the Hardware sector can have a greater impact on employment than firm growth or loss may have in the other IT sectors.

Figure 5. Massachusetts Hardware: Employment and Firm Growth, 1998 – 2008

	Massachusetts Hardware Employment							Employment Growth		
	1998	2000	2002	2004	2006	2007	2008	'98 – '00	'00 – '08	'98 – '08
All Information Technology	205,490	240,048	195,459	169,870	172,019	176,574	178,323	16.8%	-25.7%	-13.2%
Hardware	91,143	94,251	72,158	63,750	59,881	58,970	56,397	3.4%	-40.2%	-38.1%

	Massachusetts Hardware Firms							Firm Growth		
	1998	2000	2002	2004	2006	2007	2008	'98 – '00	'00 – '08	'98 – '08
All Information Technology	8,381	10,108	10,445	10,488	9,411	9,708	10,342	20.6%	2.3%	23.4%
Hardware	1,288	1,279	1,345	1,184	1,021	992	940	-0.7%	-26.5%	-27.0%

Source: MIG, Inc; EOLWD, ES-202 Series; Calculations by UMDI.

Network Communications: Connecting users with IT systems

The *IT Network Communications* sector facilitates the rapid and reliable transfer of data and information between devices and systems in workplaces and consumer environments. Creating links between individual workstations, servers, peripherals, and other computing devices through wireline and wireless networks is vital to businesses and consumers. Basic and state-of-the-art network communications infrastructure enables businesses to manage operations at multiple sites, and makes it possible for employees to maintain productivity while at remote offices or in telecommuting environments. Access to remote servers and applications, email, telephony, multimedia, and the internet together amplify the computing power and strategic value of individual machines and devices. The network communications sector creates a lifeline between many pieces of computing equipment.

The Network Communications sector includes firms that offer products and services in three subsectors:

- Wireline Providers and Internet Service Providers (ISPs)[6] : Firms in this subsector provide landline telecommunications services, including telephone and cable services, such as the transmission of television programming. Firms provide the services, but not the hardware, required for cable and wired data transfer. ISPs deliver internet access to business and residential customers. In recent years, telecommunications companies have expanded operations into the ISP space.

- Wireless Providers: Firms in this subsector provide wireless telecommunications services including cellular and satellite telecommunications.

- Communications Infrastructure: Firms in this subsector develop, construct, and maintain the basic telecommunications infrastructure, such as power and telecommunication transmission lines, that form the backbone of network communications activities.

Employment and firm growth patterns in the Network Communications sector

During the study period (1998-2008), time series data show that employment in the Network Communications sector has remained comparatively low, hovering at approximately 14 percent of total employment. However, actual employment is contracting within the sector, declining by 15.7 percent over ten years. From peak employment in 2000 and 2008, more than one in three jobs in the sector has disappeared.

Firms followed a different pattern of growth and decline between 1998 and 2008, peaking in 2002 and steadily declining since, but never falling below 1998 levels. During the same period, with employment decreasing by approximately 3,500 workers (2000-2002), the sector grew by 81 firms. The growth rate over the ten-year period (20.5 percent) is on par with growth experienced in other sectors of the IT industry. Unlike in the Hardware sector, a relatively small number of employees are concentrated in each Network Communications firm (only 20 workers per firm); this is equivalent to national ratios of employees to Network Communications firms.

Software: Enabling the operation and utilization of IT systems

Employment and firm growth in the Massachusetts IT industry is now driven, in large measure, by rapid expansion of the *Software* sector. Software firms now serve emerging markets in virtualization, new media, and mobile device applications while traditional software development remains strong (e.g., enterprise solutions for commercial environments, proprietary and open source applications for consumer environments, etc.). Custom computer programming has emerged as a major activity in the Massachusetts Software sector. Firms and employment in the Software sector have increased steadily since 1998.

Figure 6. Massachusetts Network Communications: Employment and Firm Growth, 1998 – 2008

	Massachusetts Network Communications Employment							Employment Growth		
	1998	2000	2002	2004	2006	2007	2008	'98 – '00	'00 – '08	'98 – '08
All Information Technology	205,490	240,048	195,459	169,870	172,019	176,574	178,323	16.8%	-25.7%	-13.2%
Network Communications	29,235	36,134	32,583	26,787	25,498	24,415	24,655	23.6%	-31.8%	-15.7%

	Massachusetts Network Communications Firms							Firm Growth		
	1998	2000	2002	2004	2006	2007	2008	'98 – '00	'00 – '08	'98 – '08
All Information Technology	8,381	10,108	10,445	10,488	9,411	9,708	10,342	20.6%	2.3%	23.4%
Network Communications	1,147	1,440	1,521	1,456	1,266	1,224	1,382	25.5%	-4.0%	20.5%

Source: MIG, Inc; EOLWD, ES-202 Series; Calculations by UMDI.

The Software sector includes firms that offer products and services in two subsectors:

- Systems and Applications:
  Firms in this subsector develop and publish commercial systems software (including operating systems and platforms) on which computer applications run. These firms also develop and publish applications that enable users to complete particular tasks, such as text editing, email communication, and graphics and photo editing, as well as various tasks related to specialized business functions.

- Custom Computer Programming:
  Firms and workers in this subsector are engaged in writing, modifying, testing, and supporting software to meet the specialized needs of customers—both corporate or commercial and consumer or residential. Custom programmers may be employed by small-, mid-, or large-size firms, or they may be self-employed or "freelance" workers.[7]

Employment and firm growth patterns in the Software sector

From 1998 to 2008, employment in the Software sector has grown by 34.6 percent, reaching 47,331 workers. Despite a substantial decline from dot-com bubble levels, Software has regained and surpassed 2000 employment and has shown consistent growth since 2004. The sector most recently accounted for 26.5 percent of all IT industry employment, nearly equal to the IT Services sector.

Software firm counts have seen significant gains as well, with 2008 levels increasing by 53 percent above 1998 levels. Similar to the other core IT sectors, the number of software firms grew during those years when employment declined after the dot-com bust. The number of firms in the Software sector jumped substantially between 2000 and 2002 (by 16.6 percent) and again between 2002 and 2004 (by 10.3 percent). Many of these gains were lost by 2006, but the sector rebounded in 2008, ending the ten-year period with 53.0 percent more firms than in 1998. This may be a promising sign of future growth and the overall health of the sector in Massachusetts.

IT Services: Strengthening organizations and enhancing productivity through customization, service, and support

During the IT industry's early years, many companies focused on providing critical infrastructure, components, and computing equipment to businesses and users. The industry evolved to provide customized software and operating systems for users with different needs. Continued evolution and changing demand sparked the growth of the *IT Services* sector, which assists users and organizations with customization, consulting services, training and support, and data processing and management. As IT products and services become essential to business processes and to the social, financial, and organizational needs of consumers, users at all levels require ongoing customization, maintenance, and strategic expertise that build their IT capacity.

IT Services is a growing sector in Massachusetts and is responsible for a large portion of the overall industry in the state. The sector is the second largest of the core sectors in Massachusetts in terms of employment with 49,939 jobs in 2008 and accounted for the largest number of IT firms: 4,575 or 44.2 percent. These firms have the lowest average number of employees per firm (approximately 11 workers) compared to the other core sectors, though business characteristics (such as company size) vary widely within each subsector of IT Services.

The IT Services sector includes firms that offer products and services in four subsectors:

- Systems Development and Integration:
  Firms in this subsector are engaged in designing, developing or integrating a diverse population of computer platforms and applications into compatible systems. Such integration enables diverse platforms or applications to communicate with one another or builds a single, unified platform to link the network together.

- Computer Support and Maintenance:
  Firms in this subsector provide technical expertise to users,

Figure 7. Massachusetts Software: Employment and Firm Growth, 1998 – 2008

	Massachusetts Software Employment							Employment Growth		
	1998	2000	2002	2004	2006	2007	2008	'98 – '00	'00 – '08	'98 – '08
All Information Technology	205,490	240,048	195,459	169,870	172,019	176,574	178,323	16.8%	-25.7%	-13.2%
Software	35,175	44,324	38,319	35,795	41,682	44,870	47,331	26.0%	6.8%	34.6%

	Massachusetts Software Firms							Firm Growth		
	1998	2000	2002	2004	2006	2007	2008	'98 – '00	'00 – '08	'98 – '08
All Information Technology	8,381	10,108	10,445	10,488	9,411	9,708	10,342	20.6%	2.3%	23.4%
Software	2,251	2,791	3,256	3,593	3,195	3,311	3,445	24.0%	23.4%	53.0%

Source: MIG, Inc; EOLWD, ES-202 Series; Calculations by UMDI.

maintain residential or commercial systems, and troubleshoot issues in order to keep a computer or network in working order.

- Training:
  Firms in this subsector teach a variety of skills to users, from basic to highly technical and specialized knowledge. Training assists users in developing proficiency with particular applications, pieces of hardware, network equipment, or other IT products and services.

- Online Application Service Providers (OASPs), Data Hosting and Processing Services:
  OASPs include firms that develop and distribute a diverse group of applications that are typically accessible online, including web search portals. These applications are provided as services rather than as discrete products (since revenue is generated through advertising or subscription and user fee services). Data Hosting and Processing Services involve building the infrastructure for housing data, hosting it on a server, and performing specialized data analysis or computational tasks for clients. Firms in this subsector may host, manage and distribute web content, applications, or streaming media.

Employment and firm growth patterns in the IT Services sector

In 2008, IT Services accounted for 28.0 percent of total IT employment—slightly higher than Software but several percentage points lower than Hardware. This sector's share has increased slightly since 1998 when IT Services made up 24.3 percent of all IT jobs. Through the boom, bust, and recovery years, the sector follows employment patterns similar to that of the rest of the IT industry. The sector's 2008 employment numbers are almost exactly at 1998 levels. The sector is currently an area of growth for the state's IT industry, as IT Services employment has grown 11 percent in the two years since 2006.

Characteristic of the IT Services sector, there are a significant number of firms with a low employee-to-firm ratio. The number of firms in the Commonwealth increased by 23.8 percent between 1998 and 2008, but did not rebound to above the peak experienced in 2000. Still, by 2008, more than 45 percent of Massachusetts IT firms were considered part of the IT Services sector.

Contributing at the Crossroads: Firms perform multiple functions

This study organizes IT firms into four distinct sectors; in reality, the distinction is not always clear. In many cases, IT firms conduct multiple types of business activities spanning a number of industry codes (and by extension, sectors and subsectors). Such a pattern is not typical in non-technical industry sectors. In a traditional industry, such as insurance or financial services, a firm's primary business activity can be easily identified. Consequently, these firms can be classified using only one or two NAICS codes or business categories. In contrast, IT firms typically engage in several activities that are defined by multiple industry classification codes. For example, online application service providers (including "e-tailers") include firms that may develop software and provide custom support and consulting services. Some of Massachusetts' largest and most prominent firms operate across the boundaries of the four "core" sectors.

In some cases, subsidiaries and larger firms may realize economies of scale by incorporating multiple types of operations into a single enterprise. While companies identify primary NAICS codes for the purposes of reporting to the U.S. Census Bureau, marketwatchers[8] identify and assign an exhaustive list of NAICS codes to individual firms. The research databases show that many IT companies conduct business activities spanning more than one core sector.

To illustrate this pattern, a sample of forty-one well-known IT companies was examined. Industry codes assigned to the companies by the market research databases show that about half of the forty-one companies conduct business activities that span two or more sectors. Nearly 20 percent of the companies are involved in

Figure 8. Massachusetts IT Services: Employment and Firm Growth, 1998 – 2008

	Massachusetts IT Services Employment							Employment Growth		
	1998	2000	2002	2004	2006	2007	2008	'98 – '00	'00 – '08	'98 – '08
All Information Technology	205,490	240,048	195,459	169,870	172,019	176,574	178,323	16.8%	-25.7%	-13.2%
IT Services	49,937	65,339	52,399	43,538	44,958	48,319	49,939	30.8%	-23.6%	0.0%

	Massachusetts IT Services Firms							Firm Growth		
	1998	2000	2002	2004	2006	2007	2008	'98 – '00	'00 – '08	'98 – '08
All Information Technology	8,381	10,108	10,445	10,488	9,411	9,708	10,342	20.6%	2.3%	23.4%
IT Services	3,695	4,598	4,323	4,254	3,929	4,181	4,575	24.4%	-0.5%	23.8%

Source: MIG, Inc; EOLWD, ES-202 Series; Calculations by UMDI.

Figure 9: Selected IT Firms and their Sectors by NAICS Code

● Primary sector ● Additional business activities

	Hardware	Software	IT Services	Network Communications
Cisco	●	●	●	●
Comcast				●
EMC	●	●		
Google		●	●	
IBM	●	●	●	
Microsoft		●		
Verizon			●	●

Sources: Corporate Technology Information Services, Inc. (CorpTech); Dun & Bradstreet (D & B) Marketplace; Alacra.com.

three or more of the core sectors. A variety of different types of firms provide a more concise example (see Figure 9). This figure illustrates primary as well as additional business activities conducted by each of the firms.

In order to remain competitive, firms must evolve their product lines to incorporate new technologies. Firms sometimes grow by acquiring companies with expertise in new technology or service areas. This allows firms to maintain or expand market shares as new demands arise. Several factors aid the process of firm growth. The acquisition of smaller firms by larger ones, extensive knowledge transfer, and a well-organized industry-wide network of employees all may factor into firms' decisions to diversify their IT operations.

Information technology systems do not function in a fragmented way but rather require the coordination of components across firms and across the four core sectors. By providing a full spectrum of complementary and integrated products and services, companies are able to reduce costs and add value. Offering a variety of products and services provides firms with product and sales diversity during times of economic stress and technological change.

Over time, firms may transition primary business activities from one sector to another. International Business Machines (IBM), for example, began in the computer hardware industry and became a billion dollar global corporation. However, the company has since added strategic consulting services and customized software to enhance enterprise systems to its offerings. Similarly, Microsoft, a global leader in software, has attempted to stake a claim in the billion-dollar internet search arena.

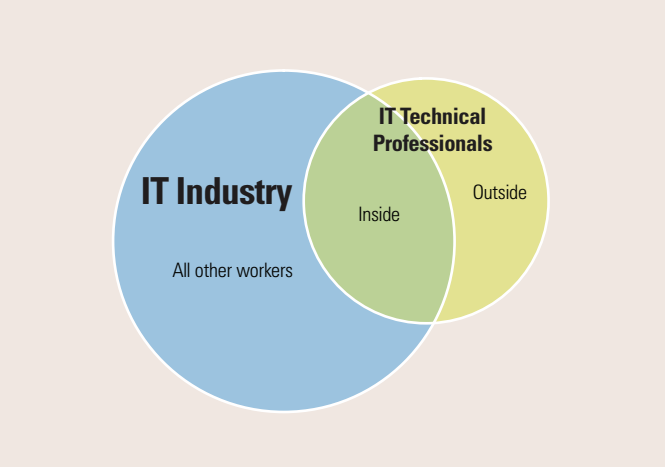
The IT industry as a whole cannot operate and expand without growth in all four core sectors of the industry. For example, mobile technologies cannot advance without innovation in Hardware, Software, and Network Communications. Working across sectors can enhance productivity, innovation, and integration.

The cross-disciplinary nature of the industry is ultimately a catalyst for innovation and is one of the primary ways new technologies are discovered and adopted. Possessing technological expertise across a broad spectrum of essential and related products and services allows firms to plant the seeds of innovation and industrial transformation. Just as the use of IT in other industries has spurred the evolution of technologies, the cross-pollination between the IT industry's core sectors allows for new sectors to emerge and continue the cycle of invention and evolution.

3 The Information Technology Workforce

This section describes key characteristics of the Massachusetts IT workforce. The IT workforce is made up of IT technical professionals as well as other non-technical workers employed within the IT industry. IT technical professionals—workers contributing specific computer and mathematical expertise—work inside and outside of the IT industry. These workers are discussed in the first part of this section. Non-technical workers in the IT industry are workers that are not employed in one of the thirteen technical IT occupations, but in myriad occupations from business development and management to human resources and marketing. These other workers make up the majority of IT industry employment and are discussed in a separate analysis at the end of the section. The figure below illustrates the make-up of the IT workforce in Massachusetts: the Massachusetts IT workforce is composed of IT technical professionals and non-technical employees inside the IT industry, plus IT technical professionals working in other industries, outside of the IT industry.

Figure 10: The Massachusetts Information Technology Workforce



Source: UMDI.

The sector definitions are founded on a functional analysis of the strategic role played by each of sectors; firms are differentiated according to the way in which they contribute to the industry as a whole.

IT Technical Professionals: Working in and outside of the IT industry

Firms need to employ a robust and skilled workforce that understands information technology across all markets in order to be agile and innovative. The **IT technical professional workforce** in Massachusetts is defined for the purposes of this report as workers who contribute computer-related technical expertise, whether working *inside* the IT industry or performing the same function *outside* of the industry. More than 128,500 of these IT technical professionals are employed in Massachusetts—and over half of these professionals work within the IT industry.

IT technical professionals are employed in thirteen **primary IT occupations** (listed in Figure 12).[9] They provide a full range of specific computer-related expertise to the IT industry and also appear in most industrial sectors within the state. The thirteen occupations include programmers, network and database administrators, system and network analysts, hardware and software engineers, information system managers, tech support, and those who research and teach computer science at the collegiate through post-graduate levels. These workers provide the full range of skills fundamental to the production of core information technologies as well as the provision of computer-related services.

Employment in primary IT occupations

Today in Massachusetts, there are more primary IT technical professionals than ever before and while the majority are located within the IT industry, significant and growing numbers of IT workers are making our state's other industries more efficient,

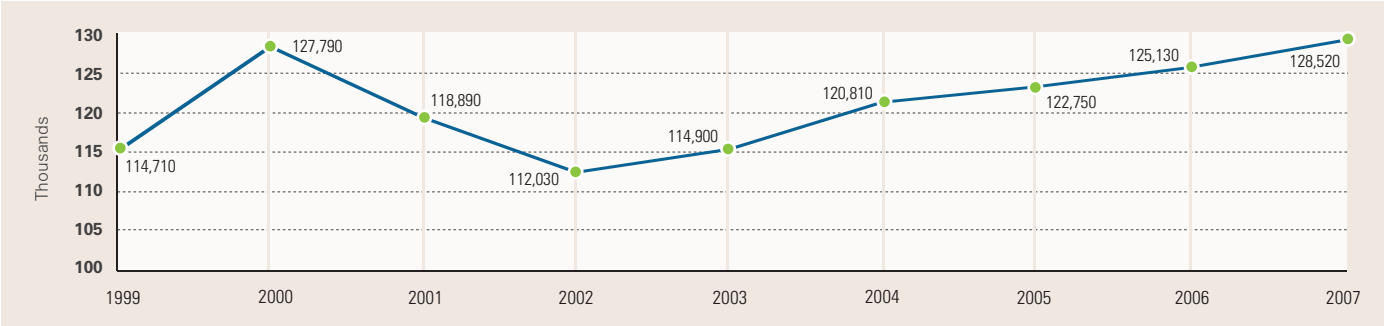
innovative, and competitive. IT professionals in Massachusetts are both exceptionally well compensated and highly educated, and their jobs are projected to grow more than three times the state average by 2016. The Commonwealth also boasts an unusually high density of IT professionals in its workforce: four percent of all Massachusetts workers are IT technical professionals. This is an asset for all types of firms wishing to tap IT-related expertise. While the number of jobs in certain sectors of the IT industry has fallen below its peak, jobs requiring IT expertise are growing across many industries.

Massachusetts is home to a strong contingent of IT professionals employed in nearly every area of the economy. In 2007, 128,520 IT professionals were employed in Massachusetts. More than 40 percent of these professionals are **software engineers**, by far the largest primary occupations.

This workforce has experienced strong growth since 2002—increasing by 16,490 positions or 14.7 percent—in stark contrast to a state growth rate of only 0.2 percent across all occupations, and despite the declining overall workforce in certain sectors of the IT industry. IT professional jobs in the state have rebounded from their low point in 2002, and by 2007, job counts eclipsed peak 2000 levels.

Time series data show that higher-level technical positions in IT are increasing in Massachusetts, while lower-level technical jobs like coding and programming are decreasing in number. Mirroring employment growth trends in software sector firms, most of the increase in the IT professional workforce has come from occupations related to software engineering—and these tend to be high-level technical positions. In 2007, more than 40 percent of all IT professionals were software engineers, by far the most significant of the primary occupations. The state added nearly 9,750 systems software engineering positions between 2002 and 2007, comprising 47.5 percent of the 16,490 IT professional jobs added during that period. Combining both types of software engineers (systems and applications), this group added 14,290 jobs, making up 87 percent of new IT professional positions generated between 2002 and 2007. Several other primary IT occupations made significant relative gains, but no absolute figures are as impressive as the increase of software engineers. On the other

Figure 11: Massachusetts IT Technical Professional Employment, May 1999 – May 2007



Source: BLS, Occupational Employment Statistics (OES) Series.

Figure 12: Massachusetts Employment in Primary IT Occupations, May 1999 – May 2007

Occupation Title	Total Workers 1999	Total Workers 2002	Total Workers 2007	Percent Change 1999 – 2007
Computer Software Engineers, Systems	11,600	14,000	23,750	104.7%
Computer Software Engineers, Applications	24,330	18,600	23,140	-4.9%
Computer Support Specialists	15,680	15,190	16,760	6.9%
Computer Systems Analysts	17,250	18,970	15,170	-12.1%
Computer and Information Systems Managers	12,030	10,890	11,070	-8.0%
Computer Programmers	16,640	12,900	10,010	-39.8%
Network and Computer Systems Administrators	7,340	7,800	9,400	28.1%
Network Systems and Data Communications Analysts	2,300	4,260	5,710	148.3%
Computer Hardware Engineers	2,350	3,470	4,500	91.5%
Database Administrators	3,910	3,900	3,810	-2.6%
Computer Specialists, All Other	N/A	N/A	2,650	N/A
Computer and Information Scientists, Research	830	1,240	1,510	81.9%
Computer Science Teachers, Postsecondary	450	810	1,040	131.1%
Total, Massachusetts Primary IT Occupations	**114,710**	**112,030**	**128,520**	**12.0%**

Source: BLS, OES Series.

end of the spectrum, since 2002 the state has lost many lower-level positions including 3,800 **computer systems analysts** and nearly 3,000 **computer programmers**.

When surveyed,[10] IT companies confirmed the growing demand for software engineers in the Commonwealth. One-third of survey respondents stated that their company has difficulty hiring experienced software engineers. More than 10 percent of companies disclosed difficulty filling entry-level software engineering positions. The loss of computer programming jobs was also noted. During a series of focus groups,[11] several participants described outsourcing to other states or countries as "inevitable." Companies cited the common practice of "farming out" lower-level technical functions, like coding, by hiring more cost-effective, entry-level workers overseas in places like the Philippines and India. Finally, with the exception of computer programmers (this category dropped by 39.8 percent from 1999 to 2007), most IT occupations continue to grow, even in the face of national economic downturns. It remains possible that the loss of computer programmer positions may reflect a redistribution of jobs, such as the retraining of programmers as analysts or engineers.

Wages in Massachusetts

Recent wage data illustrate that IT positions in the Commonwealth are high-value jobs, yielding far higher than average wages across all positions. Taken together, primary IT professionals in the Commonwealth earn almost double the average Massachusetts salary, $42.19 per hour and $87,784 per year as compared to statewide averages of $23.59 per hour and $49,070 per year. Additionally, the mean salary for workers in each of the individual primary IT occupations is also far above that of Massachusetts overall. The large number of software engineers, along with their high salaries, is notable. These findings reveal that Massachusetts IT workers, whether employed by IT firms or companies in other industries, are highly compensated for their services.

Figure 14 highlights the distribution of Massachusetts IT professionals by mean annual salary categories. The majority of IT professionals (84 percent) earn $75,000 or more. Only 13 percent of IT professionals earn less than $60,000 and the mean annual salary of each IT professional occupation is significantly higher than the statewide average across all occupations of $49,070.

Figure 13: Massachusetts Mean Wages and Salaries vs. National Salaries, by IT Occupation, May 2007

Occupation Title	Total Workers	Mean MA Hourly Wage	Mean MA Salary	Mean U.S. Salary
Statewide Total, All Occupations	3,207,840	$23.59	$49,070	N/A
Computer and Information Systems Managers	11,070	$59.53	$123,820	$113,880
Computer and Information Scientists, Research	1,510	$59.15	$123,030	$100,640
Computer Hardware Engineers	4,500	$48.58	$101,040	$94,270
Computer Software Engineers, Systems Software	23,750	$46.43	$96,580	$90,780
Computer Software Engineers, Applications	23,140	$45.95	$95,570	$85,660
Computer Science Teachers, Postsecondary	1,040	*	$90,850	$69,660
Computer Systems Analysts	15,170	$40.59	$84,420	$75,890
Network Systems and Data Communications Analysts	5,710	$39.00	$81,110	$70,760
Computer Programmers	10,010	$37.63	$78,270	$72,010
Computer Specialists, All Other	2,650	$36.96	$76,870	$72,310
Network and Computer Systems Administrators	9,400	$36.08	$75,040	$67,850
Database Administrators	3,810	$35.49	$73,830	$70,260
Computer Support Specialists	16,760	$27.35	$56,890	$45,300
Total, IT Occupations	**128,520**	**$42.19**	**$87,784**	**$79,174**

Source: BLS, OES Series.
*Wages for occupations that do not generally work year-round, full time, are reported either as hourly wages or annual salaries depending on how they are typically paid.

Figure 14: Distribution of Massachusetts IT Technical Professionals by Mean Annual Salary

Source: BLS, OES Series.

Employment and wage comparisons with competitor states and the nation

Massachusetts boasts two impressive figures with regard to its IT industry workforce. First, the state's density of primary IT professionals is higher than that of the U.S. and competitor states, with 4.0 percent of the workforce engaged in IT occupations compared to the national share of 2.7 percent. Massachusetts also bests other tech-centric state economies such as California (3.0 percent) and Texas (2.8 percent). Second, these professionals earn more than U.S. IT workers as a whole, earning average annual salaries that are 11 percent higher than the U.S. average. Average hourly and annual wages were $42.19 per hour and $87,784 per year in the Commonwealth in 2007, and $36.45 per hour and $75,752 per year for all U.S. IT workers. Massachusetts' wages as reported in 2007 were virtually identical to California's, whose primary IT workers earned $42.16 per hour and $87,685 per year.

Massachusetts IT professionals are also heavily clustered in those occupations that are very well compensated; 61.6 percent of Massachusetts IT workers fall into the six highest paying positions, with only 38.4 percent of the workforce in the seven positions that yield smaller salaries. California, by comparison, employs only 55.8 percent of its primary IT workers in these highly paid positions, and nationwide the figure drops to 48.6 percent.

Educational attainment trends

Increasingly, the Massachusetts IT industry seeks and relies on a well-educated workforce. Demand is growing for those in technical occupations with Bachelor's or Master's degrees. Though there are fewer openings for those with an Associate's degree, opportunities for these workers remain. To measure these trends, the Bureau of Labor Statistics assigns each occupation an 'expected level of education and training' based on the most commonly held educational attainment of people actually performing these jobs nationally.

While many occupations with the expectation of higher-level degrees grew robustly, occupations with the expectation of an Associate's degree have grown slowly since the late 1990s. Computer Support Specialists account for 13.0 percent of primary IT professionals, the most popular occupation after software engineering. While there was some growth within this occupation

Figure 15: Employment and Wage Comparison, Massachusetts vs. California, Texas, North Carolina, and the U.S., May 2007

	Total IT Technical Professionals	Total Workers	Share of IT Technical Professionals	Annual Pay Estimate
Massachusetts	128,520	3,207,840	4.0%	$87,784
California	453,010	15,202,530	3.0%	$87,685
Texas	277,500	10,061,750	2.8%	$73,955
North Carolina	97,170	4,013,460	2.4%	$74,394
U.S.	3,569,520	134,354,250	2.7%	$75,752

Source: BLS, OES Series.

Figure 16: Most Common Level of Education, IT Technical Professionals, Nationwide, 2007

Occupation Title	Most Common Education/ Training Level	Total in Massachusetts	Increase/ Decrease	Percent Change 1999–2007
Computer Software Engineers, Systems Software	Bachelor's Degree	23,750	12,150	104.7%
Network Systems & Data Communications Analysts	Bachelor's Degree	5,710	3,410	148.3%
Computer Hardware Engineers	Bachelor's Degree	4,500	2,150	91.5%
Network & Computer Systems Administrators	Bachelor's Degree	9,400	2,060	28.1%
Computer Support Specialists	Associate's Degree	16,760	1,080	6.9%
Computer and Information Scientists, Research	Doctorate	1,510	680	81.9%
Computer Science Teachers, Postsecondary	Master's Degree	1,040	590	131.1%
Database Administrators	Bachelor's Degree	3,810	-100	-2.6%
Computer and Information Systems Managers	Work Experience + Bachelor's or Higher	11,070	-960	-8.0%
Computer Software Engineers, Applications	Bachelor's Degree	23,140	-1,190	-4.9%
Computer Systems Analysts	Bachelor's Degree	15,170	-2,080	-12.1%
Computer Programmers	Bachelor's Degree	10,010	-6,630	-39.8%
Computer Specialists, All Other	Associate's Degree	2,650	N/A*	N/A*

Source: BLS, OES Series.
*Time series data is unavailable for the occupation "Computer Specialists, All Other".

Figure 17: Educational Attainment in Massachusetts Primary IT Occupations, 2005 – 2007

Occupation Title	Associate's degree or less	Bachelor's degree	Master's degree or more
Computer Support Specialists	52.6%	37.1%	10.2%
Network and Computer Systems Administrators	35.6%	51.3%	13.1%
Network Systems and Data Communications Analysts	35.1%	48.8%	16.1%
Computer Scientists and Systems Analysts**	24.8%	50.5%	24.7%
Computer and Information System Managers	24.6%	46.1%	29.3%
Database Administrators	24.4%	47.7%	28.0%
Computer Programmers	19.6%	52.6%	27.8%
Computer Software Engineers*** (Software and Applications)	12.0%	49.1%	38.9%
Computer Hardware Engineers	10.5%	50.7%	38.8%
All primary IT occupations, except Computer Science Teachers	**23.8%**	**48.5%**	**27.7%**

Source: U.S. Census Bureau, 2005-2007 American Communities Survey (ACS).
*This table does not include Computer Science Teachers, Postsecondary
**Contains Computer and Information Systems Managers; Computer Systems Analysts; and Computer Specialists, All Other.
***Contains both Software and Applications Software Engineers.

between 1999 and 2007, it grew at the slowest rate of all growing IT professions.

Though among technical professionals there is an emphasis on having a Bachelor's degree, there are still opportunities for those without. Between 2005 and 2007, 23.8 percent of the Commonwealth's primary IT workers had Associate's degrees or less. During the same period, 48.5 percent of primary IT professionals possessed a Bachelor's degree. In three occupations, more than a third of workers hold an Associate's degree or less: over half of Computer Support Specialists (52.6 percent); Network and Computer Systems Administrators (35.6 percent) and Network Systems and Data Communications Analysts (35.1 percent).

Distribution of IT technical professionals inside and outside the Massachusetts IT industry

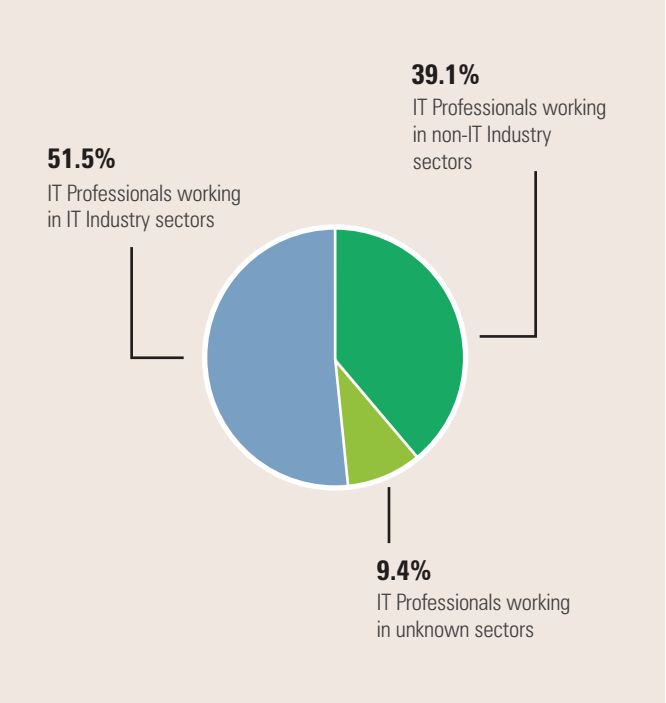
IT products are used and managed in every industry in Massachusetts and significant numbers of IT professionals are employed both inside and outside of the core IT industry. While more than 50 percent of IT professionals work within the IT industry, a large number of IT primary professionals, at least 39.1 percent[12] are supporting other important industries in the Commonwealth.

Primary IT professionals make up at least a third[13] of the total workforce in the IT industry. Outside of the IT industry, primary IT professionals are far less common. Overall, they make up an estimated 4 percent of the total Massachusetts workforce.

Of the primary occupations, Database Administrators are the most likely to be located outside of the core IT industry. Over two-thirds of these positions are found in non-IT related industries. Additionally, four other IT primary occupations are most likely to be found in non-IT sectors: Computer Support Specialists (56.8 percent), Network and Computer Systems Administrators (56.5 percent), Network Systems and Data Communications Analysts (55.5 percent), and Computer and Information Systems Managers (53.6 percent).

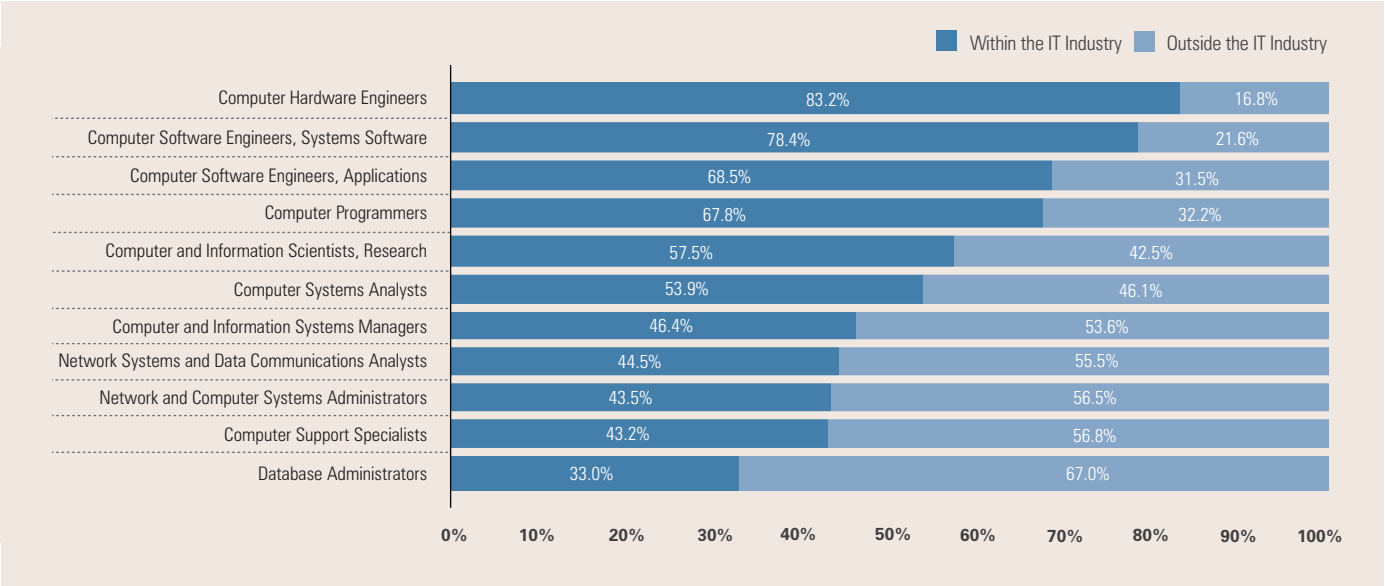
Conversely, engineering and programming positions are more likely to be found inside the core IT industry sectors. These are the production-related IT occupations, with workers responsible for developing core information technology products. More than 80

Figure 18: Distribution of MA IT Technical Professionals in IT and Non-IT Sectors, 2007



Source: EOLWD, Occupations by Industry Matrices.

Figure 19: Primary IT Occupations, Proportions In and Outside of the MA IT Industry, May 2007



Source: EOLWD, Occupations by Industry Matrices.
* Data was unavailable for the following occupations: Computer Science Teachers, Postsecondary and Computer Specialists, All Other.

percent of Massachusetts' hardware engineers work for a firm in the core IT industry. Computer Software Engineers, both Systems and Applications, are also more likely to work within the industry at 78.4 and 68.5 percent, respectively.

Regardless of occupation type, IT workers earn higher wages when employed by firms within the IT industry than by firms in other industries.[14] In all identified primary IT occupations, with the exception of Network Systems and Data Communications Analysts, IT professionals earn more annually working within the IT industry than outside of it. This constitutes an in-IT industry premium[15] that can average up to $15,745 per year *over and above* the average wage or salary earned in the same occupation in other industries (for example, the case of Computer and Information Scientists in Figure 20). In the aggregate, IT professionals earn $45.14 per hour working in any IT occupation within the industry, as compared to $39.38 per hour working outside of it. Network Systems and Data Communications Analysts, the only exception, earned $40.03 per hour inside the industry and $40.38 working outside of IT, an average in-IT industry salary penalty of just over $700 a year. From an economic standpoint, those who implement technology products and services are well compensated, but it is the innovators who conceive and develop new technologies that are getting paid exceptionally well.

IT professionals in IT-intensive industries in Massachusetts

Outside of the IT industry, IT professionals make up an estimated four percent of the workforce. A workforce analysis by industry sector confirms that several non-IT sectors contain unusually high concentrations of primary IT workers. The strong presence of IT professionals within an industry sector suggests a significant level of IT-centered or IT-enabled work (such as technology development or customization) within that sector.

Security and commodity investment activity (17.2 percent) and aerospace manufacturing (13.3 percent) garner the highest share of IT professionals outside of the IT industry. It should be noted, however, that while the share of IT professionals is high, in absolute numbers, aerospace manufacturing is a relatively small sector

Figure 20: MA IT Industry Salary Premiums, May 2007

Occupation Title	Within-IT Industry Premium on Average Salary
Computer and Information Scientists, Research	$15,744.65
Computer Software Engineers, Applications	$13,915.81
Computer Support Specialists	$12,078.35
Computer Programmers	$11,306.99
Computer Specialists, All Other	$10,530.52
Computer and Information Systems Managers	$9,780.27
Computer Systems Analysts	$5,852.24
Computer Hardware Engineers	$4,796.84
Computer Software Engineers, Systems Software	$4,686.22
Network and Computer Systems Administrators	$3,680.15
Database Administrators	$3,538.86
Network Systems and Data Communications Analysts	-$718.03

Source: EOLWD, Occupations by Industry Matrices.
*The difference between average pay in a single occupation, in vs. outside of the IT industry. Computer Science Teachers, Postsecondary work exclusively outside the IT Industry and therefore a premium could not be calculated.

Figure 21: Top IT-Intensive Sectors Outside the IT Industry in Massachusetts

NAICS	Industry	Total IT Professionals	Total Workers in Sector	Share of IT Professionals
5231	Security & Commodity Investment Activity	4,190	24,340	17.2%
3364	Aerospace Product & Parts Manufacturing	1,600	11,990	13.3%
5239	Other Financial Investment Activities	2,770	25,740	10.8%
5417	Scientific Research and Development Services	4,080	39,570	10.3%
5241	Insurance Carriers	4,200	43,550	9.6%
All Codes	**All Industries**	**128,520**	**3,207,840**	**4.0%**

Source: BLS OES Series; EOLWD, Occupations by Industry Matrices.

with less than 12,000 total employees. Scientific research and other financial services sectors also rely on substantial numbers of primary IT professionals.

Current job openings with major Massachusetts corporations, such as Fidelity and Genyzme, confirm the reliance and importance of IT workers to industries outside of the core sectors. This is discussed in greater detail in Section 5.

Current unemployment and projected growth

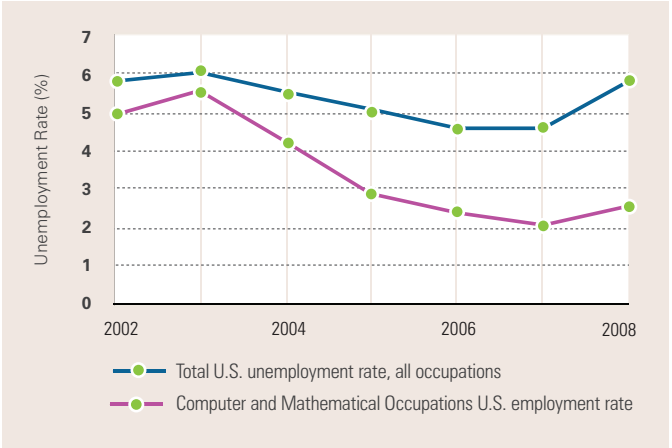
The primary occupations associated with the IT industry have been resilient through 2008. Current Population Survey data indicates how well workers in IT occupations are coping with the current recession. Between 2002 and 2008, the computer and mathematical occupations have enjoyed much lower unemployment rates than the average unemployment rate,[16] consistent with other management and professional occupations. As Figure 22 shows, in addition to being consistently lower than the overall unemployment rate for all occupations, the unemployment rate of the computer and mathematical occupational group also dropped more rapidly than the average between 2003 and 2007. This indicates that computer and mathematical occupations recovered robustly in the years following the bursting of the dot-com bubble.

Current point-in-time data

Recent data illustrate that IT workers have resilience, but are not completely immune to recession. The most recent available monthly data shows that although unemployment is rising, as of June 2009, the unemployment rate for mathematics and computer occupations remains much lower than the average for all U.S. occupations. In June 2008, the monthly unemployment rate for computer and mathematical occupations was about a third of the average. In June 2009, the monthly unemployment rate for computer and mathematical occupations was just over half the average rate.

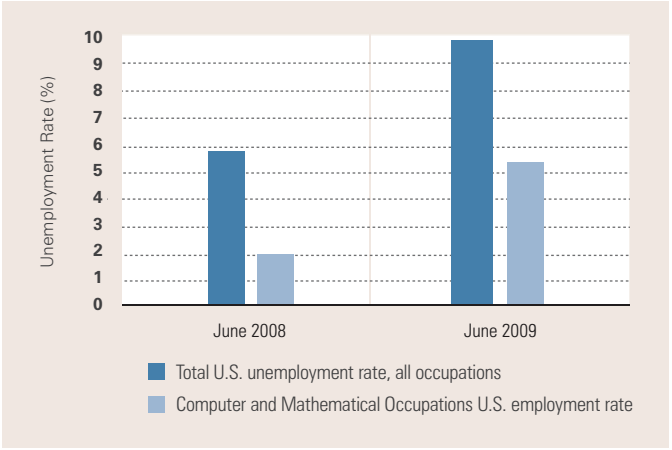
In Massachusetts, workers in IT occupations have been making fewer unemployment claims than their share of the workforce. Claimant data collected by the Massachusetts Office of Labor Workforce and Development indicate that IT workers in computer and mathematical occupations are filing for unemployment benefits at a lower rate than would be proportionate to their

Figure 22: Total Unemployment Rate vs. Computer and Mathematical Occupations Unemployment Rate



Source: BLS, Current Population Survey (CPS) Annual Average Household Data, Table 25: Unemployed Persons by Occupation and Sex.

Figure 23: Monthly Unemployment Rate in June 2008 and 2009 vs. Computer and Mathematical Unemployment Rate



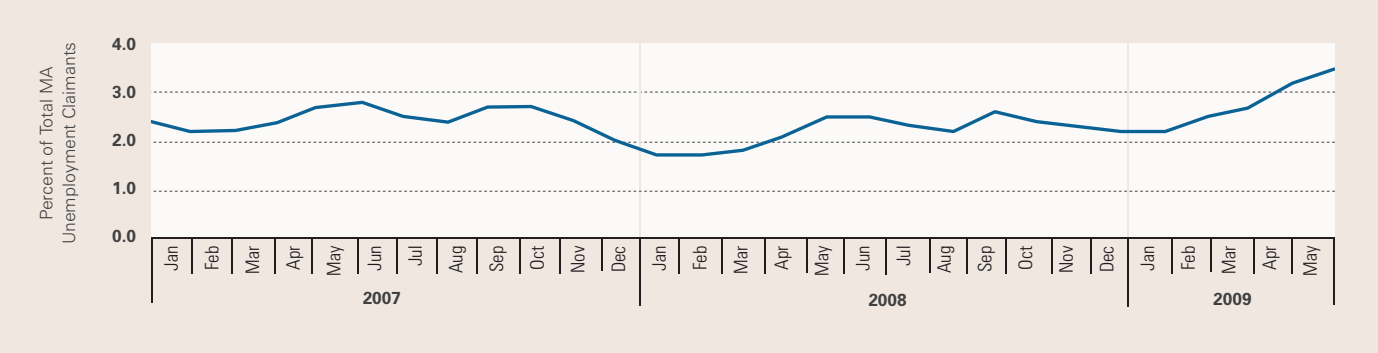
Source: BLS, CPS Monthly Household Data, Table A-30: Unemployed Persons by Occupation and Sex.

percentage of the total state workforce. In May 2008, IT workers in computer and mathematical occupations represented 3.8 percent of all workers in Massachusetts. At the same time, workers in this group made up only 2.5 percent of all claims—representing 997 fewer claims than if they made their 'fair share' of unemployment claims. The chart below indicates that the share of Massachusetts unemployment claims in computer and mathematical occupations remained steady through 2008 and began to experience an uptick after January 2009, representing a larger share of Massachusetts unemployment claims. Although this workforce has been resilient, unemployment in these occupations has been increasing.

Projected growth

Recent growth projections developed by the state suggest that demand for the most skilled IT professionals will remain very strong.[17] Network systems and data communications analysts, as well as the two software engineering occupations, are forecast to experience the greatest gains in jobs by 2016. Alternatively, Computer Support Specialists and Computer Programmers are expected to grow at the slowest pace in the state (in the case of the latter, positions are actually expected to contract). Along with information collected during focus group sessions, the projections suggest that these particular IT occupations are being outsourced to workers abroad. With that said, these are the only two primary IT occupations that are projected to grow at a rate slower than the statewide average for all occupations. The table below features projected growth rates by occupation, and reveals that in many cases, jobs are expected to grow at more than three times the Commonwealth's overall projected job growth rate. High wage jobs are projected to grow and educated workers (with at minimum a Bachelor's degree expected) will be required for the vast majority of these jobs.

Figure 24: Percentage of Massachusetts Unemployment Claims in Computer and Mathematical Occupations



Source: EOLWD, Division of Unemployment Assistance (DUA), Unemployment Insurance Claims Series.

Figure 25: Projected MA Job Growth in Primary IT Occupations, 2006 – 2016

Occupation Title	Total Jobs 2006	Percent Change 2006 – 2016	Net Jobs Differential 2006 – 2016
Network Systems & Data Communications Analysts	7,670	49.5%	3,800
Computer Software Engineers, Applications	23,660	34.9%	8,260
Computer Software Engineers, Systems Software	21,330	24.2%	5,160
Computer Systems Analysts	14,810	24.0%	3,550
Database Administrators	4,240	21.2%	900
Network & Computer Systems Administrators	9,390	20.9%	1,960
Computer Science Teachers, Postsecondary	1,410	17.8%	250
Computer and Information Scientists, Research	1,450	16.9%	250
Computer and Information Systems Managers	10,610	8.9%	940
Computer Hardware Engineers	4,660	6.3%	300
Computer Support Specialists	17,360	6.1%	1,060
Computer Specialists, All Other	2,670	4.9%	130
Computer Programmers	13,100	-2.3%	-290
Sub-total of Primary Occupations	**132,360**	**19.8%**	**26,270**
Statewide Total, All Occupations	**3,454,420**	**6.3%**	**279,650**

Source: EOLWD, Massachusetts Employment Projections, 2006 – 2016.
*This table uses a different data series than that used in previous tables. Therefore, totals differ slightly.

Further illustrating the job growth potential for IT technical professionals, recent job vacancy data show that demand for these workers remains strong even during the current economic downturn. Close to five percent of Massachusetts job vacancies in the second quarter of 2008 were in computer and mathematical occupations, almost twice the number of vacancies for life physical and social science occupations.[18]

All Workers in the IT Industry: IT technical professionals and non-technical employees

For workforce development purposes, it is important to understand the conditions affecting IT technical professionals, but it is also important to understand what is happening within the IT industry as a whole. The previous section examined IT technical professionals both inside and outside of the IT industry. This section focuses exclusively on workers inside the IT industry. The majority of workers in the IT industry are employed in non-technical occupations. When all of these other workers in the industry are considered together with the IT technical professionals, the picture of educational attainment and remuneration broadens.

Educational attainment of all workers in the IT industry

The IT industry employs workers at every level of educational attainment, from non-high school graduates to PhDs, in both the primary IT technical occupations and among the other IT industry workers. Although there is a wide distribution, all workers in the IT industry are more likely to have Bachelor's and Master's degrees than workers in other industries. The IT industry has proportionately fewer workers with Professional school degrees or workers whose educations ceased before completion of high school or just after it. Figure 26 compares the distribution of educational attainment of the Massachusetts workers inside the IT industry to the workers in all other industries in Massachusetts.

Earnings of all workers in the IT industry

When looking at the IT industry workforce overall, nearly all workers in Massachusetts IT firms average higher pay than workers in other Massachusetts industries. Just as primary IT professionals employed in the IT industry earn an "in-IT premium," workers in the IT industry as a whole make higher salaries and wages than workers outside the IT industry. As of May 2007, on average, workers in the Massachusetts IT industry earned $76,278, compared to the average of $46,529 for all other Massachusetts industries. Hourly wages of workers in the Massachusetts IT industry averaged $36.67, while workers in all other Massachusetts industries averaged considerably less at $22.37 per hour.

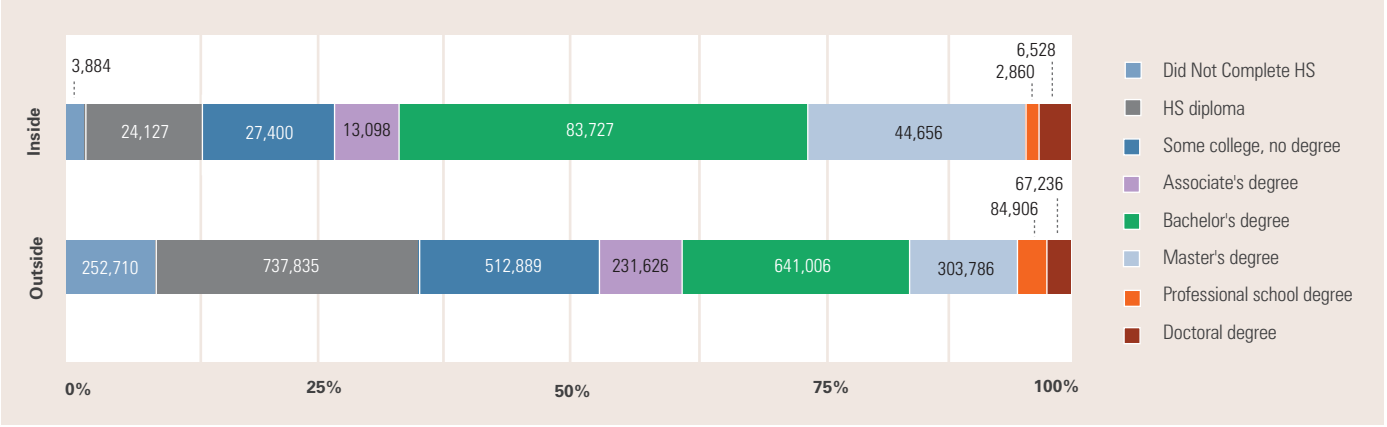
These high earnings in the IT industry include both technical IT professionals in the thirteen primary IT occupations, as well as workers in all other types of occupations working in IT firms. It is possible that salaries commanded by technical professionals raises the IT industry average. However, Figure 28 illustrates that wages within the IT industry for *each* type of occupation are higher than workers' average earnings in the same type of job in a different industry.

Massachusetts workers in each occupational group earn more working in the IT industry than outside of it, with few exceptions. In May 2007, within the eleven occupational groups contributing the most workers to the IT Industry, all groups averaged higher pay working within the IT industry than they did working outside of it, except for transportation and material handling occupations. Management, sales, and arts workers, in particular, earned considerably higher wages and salaries within the industry than they did performing the same jobs in other industries.

Non-technical workers in the IT industry

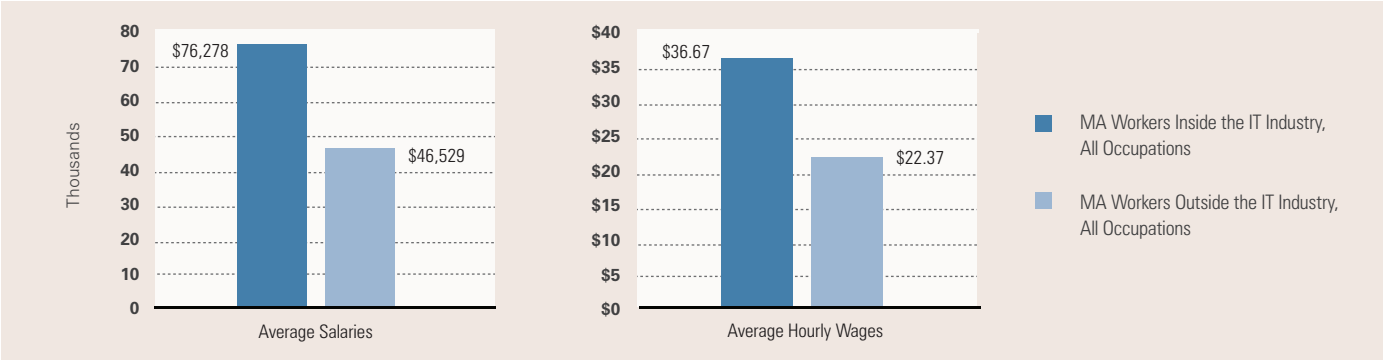
The majority of workers in the IT industry are not employed in technical primary IT occupations. These 'non-technical workers' hold a broad variety of occupations, ranging widely in educational attainment and earnings.

Figure 26: Educational Attainment of All Workers in the IT Industry vs. All Other Workers, MA



Source: U.S. Census Bureau, 2005-2007 ACS.
* Totals differ slightly due to different data source. The ACS data include sole proprietorships and self-employed, and are unsuppressed.

Figure 27: Average Massachusetts Earnings in the IT Industry vs. All Other Industries, May 2007



Source: EOLWD, Occupations by Industry Matrices.

Earnings[19] of non-technical workers in the IT industry

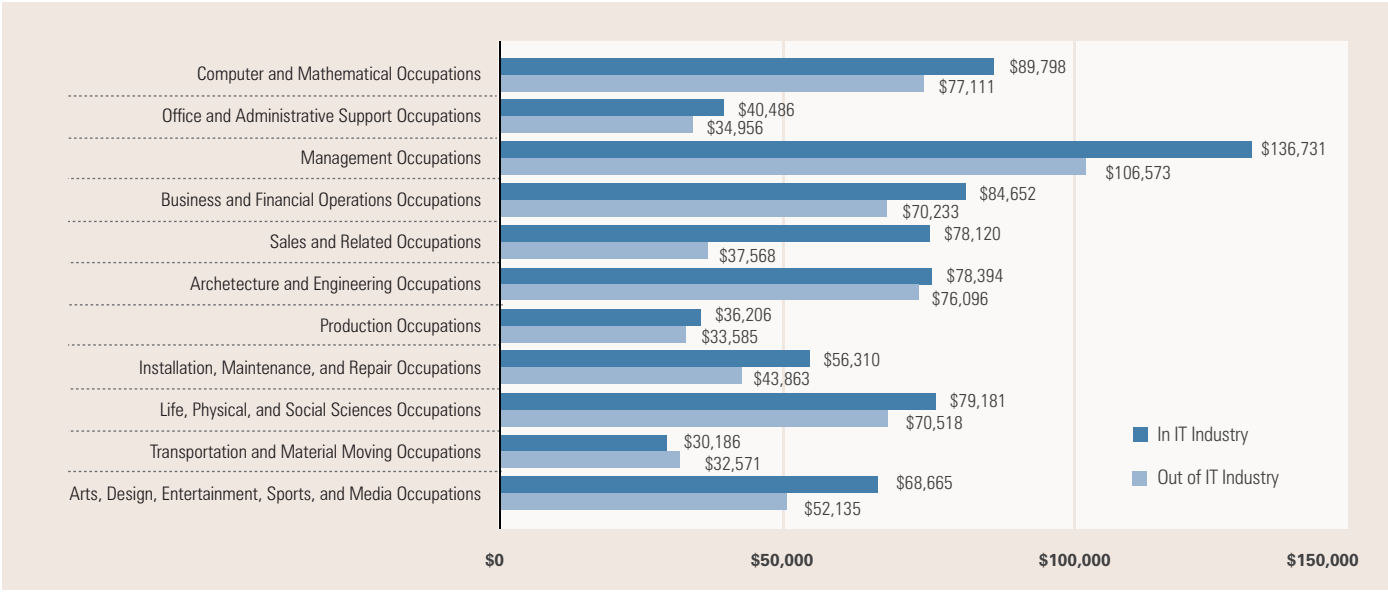
Consistent with overall IT industry workforce trends, individual non-technical occupations within the IT industry earn generally higher than average salaries. The average salaries of the ten most common non-technical occupations are higher than those professionals doing the same job outside of the IT industry. For example, management, sales, and accounting occupations have the largest numbers of non-technical workers within IT firms and boast higher average salaries than in the other industries. Other occupations follow a similar pattern.

The most common occupation amongst non-technical IT workers in the IT industry is Management Analysts. More than 15,000 Management Analysts, often referred to as management consultants in private industry, analyze and propose ways to improve an organization's structure, efficiency, or profits.[20] Over 10 percent of all workers in this occupation in Massachusetts work within the IT industry. The next largest non-technical occupation in the IT industry is Miscellaneous Managers (including Postmasters and Mail Superintendents) with over 13,000 workers. The Wholesale and Manufacturing Sales Representative and Services Sales Representative occupations each contribute over 5,500 workers to the IT industry, followed closely by accountants and auditors, over 5,000 of which work in IT firms. The remainder of the workforce is spread out over a range of different occupations, with each occupation contributing no more than 2.7 percent of the workers employed in that position within the IT industry.

Educational attainment of non-technical workers in the IT industry

Although there are some opportunities for workers with lower levels of educational attainment, the majority of non-technical workers in the IT industry possess a Bachelor's degree or more. However, compared to those in the technical occupations, educational attainment of non-technical workers is more concentrated

Figure 28: Average MA IT Industry Salaries for Relevant Occupational Groups, May 2007



Source: EOLWD, Occupations by Industry Matrices.

Figure 29: Earnings, Ten Most Common Occupations of Non-Technical Workers in the MA IT Industry

SOC Code	Occupation Title	Workers in IT Industry	Average Salary in IT Industry	Average Salary Outside of IT Industry
131111	Management Analysts	15,408	$77,124	$68,412
119190, 119199, 119131	Miscellaneous Managers, Incl. Postmasters and Mail Superindendents	13,697	$106,305	$81,752
414010	Sales Representatives, Wholesale and Manufacturing	6,017	$96,611	$61,701
413099	Sales Representatives, Services, All Other	5,574	$99,832	$63,709
132011	Accountants and Auditors	5,173	$78,132	$61,720
111011, 111031	Chief Executives and Legislators	4,941	$166,207	$142,865
172070	Electrical and Electronics Engineers	4,905	$91,370	$80,113
172161, 172199	Miscellaneous Engineers, Including Nuclear Engineers	4,851	$84,828	$81,841
112020	Marketing and Sales Managers	4,648	$110,809	$84,835
436010	Secretaries and Administrative Assistants	4,030	$39,845	$30,268

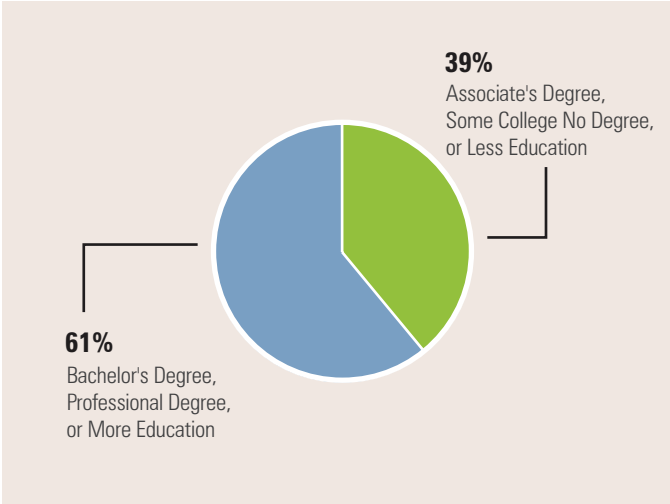
Source: Census ACS 2005-2007; EOLWD, Occupations by Industry Matrices.

in Associate's degrees and less. Approximately 18 percent of the primary technical workers in the IT industry have an Associate's degree or less education, while 39 percent of all other non-technical workers in Massachusetts' IT industry possess an Associate's or less.

In the top ten most common occupations of non-technical workers, over 77 percent of Secretaries and Administrative Assistants in the IT industry possess an Associate's degree or less. In addition, over a quarter of Wholesale and Manufacturing Sales Representatives and nearly 20 percent of Services Sales Representatives and Electrical and Electronics Engineers do not hold a Bachelor's degree.

Overall, the IT industry workforce in Massachusetts is highly educated and well compensated, particularly the IT technical professionals working both in and outside of the IT industry. Although employment levels of certain sectors of the industry are declining, certain technical occupations are projected to grow at substantial rates between now and 2016.

Figure 30: Educational Attainment, All Non-Technical Workers in the Massachusetts IT Industry



Source: U.S. Census Bureau, 2005-2007 ACS.

Figure 31: Educational Attainment, Ten Most Common Non-Technical Occupations in the MA IT Industry

SOC Code	Occupation Title	Associate's Degree or Less	Bachelor's Degree	Master's Degree or More
436010	Secretaries and Administrative Assistants	77.5%	21.2%	1.3%
414010	Sales Representatives, Wholesale and Manufacturing	28.3%	53.7%	18.0%
119190, 119199, 119131	Miscellaneous Managers, Incl. Postmasters and Mail Superintendents	23.3%	44.0%	32.7%
413099	Sales Representatives, Services, All Other	19.6%	62.8%	17.6%
172070	Electrical and Electronics Engineers	19.1%	44.2%	36.7%
112020	Marketing and Sales Managers	18.4%	54.1%	27.5%
172161, 172199	Miscellaneous Engineers, Including Nuclear Engineers	17.1%	45.5%	37.4%
132011	Accountants and Auditors	12.8%	58.3%	28.9%
111011, 111031	Chief Executives and Legislators	12.1%	38.1%	49.8%
131111	Business Management Analysts	7.3%	37.0%	55.7%

Source: U.S. Census Bureau, 2005-2007 ACS.

4 Why is the IT Industry Important for Massachusetts?

The data provided on the IT workforce offer a detailed look at the health of IT firms and individual workers who serve an IT function either inside or outside of the four core sectors of the IT industry. Although the economic well-being of these small groups of firms and workers is paramount to the Commonwealth's success, it is also imperative to examine the greater economic, industrial, and intellectual impact of the IT industry on the state. As a keystone to an "innovation economy," IT firms and professionals contribute many direct and indirect benefits to the state.

Economic Contribution to the Larger Economy

An analysis of the IT industry in Massachusetts[21] reveals that the industry is a major contributor to the state economy. In 2008, the IT industry is estimated to have spent $65 billion on operating and payroll costs (direct expenditures). We estimate that the economic activity resulting from these expenditures supports an additional $47 billion of spending (including $28.4b in indirect expenditures and $18.5b in induced expenditures) within the Massachusetts economy. In addition to driving private growth, the industry also contributes significant amounts to public coffers at the federal, state and local levels. The cumulative effects (direct, indirect, and induced) of spending by the Massachusetts IT industry and its suppliers is estimated to result in an additional $14.7 billion in taxes and fees to federal, state and local governments. Employment impacts are also significant. In addition to 178,323 workers directly employed by the industry in 2008, approximately 290,122 workers are supported through the combined effects of operational spending by Massachusetts IT firms and the household spending of employees.

It is noteworthy that the Massachusetts IT industry employs 5.5 percent of Massachusetts workers and its output is comparable in scale to nearly 18 percent of state GDP. The extraordinary scale of the IT industry in Massachusetts reflects the very high value-added nature of industry activities and very high productivity of its workforce.

Indirect and induced economic contributions

Annual spending by the IT industry was $64.9 billion in 2008, and this spending generated an additional $46.9 billion in indirect and induced contributions.

Indirect contributions

Industry spending stimulated local suppliers and contractors to purchase an estimated $28.4 billion of local goods and services. This economic activity supported an additional 153,308 jobs with $9.5 billion in annual payroll. The largest beneficiaries of IT spending include the IT industry itself (IT firms consume a significant amount of IT products and services), as well as professional services firms and the real estate sector. The Massachusetts IT industry's indirect impacts are particularly notable in wholesale trade (presumably for purchases of equipment and supplies), management of companies

Figure 32: Economic Contributions Generated by 2008 Spending in the MA IT Industry

	Direct	Indirect	Induced	Total	Multiplier
Output	$64.9B	$28.4B	$18.5B	$111.9B	1.72
Employment	178,323	153,338	136,784	468,415	2.63

Source: MIG, Inc.; UMDI.

and enterprises, computer storage device manufacturing, telecommunications, real estate establishments, semiconductor and related device manufacturing, and scientific and technical consulting.

Induced contributions

Consumer expenditures by employees of the IT industry supported an additional $18.5 billion of spending in Massachusetts and generated another 136,784 jobs in Massachusetts, with a total annual payroll of $6.0 billion. Consumer purchases in Massachusetts had the largest impact on the real estate and healthcare sectors. Other major impacts are felt in healthcare-related areas such as private hospitals and medical offices, in wholesale trade businesses, in food services and drinking places, and with insurance carriers.

Multiplier effects

The relationship between IT industry spending and the total economic effects generated by the spending illustrate that the IT industry's multiplier effect on Massachusetts is 1.72.[22] For every one hundred dollars spent in Massachusetts by the IT industry, an additional $72 is generated in the economy.

The industry's employment multiplier effect on Massachusetts is 2.63, which means that for every one hundred IT jobs, an additional 163 jobs are created by other firms in the state as a result of the cluster's local purchases and the consumer expenditures by its employees.

Tax contributions

The Massachusetts IT industry contributes to public coffers in significant ways. The total cumulative effect of 2008 spending by the Massachusetts IT industry is estimated to result in $14.7 billion in taxes and fees to federal, state, and local governments.[23] The federal government received an estimated $9.1 billion in taxes and fees as a result of direct, indirect, and induced spending effects. Major components of this total include personal income tax payments, social security contributions by employees and firms, and corporate profits taxes. State and local tax effects totaled $5.6 billion, and major components included business property tax payments, sales taxes, and personal income taxes.

Summary of economic contributions

This analysis confirms the major role played by the IT industry in contributing economic value in the state. Spending by IT firms and their employees in Massachusetts makes a significant contribution to cumulative state economic activity. With combined economic effects of $112 billion from 2008 operations, payroll,

Continued on page 31.

IT as a Contributor to Productivity

This section is based on a literature review of current economic theory on the important role played by IT in increasing productivity throughout the economy.

Current economic theory provides evidence that the products and services offered by the IT industry have generated dramatic, positive impacts within the economic system. Productivity increases have caused some of the largest economic effects.

Productivity impacts

IT has stimulated economic growth by increasing productivity. Since the early 1990s, an acceleration of improvements in IT manufacturing sectors that produce computer hardware, peripherals, semiconductors and software lowered prices for those products, increasing IT implementation in many industrial sectors.[24] The increase in productivity stimulated by the IT sector was the single largest driver of economic growth in the U.S. between 1995 and 2000.[25] Since then, IT's ongoing impact on productivity rates has been less dramatic, but IT has remained a leading driver of economic growth from 2000 on, remaining the single most important contributor to productivity growth. The implementation of IT spurs firms' labor productivity in particular. IT also can facilitate additional forms of efficiency. It is unclear if the high rates of productivity growth enjoyed by the sectors that make and use IT can be recaptured or if the current rates can be sustained. However, it is clear that when implemented thoughtfully, IT can increase efficient use of resources, including energy, while increasing worker productivity.

Productivity describes doing more with the same amount of time or resources. Most of the growth in our economy comes from productivity growth. Even a small increase in the productivity rate can have a large overall effect on the economy if the increase is sustained over several years, because in each year there is an increase in productivity at that slightly higher rate. The U.S. recently enjoyed a period of markedly increased productivity rates; productivity nearly doubled in the period between 1995 and 2000. Labor productivity, driven by continuous IT refinements as well as

continued adoption of IT in business practices, has been a major component of the recent increase in productivity.

Labor productivity: A key driver of growth

Labor productivity is a principle driver of economic growth. It is defined as a worker's output per hour of work.[26] As workers become comfortable with new technologies, their greater efficiency increases productivity, i.e., workers producing more in the same amount of time. Like other forms of equipment, information technology makes it possible for people to produce the same amount of output in less time. However, IT contributes substantially more to labor productivity growth than capital investment in other equipment does.[27]

IT adoption between 1990 and 1995 was not immediately attended by large productivity gains. This illustrated that gaining more technology per person does not immediately equate to increased productivity growth. A productivity takeoff around 1995 suggested that there may simply be a lag between the purchase of IT and increases in productivity: it takes time for workers to maximize their productivity using new technologies. Productivity is increased after the technology is integrated into the firm's business processes and after workers have fully learned how to use the IT product.

Productivity trends

IT became an important contributor to productivity trends in the early to mid-1990s. One team of researchers reported past productivity rates to be at about 1.5 percent per year from 1973 to 1995, with two-fifths of the productivity caused by IT manufacture and use, leaping to about 2.8 percent per year from 1995 to 2000, about three-fifths of which was due to IT. Since then, according to the study, IT's role dropped somewhat, accounting for about one-third of the approximately three percent productivity rate from 2000 to 2005.[28] Despite drop-off since 2005, the productivity rate from 2000 to 2005 has inspired some optimistic forecasts.

It is unclear if IT will ever return to its mid-2000s levels of contribution to productivity growth, or even sustain its current level of productivity growth. Recent positive productivity growth trends have quelled some of the concern, but data do not yet reflect the effects of the current recession. Some researchers have examined the potential of the IT industry to raise productivity levels again, through innovation and improvements fueling future reinvention of the industry.

Based on research from the Congressional Budget Office and the Council of Economic Advisors, the Federal Reserve Bank of New York staff predict sustained growth for the next decade at a level slower than the most recent decade but a sustainable level of 2.5 percent per year. Current financial conditions should modify this prediction. Another part of the equation will be how much future innovations in IT allow workers to capture labor productivity gains, as well as the nature of improvements made within the IT industry, and how wisely new IT investment is used by firms.

Enhancing IT's productivity through wise implementation

Although innovation in the manufacture of IT helped fuel economic growth, the use of IT products in businesses only allows for increases in productivity if implemented well. As one IT researcher put it, "most businesses already know that computers aren't an end in themselves. While the thousand-fold improvement in the price/performance of information technology over the past 30 years is a credit to the industry, IT creates value only if it lets users work more effectively."[29] Thoughtful implementation of IT can also capture efficiencies through reductions in energy consumption, sometimes at the same time labor productivity is increased.

Increases in energy efficiency are another way IT contributes to economic growth. By doing more with less, resource efficiency contributes to overall industrial productivity. The productivity gains and efficiency improvements that have been realized through the use of technology may more than offset the energy used to power individual systems. This increased efficiency can permit businesses to increase their productivity, using less energy to complete the same, or greater, amounts of work.

Impending climate change and fluctuations in energy prices have intensified concerns over the energy demands associated with a technology-driven economy since the 1970s. Recent research shows earlier estimates of computer and peripherals' energy use may have been overstated, and additional innovations continue to improve energy efficiency. The technological innovations and productivity gains of the late 1990s facilitated a national decline in energy intensity. Today it takes less than half the energy to produce a dollar of economic output as it did in 1970. It took 9,000 BTUs in 2008 to produce a dollar of economic output. IT "has helped reduce the level of energy resources consumed for each dollar of economic output, resulting in an average annual decline in energy intensity of 2.4%."[30]

Efforts to increase energy efficiency through wise application of IT include telework, efficient delivery routing, and dematerialization (such as **virtualization**, through

the reduction of paper and fuel for transportation with the use of email instead of physical documents, and technologically aided material use reduction such as double-sided receipts). Overall energy productivity is also being improved by reducing the energy needed to design, manufacture, and distribute IT devices and equipment. The operating efficiency of the technologies once they are installed and functioning can also be increased, as Dell does with programs installed in the computers in their offices that shut down computers when not in use.[31] IT can also optimize the performance of other energy-using systems such as controlling lighting and heat systems for efficient use. In addition, IT-based services can sometimes be substituted for goods and services produced and procured less efficiently. Just as the multiple methods of capturing energy efficiency are diverse, businesses are able to implement productivity strategies using these different energy tactics, as well as choices that increase labor productivity to upgrade current practices or when planning new ventures.

Coordination to increase labor productivity and energy efficiency

Labor productivity gains and energy efficiency can both result from a single implementation of IT. That implementation is effective when done thoughtfully. It can be completed within an operations planning process before a venture is running, or done on the fly to upgrade business processes. UPS has upgraded the way they deliver, using less fuel and reducing their drivers' time per package with sophisticated routing software and GPS units that plot the shortest delivery courses given multiple destinations while minimizing time spent idling at left-hand turns. A regional green computing venture between Accenture, EMC, and Cisco for MIT, UMass, and Boston University called the Holyoke High-Performance Computing Center will share a computer cluster facility that is hydro-powered by the Connecticut River, cooled by Holyoke's canal system, and utilized remotely over a high-speed network.[32] Such projects, whether put into place ex post facto or planned from the start, can reduce energy needs and increase labor productivity simultaneously. Similar types of innovations and thoughtful utilization of IT may sustain the growth rates the IT industry has helped drive over recent years.

The benefits that firms are able to reap as thoughtful end-users of IT are predicated on these types of productivity and efficiency gains. Although these processes transpire at the firm level, IT can also be leveraged on a broader scale to transform entire industries, both in the core IT sectors and in the rest of the economy. Massachusetts' innovation economy makes it particularly able to take advantage of these larger transformative processes that IT can fuel.

and household spending, this industry is a major contributor to private growth in the Commonwealth. Another significant, positive economic contribution comes through the combined effects of corporate taxes paid by firms in the sector and their suppliers along with personal tax payments made by IT industry employees and supplier employees. With 2008 tax impacts of an estimated $14.7 billion, the Massachusetts IT industry clearly contributes in important ways to public fiscal health.

At the Nexus of Innovation: Transforming existing markets and catalyzing new ones

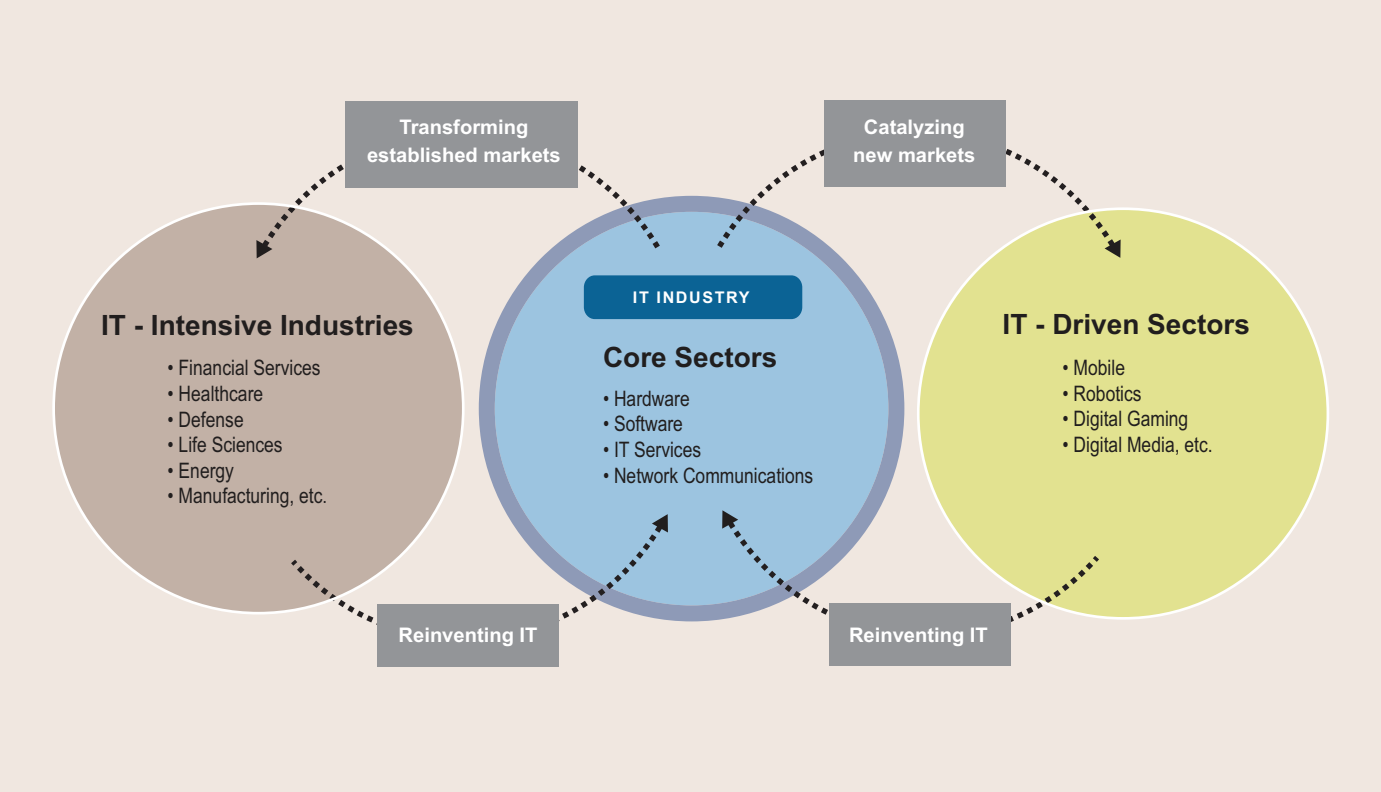
Although the quantified economic benefits of the industry are massive, there are myriad other qualitative IT benefits that have helped to refashion the Commonwealth's "innovation economy" in recent years. The core information technology sectors have played a transformative role in historically strong Massachusetts industries like financial services, life sciences, and defense, fundamentally changing the economic and industrial landscape.

Information technologies have also enabled the evolution of new digital sectors borne out of the Commonwealth's traditional strengths in advertising and marketing, graphic design, media and communications, and retail and wholesale trade. The region's established strengths have enabled the growth of new business applications for robotics and artificial intelligence and entirely new sectors like digital media and gaming.

The process by which these industries and markets interact fosters innovation, growth, and economic competitiveness. The relationship appears to be symbiotic, with growth and change in the IT industry having a positive effect on other markets, and vice versa (see Figure 33). Over time, the core IT industry reinvents itself by developing new technologies, products, and services in order to meet changing market demands. As new technologies, products, and services are developed, some existing IT-intensive industries are transformed and new industries or markets are catalyzed and created. The Massachusetts economy is nurtured by a climate that places high value on innovation, research, and development; replenishes its intellectual capital; and is committed to supporting its existing and established industries.

In the presence of an "innovation economy," a company's market share, productivity levels, workforce composition, product and

Figure 33: Massachusetts Information Technology Ecosystem



Source: UMDI.

service offerings, revenues, and general firm health are changed. Industry data and research reveal the extent to which Massachusetts' key industries—and the state's economy as a whole—influence and are influenced by the IT industry.

Reinventing the IT industry

Well-established Massachusetts industries have increasingly incorporated IT into their business practices. More important than simply using available products, these industries demand more sophisticated technology solutions in order to maintain productivity, expand their own lines of products and services, stay ahead of global and domestic competitors, and comply with regulations (such as in the case of privacy requirements for electronic health records). Emerging and expanding markets and industries such as artificial intelligence, advanced robotics, and digital media and gaming bring forth concepts and ideas that drive the IT industry to create new applications, hardware, and complex or advanced services. Here in Massachusetts, the IT industry's agile business environment has stimulated a reinvention seen in the areas of security, efficiency, and mobility.

Reinventing security

The Massachusetts IT industry has responded to the security needs of established and emerging industries by refining existing products, and by evolving the types of services offered. Notably, from 1998 to 2007, the number of workers engaged in "**custom computer programming**"—which includes security programming activity—doubled to more than 22,000 individuals. During the same time period, the number of firms that provide custom computer programming services more than doubled, topping 2,600 firms in 2007. In terms of both employment and firms engaged in these services, Massachusetts' growth rates far outpaced those seen in California and in the U.S. as a whole.

Interest in advanced and next-generation IT security is backed by investment: three of the top eleven subsectors[33] receiving venture capital dollars in Massachusetts specifically relate to security. Between 2006 and 2008, venture capital firms and investors financed more than $500 million across more than 70 individual deals. The high level of investment in Security/Firewalls and Encryption Software, Backup and Disaster Recovery, and Internet Security and Transaction Services allows the Commonwealth's IT industry to make major strides in improving products and services. In the latter two subsectors, Massachusetts outpaces California in total investment, positioning the Commonwealth to be a leading innovator in security technologies.

Reinventing efficiency

To be sure, high levels of efficiency and productivity are essential to realizing economic success (namely in the form of increased revenues). Very recent advancements in **virtualization** and

cloud computing are indicative of the IT industry's commitment to boosting computer- and technology-based efficiency.

The IT industry and Massachusetts state leaders are paying close attention to developments in virtualization technologies. While still in its early stages of research and development, the University of Massachusetts Amherst has partnered with Yahoo, Inc. along with Carnegie Mellon University and the University of California, Berkeley to research cloud computing. Ultimately, virtualization and cloud computing technologies can improve efficiency and result in cost savings for organizations. The Massachusetts' IT industry's ability to create cutting-edge virtualization technology stands out as another indicator of the industry's ability to reinvent itself in service to its customers in both established industries and emerging markets.

Reinventing mobility

While efficiency gains in corporate and commercial environments can be realized through virtualization and cloud computing, increased mobility can also provide real value to consumers and individual users. There have been major achievements in the conceptual and technical development of mobile devices and applications. Some Boston-metro area firms are now providing GPS-enabled location-based services (LBS) and companion applications to create a fully connected driving environment for users.

Survey and focus group participants agree that 'wireless and mobile' is important in Massachusetts. Nearly a quarter of firms surveyed felt that it represented a growth opportunity in the next five years and over one in five respondents cited Massachusetts as a technology leader in this area. Focus groups were in unanimous agreement that wireless and mobile presents a large, near-term opportunity for Massachusetts to grow and dominate.

Success in this area has been sponsored in large part by a huge amount of venture capital investment in wireless services and mobile communications. According to an analysis by Mobile Monday Boston, from 2006 through 2008, Massachusetts received more than $1.2 billion in 166 deals in areas relating to mobile and wireless activities. Specific investment areas included wireless communications services and components, mobile communications, messaging services, and handheld devices. There also appears to be a critical mass of mobile companies in the Commonwealth: the Mobile Monday Boston membership list cites more than 85 mobile companies with widely varying focuses, including advertising, finance, security, and search.

Transforming existing industries

Transformation and evolution are critical elements of any industry's continued success. Investments in new tools and equipment, integration of workers with IT functions and roles, and adaptation to new business and management practices are essential for turning economic difficulties into opportunities for achievement. The manufacturing, defense, financial services, and healthcare industries have been transformed by the devices, tools, and other hardware offered by the IT industry.

Investing in new tools and equipment

Individual U.S. companies[34] spend millions each year on IT tools and equipment. Between 2003 and 2007, expenditures on information and communication technology equipment totaled more than $1.21 trillion (nominal dollars). On average, U.S. companies spend $2.28 billion per year on items such as purchase and leases for computer and peripheral equipment, software development, and software licensing and service agreements. In 2007 alone, this spending accounted for 20.7 percent of total capital expenditures by all companies, including individual proprietors. This is consistent with the prior years' data, as technology spending accounted for anywhere from a low of 19.3 percent in 2006 to a high of 23.3 percent in 2003. In real dollars, the current range of annual spending on IT and computing equipment is $229.3 billion to $264.2 billion.

The finance and insurance sector and the manufacturing sector each invested billions of dollars each year in software and equipment, accounting for anywhere from 13 to 20 percent of total annual spending. These investments add up; the finance and insurance sector spent a total of $231 billion (in nominal dollars) between 2003 and 2007, and the manufacturing sector spent a total of $168 billion. It is expected that as the IT sector turns out even more innovative and sophisticated products, industries such as professional services and healthcare (currently ranking third and fourth, respectively, in terms of annual share of IT and computing spending) will continue to invest in technology equipment and software to improve their business processes and models.

Integrating workers with new functions and roles

The prevalence of employees in essential IT occupations and activities located in non-IT industries also demonstrates a heavy reliance on IT products and services across the economy in Massachusetts (e.g., data security and management, electronic communications, remote file access and file sharing, and many others).

Figure 34: Capital Expenditures in Nominal Dollars, U.S.

	2003 ($m)	2004 ($m)	2005 ($m)	2006 ($m)	2007 ($m)	Total ($b)
Total capital expenditures	$983,800	$1,047,500	$1,146,000	$1,309,400	$1,277,400	$5,764
Total expenditures for ICT equipment and computer software	$229,267	$231,943	$235,830	$253,017	$264,213	$1,214
Total equipment expenditures	$131,066	$125,316	$131,593	$138,305	$144,511	$671
Total computer software expenditures	$98,201	$106,627	$104,237	$114,712	$119,702	$543
ICT Share of Total Capital Expenditures	**23.3%**	**22.1%**	**20.6%**	**19.3%**	**20.7%**	**21.1%**

Source: U.S. Census Bureau, Information and Communication Technology Survey, 2007.

The unique diffusion of IT-related personnel across the Massachusetts economy has transformed several sectors, including financial services, defense, healthcare, and the energy sector.

As demonstrated in Section 3, the largest percentage of IT professionals working outside of the IT industry is found in financial services (14,820 IT professionals or about one-third of all IT professionals working outside of the IT industry). As of 2007, the financial services industry employed more than 174,000 workers throughout Massachusetts; 8.5 percent of those workers were IT professionals. The inclusion of IT professionals in the financial services workforce requires shifts in the capabilities of human resources managers and staff to understand and articulate specific technology needs, screen and hire capable IT professionals, and forge connections with managers in other non-IT industries whose products and services are IT-enabled. As of mid-2009, more than one-third of the employment opportunities available with Fidelity Investments were IT occupations (36.0 percent of 119 position announcements sought software engineers, data warehouse architects, database managers, and other entry-, mid-, and senior-level IT professionals). Even more striking, 77.0 percent of those IT positions were based in the Boston-metro area.[35]

The same kind of investment in recruiting IT professionals appears in the healthcare and biotechnology sectors. A point-in-time census of current positions available with Genzyme, Inc.—one of the world's leading biotechnology companies—shows that 11 percent of job openings (51 of 469 positions) are classified as "biotechnology" or "information technology" jobs. Again, a large majority (80.0 percent) of these technology-related positions are located in Massachusetts.[36]

Today, IT professionals are also spread throughout the defense industry, developing software and navigational systems, providing technical and professional services, and manufacturing aerospace equipment. Notably, a large proportion, 71.4 percent, of the IT professionals found in the manufacturing sector are clustered in Aerospace Product and Parts Manufacturing. As in the financial services industry, the prevalence of IT professionals in defense-related companies and firms transforms the character of the workplace, mandating a workforce with educational and professional experience in computer programming, hardware development, network communications, database administration and security, and many other core IT capabilities. Several economic researchers have purported a close connection between a firm's innovative capacity and its emphasis on human resources and hiring practices. Research appears to show that human resource strategies "play a key role in service sector innovation" by emphasizing the recruitment of skilled workers.

Adapting to new business and management practices

As technology products, from custom software applications to data storage hardware, become embedded in an industry, it becomes better equipped to expand or change its products and services, requiring adaptation to new business and management practices. For example, a financial services firm that is able to provide its customers with safe and secure online data or account access has been irrevocably transformed by the IT industry. At the same time, a life sciences firm that today can store vast amounts of genetic mapping data that enables advanced research has also been transformed by the IT industry. Massachusetts healthcare consumption has been changed by services like e-prescriptions; the Commonwealth leads the nation in the use of electronic prescription services with 20.5 percent of all prescriptions routed electronically in 2008.[37] This is more than five times the national average and represents a doubling of the 8.9 percent rate seen in 2006.

The financial services industry is perhaps one of the most dependent upon IT for the day-to-day functioning of its operations. Markets work at the speed of information where milliseconds equate to millions of dollars lost or gained. Computer software models are integral to the trading platforms of money managers in making decisions on when, how, and where to move positions. Controlling costs are a top priority of management in this industry, where competition stretches profit margins thin. IT produces cost savings by improving efficiency and increasing productivity of the industry's workforce and networking capabilities. IT also strengthens customer service through automated account access, 24/7 support, online banking, and interactive capabilities. The swift exploitation of network communications technologies has been integral to that industry's success.

Other business process improvements that have transformed existing industries have their roots in the IT industry. Consultation with the **Project Management Body of Knowledge (PMBOK)**, project manager certification, and techniques like the **scrum approach** and **agile project management** (or product development) are now used outside of the IT industry. According to the Project Management Institute (PMI), there are more than 331,000 certified Project Management Professionals (PMPs) at work in companies inside and outside of the IT industry. Managers in the defense, healthcare, and other Massachusetts industries see gains in productivity and success in meeting goals by applying these IT tactics.

Catalyzing new sectors and markets

In recent years, some brand new industry sectors have emerged or been catalyzed by the IT industry. They are characterized by high levels of innovation and often grew from the vibrant interactions of professionals with different skills and experiences. The propitious combination of technology tools plus a critical mass of skilled thinkers and professionals sets the stage for industrial evolution. In Massachusetts, the robotics, **digital media**, and collaboration tools sectors are three relevant examples of the power of the IT industry to stimulate activity in new markets.

Triggering advances in robotics

Robotics is a diverse industry with commercial, industrial, and consumer applications. Essentially, the field of robotics integrates hardware and software engineering with mechanical and/or electrical systems to produce devices that can independently perform functions like sensing and mobility. The attention paid to the Massachusetts robotics industry (evidenced by plans like $150,000 Robotics Roadmap Initiative led by the Massachusetts Technology

Leadership Council) allows the Commonwealth to understand the economic and industrial dimensions of the robotics field and to foster advances in the technology components.

Massachusetts has a long history in the robotics industry, being a world leader in the use of robots for semiconductor manufacturing, the development of ground robots to support U.S. troops, and a pioneer in the creation of educational and behavior-based robots. Nearly a quarter of firms surveyed cited Massachusetts as a technology leader in robotics and as of 2008, there were more than 80 firms and ten universities engaged in every segment of the robotics industry. In fact, Worcester Polytechnic Institute (WPI) offers the country's first-of-its-kind undergraduate degree program in robotics engineering (in 2009, WPI also began offering master's degrees in robotics engineering). Collaboration between the robotics and IT industries has been vital to the development of new hardware devices and applications. Contributions from the MIT Computer Science and Artificial Intelligence Lab and the Media Lab make Massachusetts a singular location for advances in robotics.

Catalyzing the digital media and gaming sectors

As the IT user base expands to capture new customers (youth, the elderly, and users with high mobility demands), the digital media and **gaming** sectors have also responded with innovative products and services. Many companies view digital media as having great potential and over 25 percent of survey respondents cited digital media as a significant growth opportunity for their company in the next five years. By tapping strengths in software and digital media, Massachusetts has grown its game development economy, most notably 'the digital gaming corridor' that extends along Route 128. These companies create recreational games for consumers as well as 'serious games' for decision support in the defense and other industries. Digital gaming companies tend to incorporate multiple activities into a single enterprise—software development, network communications, custom programming, and application marketing. In some cases, gaming organizations utilize available technologies and apply them in consumer recreational applications. Despite the national success of particular companies (such as Harmonix, maker of "Rock Band" and "Guitar Hero"), raising funds from venture capitalists and firms continues to be a challenge because of the risk and difficulty in predicting which games will succeed in the consumer market.

Digital media development in the Boston area benefits from proximity to New York City's media corporations that play a role in the distribution and marketing of games and other products. There seems to be a niche in Massachusetts for companies that provide technical development services and analytics to these major media companies, allowing customization and further specialized uses for off-the-shelf products. Statewide growth in the gaming industry has largely been centered in the Boston area, but many new companies and independent contractors are also located in the central and western parts of the state. Firms have capitalized on academic programs and institutes like the MIT Game Lab and their stock of student gamers (who often serve as beta testers). IT industry leaders cite WPI's new Interactive Media and Game Development major as a promising cross-disciplinary opportunity for students. Finally, the industry has successfully organized ad-hoc associations or consortia of companies and employees who are interested in networking, technology transfer, professional development, business alliances, and the like.

Igniting a market for communication and collaboration tools

Early IT applications such as email and the internet were created to facilitate the sharing of raw data and files in various formats. Over time, the availability of these basic applications sparked the development of custom applications, programs, products, and services that allow users to communicate and collaborate in sophisticated ways. Many web 2.0 projects combine basic communication functions with related capabilities and advertising to create an entirely new market. Indeed, more than 40 percent of survey respondents identify their companies as part of the communication/collaboration tools market. Massachusetts has been especially successful at growing companies that develop and market collaboration tools; one-quarter of companies surveyed consider this emerging market to be a major potential growth area over the next five years.

The contributions of the IT industry to the Commonwealth can be measured by substantial direct and indirect monetary impacts. Other impacts affect the character of the statewide economy: innovative capacity, the transformation of existing industries, the reinvention of IT products and services, and the emergence of new markets. Together, these trends underscore why the IT sector is vitally important to Massachusetts' industrial ecosystem.

5 What is Massachusetts' Role in the Global IT Industry?

As demonstrated by firm, employment, and occupational data, the IT industry within Massachusetts is strong, providing higher-than-median wage jobs, an economic climate that supports start-up ventures, and a quality of life that makes the state an attractive location for experienced professionals. As a result, the Commonwealth also enjoys a competitive position in the *global* IT industry, standing out as a leading business location that generates top-notch technologies, people, and ideas.

The Technologies

Technology development by market leaders

Massachusetts has become an important location for IT technology development, providing firms with a fertile environment to grow into market leaders. A pioneer in data storage technologies, Massachusetts-based EMC Corp. designs, manufactures, markets, and supports a wide range of hardware and software products related to the storage, management, protection, and sharing of electronic information. EMC and Cisco Systems recently announced a partnership to co-develop new products related to cloud-based data storage and management, and for EMC to provide storage and information management systems to Cisco.[38]

Verizon Communications is a company with a strong presence in Massachusetts providing access to the internet. Its Massachusetts-based product and technology development lab has recently been involved in the development and launch of groundbreaking new optical technologies to better serve the multiple-dwelling unit market.[39]

Technology development through cross-industry collaboration

Many leading health IT products and life sciences technologies have been developed in Massachusetts. These companies capitalize on the state's strong medical and health systems cluster, partnering in various ways with medical experts and institutions in the state. In 2007, four out of ten companies cited as "top health IT innovators" by FierceHealthIT.com were Boston-area firms. These included "top innovator for 2007" Enhanced Medical Decisions, of Cambridge along with NaviMedex, PatientsLikeMe, and athenahealth.

IBM's Emerging Internet Technology Group has been collaborating with a team at Brigham and Women's hospital to develop the first telemedicine application for Blue Spruce, IBM's proprietary web application development platform. The group has developed a prototype called the Radiology Theatre, which provides a web-based environment allowing doctors in different locations to examine high-resolution images (CT scans, MRIs, X-rays etc.) and share information over audio and video links. This innovation promises to aid doctors collaborating across great distances and doctor / patient interactions as well.

The People

Each year, thousands of students graduate from Massachusetts colleges and universities with computer science and IT-related degrees – from Associate's degrees and professional certificates to Master's degrees and Doctorates. There are 81 institutions in Massachusetts that grant IT-related degrees and certificates. These include two-year private and public schools as well as four-year private and public colleges and universities (both for-profit and non-profit). More than two-thirds of these are four-year institutions that allow students to earn advanced technical degrees.

In real terms, Massachusetts educational institutions graduated 1,235 students in 2007 with IT-related Bachelor's degrees. In that same year, another 3,083 certificate holders and advanced-degree holders were graduated. As the workforce analysis indicates, there are many career opportunities for certificate and degree holders in both the IT industry and in IT professions in other industries, such as, finance and healthcare. Mean incomes in these jobs—even

those that require professional certificates or two-year degrees at a minimum—are consistently higher than statewide mean incomes for all industries. Professionals with advanced degrees in IT-related fields earn significantly more than their counterparts in other occupations. These individuals often serve as thought leaders, spokespeople, and coordinators of national and international dialogues and initiatives that move the industry forward.

New specialty programs have been recently launched or are being developed by several of the Commonwealth's prestigious institutions, further establishing Massachusetts as an internationally significant destination for students seeking Bachelor's and advanced degrees in robotics engineering, interactive media and game development, artificial intelligence, and other fields.

The Ideas

In spite of a dramatic fall in venture capital investments globally, Massachusetts has remained competitive, maintaining its position as one of the top locations for IT-related venture capital investment. Of the U.S. states, Massachusetts was second in total investment and deal counts with $4,634,192,200 and 691 deals through the years 2006-2008. During those years, 50.0 percent of all of the state's venture capital investment went to IT. California still dominates venture capital funding across most IT industry sectors and subsectors. Investments in California totaled $23,696,334,600 within this same period, through 3,171 deals. While the Commonwealth ranks second to California in absolute dollars and deals, per capita venture capital investment is clearly competitive with California.

The first quarter of 2009 was marked by a dramatic drop in all venture capital investment activity brought on by the decreasing supply of venture capital and decreasing economic activity. Nationally, total venture capital investments in the first quarter of 2009 were down 42.0 percent from the fourth quarter of 2008 and down 62.0 percent from the first quarter of 2008. Although improvements in the overall economy should translate into an increase in venture capital in the future, the timing of this turnaround is uncertain.

Investment strengths in Massachusetts, 2006-2008 [41]

Between 2006 and 2008, Massachusetts venture capital has been primarily invested in the products that make devices work better and faster, with a focus on software, telecommunications, and IT services. Software firms stand out, attracting by far the highest levels of investment with the largest software investments made in security and enterprise applications.

Comparing current investments to those in 2000, the Commonwealth's strength in software is a continuing trend. However, there has been transition into fresh areas of focus as new strengths have emerged from the evolution of the IT industry. Massachusetts' investments have moved towards telecommunications, IT services, and **distributed computing** (see Figure 37). Meanwhile, venture capital investment has moved away from equipment and dot-com internet startup investments. The 'internet age' has placed demands on new areas of IT, including proportionately increased emphasis on custom software, support, and mobility. Solid venture capital investments are strong indicators that Massachusetts is a key producer of these recent innovations.

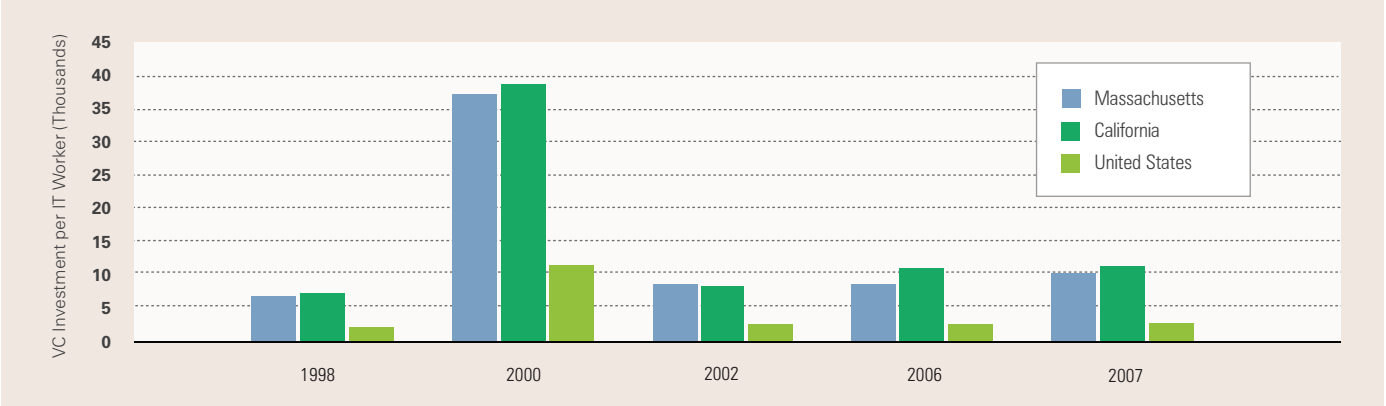
At present in Massachusetts, Software commands the largest infusions of capital. Software has received 44.7 percent of the

Figure 35: IT Venture Capital Investments per IT Worker

Region	1998	2000	2002	2006	2007
Massachusetts	$6,718	$37,283	$8,582	$8,650	$10,257
California	$7,327	$38,841	$8,384	$10,583	$11,361
United States	$2,168	$11,512	$2,674	$2,707	$2,780

Source: PricewaterhouseCoopers/National Venture Capital Association (PwC/NVCA) MoneyTree™ Report, Data: Thomson Reuters; MIG, Inc.; EOLWD, ES-202; Calculations by UMDI.

Figure 36: IT Venture Capital Investments per IT Worker



Source: PwC/NVCA MoneyTree, Data: Thomson Reuters; MIG, Inc.; EOLWD, ES-202; Calculations by UMDI.

state's total IT venture capital investment since 2006. Between 2006 and 2008, there were 318 deals in Software and more than $2 billion in investments. Major investment categories in Software include Security/Firewalls and Encryption Software, Database and File Management Software, and Business and Office Software.

The sectors with the next largest investment levels are Telecommunications and IT Services. Between 2006 and 2008, Telecommunications and IT Services generated $595 million and $588 million in investments, respectively. Wireless Communications Services leads Telecommunications-related investments, garnering nearly half of the $595 million in investment and the second-highest level of Massachusetts investment for any technology. Investment in IT Services has been driven by investments in Backup and Disaster Recovery and Internet Security and Transaction Software. The Media and Entertainment industry ranked fourth during this period, gaining $456 million in investment, largely attributed to investments in the Recreation/Entertainment/Music/Movies subsector, home to the gaming industry. Investments to Hardware-related technologies rounded out the mix with $338 million to Semiconductors, $232 million to Networking and Equipment and $205 million to Computers and Peripherals.

Massachusetts is particularly strong, when compared in absolute dollars to California, in Backup and Disaster Recovery, Internet Security and Transaction Services, and Other Software Services (likely custom computer programming). Venture capital investment in only these three subsectors outperformed absolute investment in California, as seen in Figure 38. Additional data comparing Massachusetts IT venture capital investment to that of California is available in Appendix D.

Although the last two quarters have seen sharp declines in investments, eventual economic recovery and the resilience of the IT industry will again attract investors to technologies that will provide economic growth and contribute to Massachusetts' innovative capacity.

Research and development funding

Despite a relatively small population of workers, Massachusetts leverages its "brains over brawn" to garner a disproportionately large share of federal research and development funding. This funding is available only to U.S.-based institutions, yet it generates research outcomes and impacts that propel the Commonwealth to international renown (see Figure 39).

Massachusetts businesses and educational institutions receive significant funding through three key programs: scientific research grants from the National Science Foundation (NSF), health research grants from the National Institutes of Health (NIH), and defense-related research and development contracts from the Department of Defense (DOD).

Massachusetts is a top recipient of computer and IT research grants from the NSF[43] and the NIH.[44] While in FY 2008 California received the largest share of funding in both programs, Massachusetts ranked second, outpacing many other large states with strong IT industries. In 2008, the Commonwealth was awarded 9.2 percent of total NSF, Program 47.070, funding ($52,016,905) and 14.3 percent of NIH Networking and Information Technology R&D funding ($104,692,678). On a per capita basis, Massachusetts far surpasses all other states, including California.

Defense-related IT research and development contracts[45]
An analysis of DOD program data shows that Massachusetts is, again, a top recipient of funds dedicated to defense-related IT research and development. The state ranked as the number one recipient of defense electronics and communications equipment R&D in FY2008, attracting $1,149,662,437—23.8 percent of total funds awarded. Massachusetts' success in securing these contracts is further proven when funding is calculated on a per capita basis by IT employment in each state. In this program, Massachusetts received almost five times (476.9 percent) more funding per IT employee than California, and almost six and a half times, more funding per IT employee than the nation as a whole.

The Place

Massachusetts as a global destination for IT firms and employees

Massachusetts' long history of producing and attracting a highly skilled workforce, and acting as a magnet for investment, makes it an extremely compelling business location for IT firms. The unique convergence of brain power, entrepreneurship, and innovation in IT and other industries, makes the Commonwealth an unparalleled part of the global IT industry. Analysis of employment and firm data shows the industry's resilience in the face of recession, with job losses since 2000 in one sector offset by gains in others and unemployment still lower than average in IT professional occupations. The state's ability to garner large sums of investment capital—both from private venture capitalists and from federally funded research and development programs—is an indicator of a healthy "entrepreneurial climate." Research funding invested into educational institutions and private laboratories creates a critical mass of world-class research partners throughout the state.

A majority of Massachusetts IT firms surveyed in 2009 agree that the state is an appealing business location. These respondents viewed Massachusetts and California as IT leaders, far ahead of both their domestic and international competitors. Additionally, growing technology countries like India, China, and Israel trumped much-marketed domestic regions, like North Carolina and Texas, with regard to presenting the best opportunities for innovation and growth in the IT industry (see Figure 40).

Not surprisingly, focus groups continuously touted Massachusetts' higher education institutions—their unusual density in the Commonwealth, their regular influx and output of talent, and their research capacities—as Massachusetts' leading strength and our "natural advantage." As one participant put it, "there is only one place where MIT will ever be." Nearly half of survey respondents

Figure 37: MA IT Investment by Industry Subsector, 2006 – 2008

Industry	Industry Sector	Industry Subsector	Deals	Amount	% of Total Investment
SOFTWARE			318	$2,070,143,400	44.7%
	Computer Software	Security/Firewalls, Encryption Software	47	$300,395,100	6.5%
	Computer Software	Database and File Management	30	$264,923,500	5.7%
	Computer Software	Business and Office Software	45	$211,803,200	4.6%
	Computer Software	Other Communications/Networking Software	13	$157,201,200	3.4%
	Computer Software	Medical/Health Software	21	$115,829,200	2.5%
	Computer Software	Multimedia Software	15	$112,324,000	2.4%
	Computer Software	Transportation Software	2	$102,500,200	2.2%
	Internet Software	Internet Search Software and Engines	9	$99,068,900	2.1%
	Internet Software	E-commerce Enabling Software	14	$67,643,300	1.5%
	Computer Software	Other Industry-specific Software	7	$58,457,000	1.3%
	Computer Software	Operating Systems and Utilities	6	$56,724,800	1.2%
	N/A*	Other Software subsectors	109	$523,273,000	11.3%
TELECOMMUNICATIONS			91	$594,790,100	12.8%
	Wireless Communications	Wireless Communications Services	31	$271,599,800	5.9%
	Internet Communications	Internet Backbone Infrastructure	8	$60,260,100	1.3%
	N/A*	Other Telecommunications subsectors	52	$262,930,200	5.7%
IT SERVICES			70	$588,498,800	12.7%
	Computer Services	Backup and Disaster Recovery	12	$123,720,000	2.7%
	E-commerce Technology	Internet Security and Transaction Services	12	$104,714,100	2.3%
	Computer Programming	Other Software Services	8	$63,289,100	1.4%
	N/A*	Other IT Services subsectors	38	$296,775,600	6.4%
MEDIA AND ENTERTAINMENT			81	$456,174,600	9.8%
	Internet Content	Recreation/Entertainment/Music/Movies	32	$122,884,000	2.7%
	Internet E-commerce	Recreation/Entertainment/Music/Movies	6	$118,602,700	2.6%
	Internet Content	Consumer Info/Content	14	$66,083,000	1.4%
	N/A*	Other Media and Entertainment subsectors	29	$148,604,900	3.2%
SEMICONDUCTORS			41	$338,368,000	7.3%
	Semiconductors/Other Electronics	Other Semiconductors	10	$142,999,700	3.1%
	Semiconductors/Other Electronics	Semiconductors	10	$69,804,500	1.5%
	Semiconductors/Other Electronics	Customized Semiconductors	11	$60,500,400	1.3%
	Semiconductors/Other Electronics	Sensors	8	$56,097,000	1.2%
	N/A*	Other Semiconductors subsectors	2	$8,966,400	0.2%
NETWORKING AND EQUIPMENT			33	$231,969,000	5.0%
	Data Communications	Switches/Hubs/Routers/Gateways/ATM	11	$76,816,300	1.7%
	N/A*	Other Networking and Equipment subsectors	22	$155,152,700	3.3%
COMPUTERS AND PERIPHERALS			22	$205,184,100	4.4%
	Computers Hardware	Servers	3	$52,000,000	1.1%
	N/A*	Other Computers and Peripherals subsectors	19	$153,184,100	3.3%
ALL OTHER IT SECTORS			35	$149,064,200	3.2%
		Total Investments	**691**	**$4,634,192,200**	

Source: PwC/NVCA MoneyTree, Data: Thomson Reuters
*This category contains multiple sectors.

Figure 38: Massachusetts Investment Strengths, Massachusetts vs. California, 2006 – 2008

	Massachusetts		California	
Industry Subsector	Deals	Investment Amount	Deals	Investment Amount
Backup and Disaster Recovery	12	123,720,000	15	$107,876,300
Internet Security and Transaction Services	12	104,714,100	22	$95,677,200
Other Software Services	8	63,289,100	5	$27,000,100

Source: PwC/NVCA MoneyTree, Data: Thomson Reuters.

Figure 39: R&D Investment per IT Worker in Massachusetts, California and the U.S.

		Dollars per IT Worker	
Source of Capital	MA	CA	U.S.
NIH Networking and Information Technology R&D	$593	$182	$154
NSF Computer and Information Technology R&D	$295	$143	$119
DOD Defense Electronics and Communication Equipment R&D	$6,511	$1,365	$1,012

Source: National Institutes of Health (NIH), Research Portfolio Reporting Tool (RePORT), <http://report.nih.gov/rcdc>; USAspending.gov.

cited the "availability of skilled workers," or the primary output of the higher educational institutions, as a regional strength of the Commonwealth. The state's density of primary IT professionals (see Section 4) is higher than that of the U.S. or competitor states, with 4.0 percent of the workforce engaged in IT occupations compared to the national share of 2.7 percent and 3.0 percent in California. In addition, almost two-thirds of those surveyed responded that Massachusetts, against all competitor regions, was an ideal business location because of its "access to world class research partners" (see Figure 41).

The Bay State's cultural amenities also received major attention in the survey. Seventy percent of respondents cited "access to cultural amenities" as a regional strength and advantage for IT businesses when compared to all other regions. The concentration of cultural amenities in the compact geography of Massachusetts might be almost as hard to reproduce in other regions as the higher education advantage would be. The variety of arts and entertainment opportunities, cultural institutions and events, sports and leisure activities, and world-renowned vacation destinations from the Cape and Islands to the Berkshires are important assets for IT firms and their employees.

Figure 40: What regions of the world present the best opportunities for innovation and growth?

Region	Share of Positive Responses
California	53.4%
Massachusetts	51.5%
India	34.8%
China	30.6%
Israel	20.4%
Eastern Europe and Russia	17.8%
North Carolina	15.9%
Washington DC/Northern Virginia	14.1%
Texas	10.9%

Source: UMDI Survey of Massachusetts Information Technology Businesses, February 2009.

Figure 41: What are Massachusetts' specific regional strengths as a location for IT businesses?

Regional Strength	Share identifying MA as an ideal business location
Quality of Life: Access to cultural amenities	70.0%
Climate for Innovation: Access to world class research partners	63.9%
Climate for Innovation: Presence of world class business networks and colleagues	58.6%
Quality of Life: Presence of strong school systems	56.8%
Workforce: Availability of skilled workers	48.4%

Source: UMDI Survey of Massachusetts Information Technology Businesses, February 2009.

Nearly 60.0 percent of survey respondents indicated that "the presence of world class business networks and colleagues" was a regional strength of Massachusetts. Along with large established companies and crops of startups, numerous out-of-state IT powerhouses have satellite offices in Massachusetts to take advantage of the world class networks of IT businesses and IT workers. Focus group participants emphasized that their business locations were very much linked to those networks. For example, both a startup and an anchor company felt that their Kendall Square location was essential to their business operations. The young company had access to other start-up companies, representing various parts of the IT industry as well as other industries, because they all operate within a close proximity. The larger, more established company echoed this sentiment about Kendall Square's "network" and stated that they could never imagine leaving that "micro-system" even with growing size constraints. Constantly occurring interactions between the campus and the firm and proximity to MIT were essential to their business.

In addition, because other global leaders in industries like biotechnology and health care are firmly planted in Massachusetts, focus group participants felt that the Commonwealth's IT industry is also uniquely positioned to capitalize on the convergence with leaders in other like-minded innovation sectors. When surveyed, Massachusetts IT businesses saw health care, second only to IT itself, as the industry representing the most significant growth opportunities in the next five years. With Massachusetts home to some of the best hospitals in the world, focus group participants agreed that the relationship between health care and IT is going to be very important to the state, particularly in terms of potential stimulus dollars.

Figure 42: Which of the following IT-intensive industries represent the most significant growth opportunities for your company in the next 5 years?

Industry	Share of Positive Responses
Information Technology	43.3%
Health Care	39.0%
Media/Entertainment	27.6%
Financial Services	20.6%
Other	19.8%
Life Sciences	15.1%
Energy	14.5%
Education	12.3%
Defense	7.9%
Manufacturing	7.5%
Legal	3.6%

Source: UMDI Survey of Massachusetts Information Technology Businesses, February 2009.

6 The Path Forward: Policy Priorities and Challenges

Challenges Facing the IT Industry in Massachusetts

The focus groups and the survey of Massachusetts IT businesses conducted over the course of the study period were designed to assist in identifying major challenges and policy concerns and their relative importance to the industry. The survey also gave respondents an opportunity to compare Massachusetts' regional strengths and challenges to that of the global IT community as well as our biggest competitor, California. Although there is no doubt that Massachusetts boasts important and unique business advantages, focus group participants and survey respondents reported no shortage of challenges.

Overall policy priorities: Improving costs, information infrastructure, and the pipeline of workers

Cost concerns

When surveyed about overall policy priorities, three policy solutions emerged as the most significant, or "high priority," to the majority of respondents (see Figure 43). Foremost, IT firms overwhelmingly identified the need to offset business costs as high priority. Over 70 percent of firms responding to this question felt that reducing business costs is a high policy priority for their business. Several focus group participants also expressed concerns about costs. One participant, representing a large, multi-state company, felt that Massachusetts is currently at a competitive disadvantage compared to other states that offer financial incentives to locate facilities. He and others also indicated that consistency and predictability in tax policy was essential for their business decision making.

Improving information infrastructure

In addition to business costs, surveyed firms identified the improvement of information infrastructure (broadband, wireless access, connectivity, etc.) as imperative. Although the focus groups did not spend a lot of time on infrastructure issues, there was some discussion about coming up with mutually beneficial solutions for infrastructure needs. For example, one company suggested that the state could better support network communications companies in exchange for building infrastructure in less densely populated and underserved areas of the state (areas which would otherwise be unprofitable to these companies). This would open up these areas to IT firm expansion possibilities and open up new markets for IT products and services.

Developing the workforce

Like the survey respondents, focus group participants had a number of concerns with regard to the pipeline of science, technology, engineering and mathematics (STEM) workers. Issues surrounding K-12 STEM education as well as training undergraduates for employment in the IT industry emerged repeatedly. Participants noted that "real world" experience, in the form of internships, co-ops, and marketable skills upon graduation, was essential to accessing and "capturing" young workers. However, running effective programs was a challenge because getting interns up to speed in the short period of their internship was difficult. Additionally, several participants felt that getting K-12 students interested in technology and keeping them in Massachusetts should be priorities.

With regard to the workforce, finding senior level talent was a concern for focus group participants. Nearly a third of survey respondents also reported having difficulty finding experienced workers, software engineers in particular. Focus group participants cited the lack of startup experience in the workforce in Massachusetts. One respondent noted that there is a shortage of "people who have run, packaged, created and shipped product" in Massachusetts and marketing and business development talent was especially scarce. While training was necessary for junior-level employees, most focus group participants agreed that finding these employees wasn't difficult.

Massachusetts versus all other locations: High costs in the Commonwealth

The survey also gave respondents the opportunity to identify regional competitiveness challenges when compared to other IT

locations throughout the world. Echoing the policy priorities, Massachusetts firms identified the high cost of doing business in the Commonwealth as a major competitiveness issue. The high cost of living was also identified as a significant issue. Nearly two-thirds of respondents (64.3 percent) cited the cost of housing as a major factor making Massachusetts a non-competitive business location. A majority of survey respondents (56.4 percent) also cited general business costs as a challenge (see Figure 44).

Massachusetts versus California: Strengthening our innovative climate

Although high costs in the Commonwealth emerged as a major issue when compared to all other business locations, the competitiveness challenges were quite different when firms were asked to compare Massachusetts to our biggest rival. When compared specifically to California, survey respondents viewed our innovative climate as the most significant issue. Focus group participants concluded the same and the discussions consistently focused on the comparison of Massachusetts' business environment to that of California.

Accessibility of venture capital funding

Echoing the refrain from focus groups, nearly half of survey respondents found "access to venture capital and funding" to be a major obstacle in Massachusetts. A number of focus group participants believe that venture funding on the East Coast is much more "risk averse" and the Commonwealth's history as a leader in enterprise software and other more traditional products makes funding riskier new endeavors even more difficult. Given recent economic

Figure 43: What Potential Policy Solutions are Priorities for Your Business?

Policy Solutions	Share Identifying as High Priority
Reducing business costs: taxes — corporate taxes, UI, workers compensation, etc.	70.8%
Improving information infrastructure: broadband, wireless access, connectivity, etc	56.7%
Improving the pipeline of science, technology, engineering, and math (STEM) workers	50.1%
Marketing and promotion in support of the IT industry in MA	45.8%
Developing more effective public/private/government collaborations	40.3%
Creating more affordable housing	38.5%
Reducing business costs: energy costs	38.5%
Improving the regulatory climate (fees, permitting, zoning, etc.)	38.3%
Promoting advocacy for the industry in Washington, D.C.	34.2%
Improving physical infrastructure: roads, airports, commuter rails, etc.	29.9%

Source: UMDI Survey of Massachusetts Information Technology Businesses, February 2009.

Figure 44: Massachusetts vs. All Other Locations, Competitiveness Issues

Issue	MA is a neutral business location	MA is a non-competitive business location
Quality of Life: Cost of housing	34.2%	64.3%
Business Costs: General business costs (facilities, utilities, etc.)	41.0%	56.4%
Business Costs: MA payroll taxes, e.g., unemployment and workers comp.	50.3%	46.2%
Business Climate: Effective state government response to industry needs	43.9%	44.2%
Quality of Life: Ease of commuting	42.8%	41.7%

Source: UMDI Survey of Massachusetts Information Technology Businesses, February 2009.

Figure 45: Massachusetts v. California, Competitiveness Issues

Issue	MA is a neutral business location	MA is a non-competitive business location
Climate for innovation: Access to venture capital and funding	35.3%	49.4%
Climate for innovation: Supportive environment for startups and entrepreneurs	39.1%	46.1%
Climate for innovation: Presence of promising startups and young companies	44.4%	43.1%
Business Climate: Effective state government response to industry needs	58.0%	31.0%
Workforce: Potential to attract and retain highly qualified employees	53.1%	29.2%

Source: UMDI Survey of Massachusetts Information Technology Businesses, February 2009.

turmoil, some participants feel that venture firms are focusing on "known quantities" and only the serial, experienced entrepreneur receives funding. These perspectives present an interesting contrast to the promising picture that emerges in the analysis of venture capital patterns in the Commonwealth. Even though the state remains a top-ranked competitor for national venture capital funds in IT, serious concerns persist.

Building a more supportive environment for startups and entrepreneurs

Closely linked to access to funding, and raised in both the focus groups and the survey, is a concern for creating a more supportive environment for entrepreneurs and startups in the Commonwealth as well as more promising startups overall. Nearly half of survey respondents found Massachusetts to be non-competitive with California in this regard. In focus group sessions, several participants expressed that there were stark differences between Massachusetts and California on this front and felt that California "had more openness and interconnected social networks that work on multiple levels to fuel the industry." Participants noted that the nature of the IT industry in California promotes familiarity, trust, and connections among businesses, which in turn promotes a more active venture environment for startups, as well as support and mentorship.

Additional challenges facing the industry

A deficit of anchor companies and companies "grown" to scale

Focus groups noted that California's thriving interconnected industry social networks are, in part, the result of the presence of large numbers of "anchor companies" or massive, headquartered enterprises that employ critical numbers of professionals. Anchor companies play a significant role in an IT ecosystem by solidifying capital markets, training the workforce and, importantly, in this case, providing a highly connected social network. At various stages of their careers, professionals from these large firms move on to other companies or start their own but are connected within the industry through relationships developed with former colleagues and other industry insiders from their time at the anchor. It is widely known that Massachusetts has a knack for producing startups. However, focus group participants felt that growing companies to scale, and, in turn, developing an environment flush with industry-wide "family trees," along with long-term job creation and a critical mass of anchor companies, are challenges. Massachusetts is home to only a few anchor companies but attracts satellite offices from arguably all the major players, including Cisco, IBM, Google, and Microsoft. These companies are here because of the Commonwealth's innovative capacity and its talent and potential for developing cutting-edge technologies. As one participant put it, many companies don't conduct R & D, they acquire it. As a result, successful startups are acquired by large companies and never grow to scale. Although small companies may not grow to scale as often here, some focus group participants argued that those satellite operations may be as important to Massachusetts, and its climate for innovation, as the state is to out-of-state powerhouses. One participant in the focus groups noted that "we have at least ten significant out-of-state companies that together have the equivalent impact of one 'good anchor'."

Figure 46: What types of collaboration is your firm a part of within the Massachusetts IT industry?

Type of Collaboration	Percent Yes
Marketing partnerships with other companies	66.0%
R&D partnerships with startups/young firms	30.8%
R&D partnerships with established firms	27.9%
R&D partnerships with universities	23.9%
Collaborative curriculum development with universities	22.1%
Corporate ventures with MA startups	21.1%
License agreements with startups	16.5%
R&D partnerships with government	12.9%
License agreements with universities	12.0%

Source: UMDI Survey of Massachusetts Information Technology Businesses, February 2009.

Increasing collaboration

With startups, venture capital firms, educational institutions, anchor companies, satellite offices, and industry groups operating, as one focus group participant framed it, in their "individual silos," many participants expressed support for efforts to create a more collaborative industry in Massachusetts. When surveyed on the types of collaborations that Massachusetts IT businesses are engaged in, the lack of collaboration was striking. Although nearly two-thirds of IT firms in Massachusetts collaborate on marketing partnerships, less than a third had research and development partnerships with startups, established firms, and universities (see Figure 46).

Overcoming regional disparities

Over 70 percent of venture capital funding was directed to Greater Boston and, in absolute terms, Cambridge itself attracted the top investment dollars, garnering over $716 billion between 2006 and 2008. Some focus group participants noted the regional disparities within the Commonwealth. One business owner expressed his interest in keeping jobs in Massachusetts, and in particular, more distressed regions, and noted his unique "off-shoring" strategy (sometimes referred to as "domestic in-sourcing") for lower skill level jobs by opening a site in Fall River. Regionally, the greater the distance from Boston, the less impact the IT industry has. Although other regions in the state can offer much needed space, workforce challenges, infrastructure issues, and the nature of the industry in Massachusetts have prevented the IT industry to date from moving beyond I-495.

Conclusions

Out of challenges grow opportunities. Having successfully survived the dot-com bust earlier in the decade, Massachusetts possesses many assets and resources that can be leveraged for continued economic growth of its IT industry. This growth may ebb and flow in different core sectors, and the character of the industrial ecosystem may change, but the possibilities for maintaining global prominence remain.

Looking ahead, one of the single most important strengths of the Massachusetts IT industry is its capacity for creative thinking and partnership. The ability of the state's business leaders to organize and sustain ad-hoc business groups (e.g., Mobile Mondays, Boston Postmortem) and formal partnerships (e.g., the newly formed IT Collaborative and the myriad industry organizations) presents an opportunity to take ownership of the industry's continued success. Strategic thinking—designed to meet both short- and long-term goals—can result in partnerships and collaborations rarely seen in other industries or in other states. The cross-marketing of EMC and Cisco technology products and the recently announced commitment of Cisco, EMC, UMass, and MIT to build a Holyoke-based computing facility are but two remarkable examples.

The Massachusetts IT industry can continue to leverage its many resources: the universities that act as a magnet for intelligent, creative individuals; firms in core IT sectors that are well integrated with one another; and the ability to quickly capitalize on innovations in order to grow the people and companies essential to the Commonwealth's prominence and economic well-being.

Appendix A: Glossary of Terms

This glossary of terms was compiled through numerous sources including Wikipedia.com, Dictionary.com, and staff knowledge.

Agile project management	A system of software development practices in which solutions are developed through collaboration and self-organizing cross-functional teams.
Cloud computing	Cloud computing is a style of computing in which dynamically scalable and often virtualized resources are provided as a service over the internet.
Core information technology sectors	As defined by UMDI, these sectors refer to the four significant areas of the IT industry which encompass the vast majority of IT activity. They contain the essential business elements that make up the functionary processes of information technology.
Custom computer programming	Programming that is facilitated on a case-by-case basis in a consultative manner rather than standardized or mass produced.
Data center	A facility that houses large servers and/or computer systems and components. They are often considered vital to business and organizational operation and functionality. They are also known as server farms.
Digital media	Emerging market in the IT industry that includes webcasters, online media, digital services, videogame creators, digital marketing, and related multimedia activities.
Distributed computing	A distributed system consists of multiple autonomous computers that communicate through a computer network. The computers interact with each other in order to achieve a common goal. Examples of distributed systems and applications of distributed computing include: telecommunications and computer networks; world wide web and peer-to-peer networks; distributed database systems and network file systems; scientific computing, including cluster computing and grid computing, and various distributed computing projects.
Dot-com	Refers to an internet or world wide web address. Often refers to business ventures which operate primarily on the internet and are given this nickname because the web address ends in '.com'
Gaming (also digital gaming, online gaming)	Formerly referred to as interactive entertainment, gaming is the economic sector involved with the development, marketing, and sale of video games.
Hardware	Hardware equips users with the physical tools needed to manage, store, and share information.

Information Technology (IT) industry	A collection of corporations, organizations, groups, professionals, knowledge, and capacity which function as an economic unit that studies, designs, develops, implements, and supports computer-based information systems.
IT Services	IT Services strengthens organizations by customizing products and services, and provides technical strategy and support services that enhance productivity.
IT technical professional	Professionals who contribute specific computer-related technical expertise to their firm, whether working inside the IT industry or performing the same function outside the industry.
Labor productivity	The amount of goods or services that a worker produces in a given amount of time.
Network Communications	Network communications firms connect users and their systems by providing core communications infrastructure and products.
Open source	Refers to the development, design, distribution and production of software which allows for open accessibility to software source code to the general public with no or lenient copyright restrictions.
Project Management Body of Knowledge (PMBOK)	An international recognized set of guiding principles that lays forth the essential elements of project management as they apply to a number of wide range projects.
Scrum approach	A software development process which can be used to manage and control complex software and product development using iterative, incremental practices. It is often recognized as an agile project management approach.
Software	Software firms enable users to utilize hardware, access networks, and operate IT systems.
Virtualization	An umbrella term for software that improves portability, manageability and compatibility of applications by encapsulating them from the underlying operating system on which they are executed. A fully virtualized application is not installed in the traditional sense; the application is fooled at runtime into believing that it is directly interfacing with the original operating system and all the resources managed by it. Additionally, entire operating systems can also be virtualized, rather than only specific applications.

Appendix B: IT Industry Definition

Defining the IT industry

As a first step in conducting a meaningful study, the research team developed a definition of the IT industry by consulting a combination of data, literature, and other pertinent information. For the purposes of this study, the IT industry is defined by a detailed set of industrial codes that describe companies' operations. In addition to defining the industry at a broad level, the team further identified core sectors and subsectors within the industry through small groupings of industry codes to facilitate fine-grained analysis.

Industrial classification schemes like the North American Industrial Classification System[46] (NAICS) have been transformed over time to accommodate shifts in particular industrial sectors. The high degree of change and innovation seen in the IT industry has resulted in significant adjustments to industry definitions between 1997 and 2007—more so than those seen in other industry sectors.[47] The NAICS features 23 two-digit codes, and thousands of four-, five-, and six-digit codes that describe industrial activity with increasingly higher levels of detail. The NAICS codes are production-oriented, which results in groupings of firms that have similar production processes.

In order to create as detailed a definition as possible (and by extension, as sophisticated an analysis as possible), primarily six-digit NAICS codes are used to classify units in the IT industry. A "bridging" exercise examined the relationship between 1997, 2002, and 2007 NAICS codes that describe IT industries. After identifying the IT industry as a whole, its sectors and subsectors were identified. Companies associated with these NAICS codes and descriptions comprise the IT sectors and subsectors analyzed in this study.

NAICS codes by core sector and subsector

Most of the economic data sets that were consulted provide information at the NAICS six-digit level. In the case of some series (for example, U.S. Census births and deaths of establishments), data were available at aggregated at four-digit and five-digit levels; as a result, certain analyses may include companies that are related to, but not exclusively part of the IT sector. In no case is any part of this analysis limited to data aggregated at the NAICS two-digit level. The table below displays the distribution of 2002 NAICS codes across the IT sector and its subsectors. See the notes below the table for a complete description of NAICS codes that make up each of the IT subsectors.

Sector	Subsector
Hardware	• Semiconductors and equipment • Computers, peripherals & devices, including storage • Communications equipment and devices including mobile • Network hardware
Network Communications	• Wireline providers • Wireless providers • Internet service providers (ISPs) • Communications infrastructure
Software	• Systems and applications • Custom computer programming
IT Services	• Systems development and integration • Computer support and maintenance • Training • Online application service providers and data hosting and processing services

HARDWARE	
Semiconductors and equipment	
333295	Semiconductor machinery manufacturing
333314	Optical instruments and lens manufacturing
334411	Electron tube manufacturing
334412	Bare Printed Circuit Board Manufacturing
334413	Semiconductor and related device manufacturing
334414	Electronic Capacitor Manufacturing
334415	Electronic Resistor Manufacturing
334416	Electronic Coil, Transformer, and Other Inductor Manufacturing
334417	Electronic Connector Manufacturing
334418	Printed Circuit Assembly (Electronic Assembly) Manufacturing
334419	Other Electronic Component Manufacturing
Computers, peripherals & devices, including storage	
334111	Electronic computer manufacturing
334112	Computer storage device manufacturing
334113	Computer terminal manufacturing
334119	Other computer peripheral equipment manufacturing
334613	Magnetic and optical media manufacturing
42343	Computer and Computer Peripheral Equipment and Software Merchant Wholesalers

HARDWARE, CONTINUED	
Communications equipment and devices including mobile	
334210	Telephone apparatus manufacturing
334220	Radio and television broadcasting and wireless communications equipment manufacturing
334515	Instrument manufacturing for measuring testing electricity and electrical signals
Network hardware	
334290	Other communications equipment manufacturing
3359	Other electrical equipment and component manufacturing
335921	Fiber optic cable manufacturing
335929	Other communication and energy wire manufacturing

SOFTWARE	
Systems and applications	
334611	Software reproducing
511210	Software publishers
Custom computer programming	
541511	Custom computer programming services

NETWORK COMMUNICATIONS	
Wireline and Internet service providers (ISPs)	
515210	Cable and other subscription programming
517110	Wired Telecommunications Carriers
51750	Cable and other program distribution
517310	Telecommunications Resellers
517910	Other Telecommunications (includes VOIP)
518111	Internet Service Providers
Wireless providers	
517211	Paging
517212	Cellular and Other Wireless Telecommunications
517410	Satellite telecommunications
Communications infrastructure	
238210 (part)	Electrical contractors

IT SERVICES	
Systems development and integration	
541512	Computer systems design services
541618 (part)	Other management consulting services (pt) - for computer- and telecom- management services
Computer support and maintenance	
541513	Computer facilities management services
541519	Other computer related services
811212	Computer and office machine repair and maintenance
811213	Communication equipment repair and maintenance
Training	
611420	Computer Training
Online application service providers and data hosting and processing services	
518112	Web Search Portals
518210	Data processing, hosting, and related services
516110	Internet publishing and broadcasting
4541	Electronic shopping

Note for all codes: 2002 NAICS codes and definitions used

Note for Code 238210: This NAICS code was apportioned using the following method:

1) We first used our SIC-NAICS bridge to ascertain that NAICS 2002 code 238210 bridges directly to SIC code 1730 (Electrical Work).

2) We used Dun & Bradstreet (D&B) MarketPlace to determine which portion of SIC 1731 (Electrical Work) is made up by 1731-03 (Communication Specialization).

3) We applied this proportion to the ES-202 count of employment for 238210.

4) The proportions we applied are as follows (all data based on D&B MarketPlace 1st Quarter 2006):

   a. MA: .0908 b. CA: .1248 c. US: .1146

Note for Code 541618:

This NAICS code was apportioned using the following method:

1) We used industry occupation matrices to determine the proportion of workers in NAICS 5416 who are in IT "core occupations." (See Appendix VII)

2) We made the assumption that all of these workers, plus a proportion of all other workers in the sector equal to proportion of workers who are in "core occupations," are part of the industry.

3) We calculated the resulting proportion using the formula proportion = ((1-x)*x)+x where x=the proportion of workers in 5416 who are in "core occupations." So, if 25 percent of workers in 5416 were in core occupations, we would assume that all of these workers, plus an additional 25 percent of the remaining 75 percent of workers, for a total of 43.8 percent, were part of the IT industry.

4) We applied the resulting proportion to ES-202 count of employment for 541618

5) The proportions we applied are as follows (MA and US data are based on May 2007 Industry Occupation Matrices. CA data are based on 2006 Industry Occupation Matrix, which was the latest available at the time of writing.)

   a. MA: .3252 b. CA: .2053 c. US: .1801

Appendix C: Primary IT Occupations

The following set of primary IT occupations contribute specific technical expertise to production in the IT industry and also appears in every industrial sector in the state. These thirteen occupations include programmers, network and database administrators, system and network analysts, hardware and software engineers, information system managers, tech support, and those that research and teach computer science at the collegiate through post-graduate levels. These workers provide the full range of skills fundamental to the production of core information technologies as well as the provision of computer-related services.

Below are the selected primary IT occupations, followed by their identifying Standard Occupational Classification (SOC) code.

- Computer and Information Systems Managers (11-3021)
- Computer and Information Scientists, Research (15-1011)
- Computer Programmers (15-1021)
- Computer Software Engineers, Applications (15-1031)
- Computer Software Engineers, Systems Software (15-1032)
- Computer Support Specialists (15-1041)
- Computer Systems Analysts (15-1051)
- Database Administrators (15-1061)
- Network and Computer Systems Administrators (15-1071)
- Network Systems and Data Communications Analysts (15-1081)
- Computer Specialists, all other (15-1099)
- Computer Hardware Engineers (17-2061)
- Computer Science Teachers, Postsecondary (25-1021)

The Bureau of Labor Statistics provides occupational information for each of the job categories in the Standard Occupational Classification system.[48] It defines the typical work activities and responsibilities for the primary IT occupations as follows:

11-3021: Computer and Information Systems Managers:
Plan, direct, or coordinate activities in such fields as electronic data processing, information systems, systems analysis, and computer programming. Exclude "Computer Specialists" (15-1011 through 15-1099).

15-1011: Computer and Information Scientists, Research:
Conduct research into fundamental computer and information science as theorists, designers, or inventors. Solve or develop solutions to problems in the field of computer hardware and software.

15-1021: Computer Programmers:
Convert project specifications and statements of problems and procedures to detailed logical flow charts for coding into computer language. Develop and write computer programs to store, locate, and retrieve specific documents, data, and information. May program web sites.

15-1031: Computer Software Engineers, Applications:
Develop, create, and modify general computer applications software or specialized utility programs. Analyze user needs and develop software solutions. Design software or customize software for client use with the aim of optimizing operational efficiency. May analyze and design databases within an application area, working individually or coordinating database development as part of a team. Exclude "Computer Hardware Engineers" (17-2061).

15-1032: Computer Software Engineers, Systems Software:
Research, design, develop, and test operating systems-level software, compilers, and network distribution software for medical, industrial, military, communications, aerospace, business, scientific, and general computing applications. Set operational specifications and formulate and analyze software requirements. Apply principles and techniques of computer science, engineering, and mathematical analysis.

15-1041: Computer Support Specialists:
Provide technical assistance to computer system users. Answer questions or resolve computer problems for clients in person, via telephone or from remote location. May provide assistance concerning the use of computer hardware and software, including printing, installation, word processing, electronic mail, and operating systems. Exclude "Network and Computer Systems Administrators" (15-1071).

15-1051: Computer Systems Analysts:
Analyze science, engineering, business, and all other data processing problems for application to electronic data processing systems. Analyze user requirements, procedures, and problems to automate or improve existing systems and review computer system capabilities, workflow, and scheduling limitations. May analyze or recommend commercially available software. Exclude persons working primarily as "Engineers" (17-2011 through 17-2199), "Mathematicians" (15-2021), or "Scientists" (19-1011 through 19-3099). May supervise computer programmers.

15-1061: Database Administrators:
Coordinate changes to computer databases, test and implement the database applying knowledge of database management systems. May plan, coordinate, and implement security measures to safeguard computer databases.

15-1071: Network and Computer Systems Administrators:
Install, configure, and support an organization's local area network (LAN), wide area network (WAN), and internet system or a segment of a network system. Maintain network hardware and software. Monitor network to ensure network availability to all system users and perform necessary maintenance to support network

availability. May supervise other network support and client server specialists and plan, coordinate, and implement network security measures. Exclude "Computer Support Specialists" (15-1041).

15-1081: Network Systems and Data Communications Analysts:
Analyze, design, test, and evaluate network systems, such as local area networks (LAN), wide area networks (WAN), internet, intranet, and other data communications systems. Perform network modeling, analysis, and planning. Research and recommend network and data communications hardware and software. Include telecommunications specialists who deal with the interfacing of computer and communications equipment. May supervise computer programmers.

15-1099: Computer Specialists, all other:
All computer specialists not listed separately.

17-2061: Computer Hardware Engineers:
Research, design, develop, and test computer or computer-related equipment for commercial, industrial, military, or scientific use. May supervise the manufacturing and installation of computer or computer-related equipment and components. Exclude "Computer Software Engineers, Applications" (15-1031) and "Computer Software Engineers, Systems Software."

25-1021: Computer Science Teachers, Postsecondary:
Teach courses in computer science. May specialize in a field of computer science, such as the design and function of computers or operations and research analysis. Include both teachers primarily engaged in teaching and those who do a combination of both teaching and research.

Appendix D: The Massachusetts IT Industry in a National Context

Overview of IT industry employment patterns[49]

While the IT industry is a significant employer in Massachusetts, with IT firms employing approximately 5.5 percent of the total workforce,[50] the sector represents a relatively modest portion of the national workforce. Nationally, the IT industry directly employed approximately 4,777,569 persons in 2007 (see figure D1 below). In that same year, the Massachusetts IT industry comprised roughly 3.7 percent of national IT employment, with a total of 176,574 employees. In comparison, California held a 15.5 percent share of total national IT employment, at 743,039. In that same year—the most recent for which data are available—there were 316,923 IT-related establishments in the U.S., with 9,708 of those, or roughly 3.1 percent, located in the Commonwealth (see figure D2 below). California was home to about 36,300 firms, or 11.5 percent, in the same year.

The tables below demonstrate the growth and change patterns of the IT industry's employment and firms. All three locations experienced a consistent employment pattern of strong growth in the latter 1990s into 2000, followed by sharp declines over the next four years before engaging in a recovery which extended through 2007. The most recent years (2006 and 2007) show only modest gains in employment, still short of boom period levels. Massachusetts has not yet recovered to 1998 employment levels, and is growing more slowly than California and the nation. The Commonwealth remained 14 percent below 1998 employment levels and 26 percent below its peak in 2000. U.S. totals were down just 5.7 percent in 2007 from 1998 numbers and 17.9 percent lower than peak 2000 totals.

However, firm totals show a slightly different pattern: firm numbers grew in the four years following 2000 crash. Massachusetts saw its share of firms increase both in 2002 and 2004, and witnessed a net gain in firms between 1998 and 2007. Firm growth was strongest during this period at the national level, with the national rate of change reaching 31.6 percent. Massachusetts boasted 16 percent more firms in 2007 than 1998, although firm numbers were still short of the 2000 peak level of 10,108. In contrast, California saw only a modest 2.7 percent increase from its 1998 numbers.

These differences in growth patterns between employment and firm numbers could be explained by small, newly created firms following significant industry-wide layoffs in 2000. Although all years witnessed firm dissolutions, these numbers were likely offset by a rise in new firm starts by the recently unemployed seeking to go into business for themselves. It is a characteristic of the IT industry to build on opportunity in times of economic stress, and IT workers have become adept at leveraging independent contracting opportunities.

Sector changes

While the previous discussion pertained to the IT industry overall, marked variations are evident among the four core IT sectors, pointing to major structural changes taking place within the IT industry. Among regions of the U.S., we have seen similar patterns of change, although the scale of growth and decline do vary. In general, the Software sector demonstrated resilience for the ten year period 1998-2007, growing significantly in some regions, including in Massachusetts. At the same time, the Hardware sector suffered continuing employment declines (see Figure D3). IT Services employment numbers decreased slightly in Massachusetts while increasing in California and nationally between 1998 and 2007, while Network Communications

Figure D1: Massachusetts, California, and United States IT Industry Employment, 1998 – 2007

	Information Technology Industry Employment						Employment Growth		
	1998	2000	2002	2004	2006	2007	'98 – '00	'00 – '07	'98 – '07
Massachusetts	205,490	240,047	195,459	169,871	172,019	176,574	16.8%	-26.4%	-14.1%
California	804,147	970,287	808,173	723,563	743,039	743,227	20.7%	-23.4%	-7.6%
United States	5,063,923	5,817,964	5,043,714	4,609,351	4,714,996	4,777,569	14.9%	-17.9%	-5.7%

Source: IMPLAN QCEW Data with UMDI Calculations.

Figure D2: Massachusetts, California and United States IT Industry Firms, 1998 – 2007

							Firm Growth		
	1998	2000	2002	2004	2006	2007	'98 – '00	'00 – '07	'98 – '07
Massachusetts	8,381	10,108	10,445	10,488	9,411	9,708	20.6%	-4.0%	15.8%
California	35,341	39,171	40,534	37,246	37,770	36,310	10.8%	-7.3%	2.7%
United States	240,796	288,973	301,637	292,605	306,554	316,923	20.0%	9.7%	31.6%

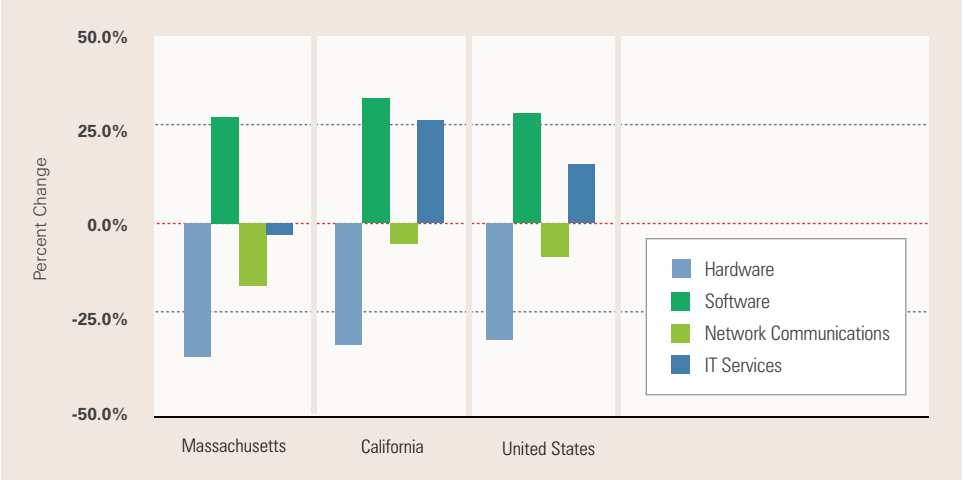
Source: IMPLAN QCEW Data with UMDI Calculations.

employment decreased across the board during the same period.

Venture capital

In absolute dollars, California consistently outperformed Massachusetts. Venture capital investment in California's security/firewalls subsector, our top investment subsector, is nearly three times that of Massachusetts. However, as noted in the report, Massachusetts leads California in several subsectors, including Backup and Disaster recovery, Internet Security and Transaction Services, and Other Software Services.

Figure D3: Massachusetts, California, and United States IT Industry Sector Employment Growth, 1998 – 2007



Source: IMPLAN QCEW Data with UMDI Calculations.

Figure D4: IT Investment by Industry Subsector, Massachusetts' Top Subsectors, 2006 – 2008

	Massachusetts		California*	
	Deals	Investment Amount	Deals	Investment Amount
Security/Firewalls, Encryption Software	47	300,395,100	148	$1,034,439,800
Wireless Communications Services	31	271,599,800	123	$1,257,179,600
Database & File Management	30	264,923,500	78	$635,335,300
Recreation/Entertainment/Music/Movies**	38	241,486,700	266	$1,453,016,500
Business and Office Software	45	211,803,200	137	$827,007,800
Other Communications/Networking Software	13	157,201,200	54	$368,319,300
Other Semiconductors	10	142,999,700	51	$400,353,500
Backup and Disaster Recovery	12	123,720,000	15	$107,876,300
Medical/Health Software	21	115,829,200	28	$159,151,300
Multimedia Software	15	112,324,000	34	$207,615,900
Internet Security and Transaction Services	12	104,714,100	22	$95,677,200
Transportation Software	2	102,500,200	13	$152,499,100
Internet Search Software and Engines	9	99,068,900	110	$685,966,500
Switches/Hubs/Routers/Gateways/ATM	11	76,816,300	57	$682,599,000
Semiconductors	10	69,804,500	29	$316,470,400
E-commerce Enabling Software	14	67,643,300	15	$72,338,600
Consumer Info/Content	14	66,083,000	55	$358,872,400
Other Software Services	8	63,289,100	5	$27,000,100
Customized Semiconductors	11	60,500,400	143	$1,604,484,000
Internet Backbone Infrastructure	8	60,260,100	9	$83,688,900
Other Industry-Specific Software	7	58,457,000	45	$343,979,800
Operating Systems & Utilities	6	56,724,800	21	$143,984,100
Sensors	8	56,097,000	26	$240,663,200
Servers	3	52,000,000	13	$161,951,100
Other Sub-sectors	306	1,697,951,100	1,674	$12,275,864,900
Total Investments	**691**	**$4,634,192,200**	**3,171**	**$23,696,334,600**

Source: PwC/NVCA MoneyTree, Data: Thomson Reuters
*California subsectors listed are not necessarily the top subsectors for the state as a whole.
**Aggregate totals of subsectors of the same title from Media/Internet Content and Media/Internet E-commerce primary sectors.

Endnotes

1. California data were only available for this analysis between 1998 and 2007.

2. This study's calculation uses the NAICS-based definition discussed in Appendix B: IT Industry Definition—NAICS Codes by Core Sector and Subsector.

3. According to the Massachusetts Executive Office of Labor and Workforce Development, ES-202 Series, a total of 213,926 public and private sector establishments employed 3,245,713 workers in Massachusetts in 2008.

4. Key industry clusters were defined according to the Massachusetts Technology Collaborative's *Index of the Innovation Economy.*

5. For more information on the broader IT industry ecosystem, see Section 4, p. 31: *At the Nexus of Innovation*.

6. Industry code revisions affecting the 2008 data necessitated the grouping of wireline providers and internet service providers into the same subsector.

7. This data series analyzed for this study do not include self-employed workers. These individuals are not represented in employment and workforce figures.

8. Dun & Bradstreet, CorpTech, and Alacra.com.

9. The U.S. Bureau of Labor Statistics (BLS) definitions of typical work activities and responsibilities are available in Appendix C.

10. As part of this study, a survey of Massachusetts IT industry businesses was conducted in February 2009. The survey and its findings are available upon request from UMDI.

11. Key informant interviews and focus groups were conducted in Winter 2008-2009. Additional information regarding these interviews and focus groups is available upon request from UMDI.

12. Due to suppressed data, 9.4 percent of IT professionals were not assigned to an industry sector and may be in sectors either inside or outside of the core IT industry sectors (see Figure 18).

13. This calculation required a slightly broader industry definition than the method used to calculate total industry employment. This represents the most conservative estimate of the share of IT technical professionals in the IT industry.

14. Industry insiders suggest that an additional benefit for IT workers has been the availability of equity-based compensation, although the research done for this study did not cover this form of compensation.

15. Premium is calculated as the difference between average salaries in the same occupation working within and outside of the IT industry, not weighted by number of workers.

16. The BLS-defined occupational category SOC 15, "Computer and Mathematical Occupations," is used to stand in for IT occupations because it contains 10 of the 13 occupations identified as primary IT occupations in this study. The occupational category contains 111,910 of this study's 128,520 identified primary Massachusetts IT workers. This is not a perfect comparison because SOC 15 includes mathematicians and excludes three occupations this study identifies as primary IT occupations (SOC codes 11-3021, 17-2061, and 25-1021).

17. Note that this section uses two sets of data developed by agencies of the Commonwealth of Massachusetts to provide customized occupational counts and projections for Massachusetts. The data are different from—but consistent with—Bureau of Labor Statistics occupational statistics.

18. "Datapoints, a weekly snapshot of regional technology business information: STEM job vacancies," MassHighTech, the Journal of New England Technology 27:33 (August 14-20, 2009), 8.

19. These average salaries are not adjusted for inflation and are conservative estimates due to topcoding.

20. According to BLS, this category includes program analysts and management consultants, and excludes computer systems analysts (151051) and operations research analysts (152031).

21. The economic contribution analysis is conducted using IMPLAN software from the Minnesota IMPLAN Group, Inc (MIG, Inc). The software allows the user to model the economic relationships between industries, the average salary by industry type, the output per worker, and household spending patterns. The analysis calculates the total impacts on the MA economy both in terms of total economic production and the number of jobs supported. Direct, indirect, and induced effects are realized as spending by the IT industry flows through the economy, resulting in a multiplier effect. *Direct effects* are spending by the IT industry itself —such as payroll and operations. *Indirect effects* are the ripple effects in other sectors that supply the IT industry, for example, IT manufacturers must purchase from plastics manufacturers. Finally, *induced effects* are the impacts of household expenditures from wages and salaries that result in new business activity and new, higher levels of production. The output multiplier is an index of how many times each dollar is "re-spent" in Massachusetts. An employment multiplier can also be quantified; it is an index of the extent to which each job in the IT industry supports related jobs in other industries.

22. The multiplier is calculated by dividing total impacts by direct impacts.

23. This total includes taxes and fees resulting from direct, indirect, and induced effects. As such, it not only represents taxes and fees paid by IT companies and their employees but taxes and fees resulting from IT industry spending in other industries (and paid by supplier firms and employees) and also by taxes and fees generated by the household spending of IT employees.

24. A number of researchers offer analysis of the correlation but seven researchers have emerged as authorities: Dale Jorgenson with Kevin Stiroh and Mun Ho, Stephen Oliner with Daniel Sichel, Robert Gordon, and Kevin Whelan.

25. Brynjolfsson, Erik. 2003. "The IT Productivity Gap." MIT Center for Digital Business. *Optimize*. July, Issue 21; and Jorgenson, Dale, Mun Ho and Kevin Stiroh. 2008. "A Retrospective Look at the U.S. Productivity Growth Resurgence." *The C.F.A. Digest 38(3)*.

26. Jorgenson, Dale, Mun Ho and Kevin Stiroh, November, 2002. "Projecting Productivity Growth: Lessons from the U.S. Growth Resurgence." Federal Reserve Bank of New York, presentation to the Board of Trustees, Federal Old-Age and Survivors Insurance and Disability Insurance Trust Funds (Washington, D.C.); Atkinson, Robert D. and Andrew S. McKay. 2007. *Digital Prosperity: Understanding the Economic Benefits of the Information Technology Revolution.* Washington, D.C: ITIF; and Laitner, John, and Karen Ehrhardt-Martinez. 2008. *Information and Communication Technologies: The Power of Productivity.* How ICT Sectors are Transforming the Economy While Driving Gains in Energy Productivity. Washington, DC: Report Number E081. The American Council for an Energy-Efficient Economy.

27. Atkinson, Robert D. and Andrew S. McKay (2007).

28. Jorgenson, Dale, Mun Ho and Kevin Stiroh (2008).

29. Brynjolfsson, Erik (2003).

30. Laitner, John, and Karen Ehrhardt-Martinez (2008).

31. *ibid.*

32. Massachusetts Technology Collaborative, 2009. <http://www.masstech.org/it_collaborative/061809.html>. Accessed June 2009.

33. This section refers to "subsectors" defined by industry analysts, specifically The MoneyTree™ Report from PricewaterhouseCoopers and the National Venture Capital Association based on data from Thomson Reuters. These subsector definitions are similar, but not identical to, those created by UMDI for this study. For more information about the subsectors included in the analysis of venture capital investment, see Section 5, p. 39.

34. Refers only to companies with more than one employee and does not include self-employed workers.

35. Information is based on review of 119 position announcements posted on the Fidelity Careers website, jobs.fidelity.com Accessed on July 6, 2009. Includes Boston, MA; Marlborough, MA; Smithfield, RI; and Merrimack, NH

36. Information is based on a review of 469 position announcements posted on the Genzyme Careers website, <www.genzyme.com/corp/careers/fulltime_positions.asp>. Accessed on July 6, 2009. "Biotechnology" and "information technology" are categories pre-defined by Genzyme.

37. Surescripts Massachusetts State Progress Report on Electronic Prescribing, 2009. Available at <www.surescripts.net/safe-rx-awards.html>.

38. Jackie Noblett, "EMC, CISCO: Not-so-strange bedfellows?" *Mass High Tech: The Journal of New England Technology*, July 10-16, 2009.

39. Yahoo Finance, Verizon Begins Deploying Breakthrough Optical Technology That Saves Space and Makes It Easier to Install FiOS Services in Apartment Buildings, <http://finance.yahoo.com/news/Verizon-Begins-Deploying-prnews-2239003201.html?x=0&.v=1> July 28, 2009.

40. Wade Roush, "Brigham Docs Share Medical Scans Remotely Using IBM Web Browser Technology," Xconomy Boston,<http://www.xconomy.com/boston/2009/03/13/brigham-docs-share-medical-scans-remotely-using-ibm-web-browser-technology/> March 13, 2009.

41. This section refers to "industries," "sectors," and "subsectors" as defined in the MoneyTree™ Report from PricewaterhouseCoopers and the National Venture Capital Association based on data from Thomson Reuters. These definitions are similar, but not identical, to those created by UMDI for this study.

42. For a comparison of investments in these sectors and subsectors to California, see Appendix D: The Massachusetts Industry in a National Context.

43. The NSF's program 47.070: Computer and Information Science and Engineer objective is "[t]o support investigator-initiated research in all areas of computer science and engineering and related fields and contribute to the education and training of future generations of computing professionals, ensuring a supply of qualified technical personnel commensurate with national needs."<http://www.cfda.gov/CFDA.pdf>, p. 835.

44. NIH's IT-related R&D classification is "Networking and Information Technology R&D." Categorization determined through the Research, Condition, and Disease Categorization (RCDC) System computer-based process which sorts NIH-funded projects at the end of each fiscal year into "each of 215 historically reported categories of disease, or condition, or research area." To see the RDCD steps see: <http://report.nih.gov/rcdc/category_process/Default.aspx>.

45. All state designations throughout the "Defense-related IT research and development contracts" section is based on the

award's "Principal Place State," which is the state in which the work was primarily performed.

46. According to the U.S. Bureau of the Census, NAICS was developed "under the auspices of the Office of Management and Budget (OMB), and adopted in 1997 to replace the Standard Industrial Classification (SIC) system." Canadian, Mexican, and U.S. agencies jointly developed the NAICS to allow for detailed research on North American economic activities.

47. According to the U.S. Census, "only six of the twenty NAICS sectors had changes during the 2002 revision of NAICS, and only two with substantial changes that included complete revisions of codes." These six included Construction; Wholesale Trade; Information; Retail Trade; Mining; and Administrative and Support and Waste Management. In sector 51 (nformation), "a new industry was created for establishments publishing or broadcasting exclusively on the Internet. Also, the 1997 subsector for Broadcasting and Telecommunications was split into two separate subsectors with some industry changes, to reflect changes in the Telecommunications area as well as to further distinguish between production processes of creating and/or acquiring content (Broadcasting) versus transmitting content (Telecommunications)." From <www.census.gov/epcd/www/drnaics.htm>.

48. Bureau of Labor Statistics Standard Occupational Classification System, <http://www.bls.gov/soc/>. Accessed June 10, 2009.

49. Data availability for both employment and firm numbers limit UMDI analysis through year 2007. Data for year 2008 will be released as a supplementary analysis in the third quarter of 2009.

50. A total of 211,843 public and private sector establishments employed 3,236,118 workers in Massachusetts in 2007, according to the Massachusetts Division of Workforce Development, ES-202 series.