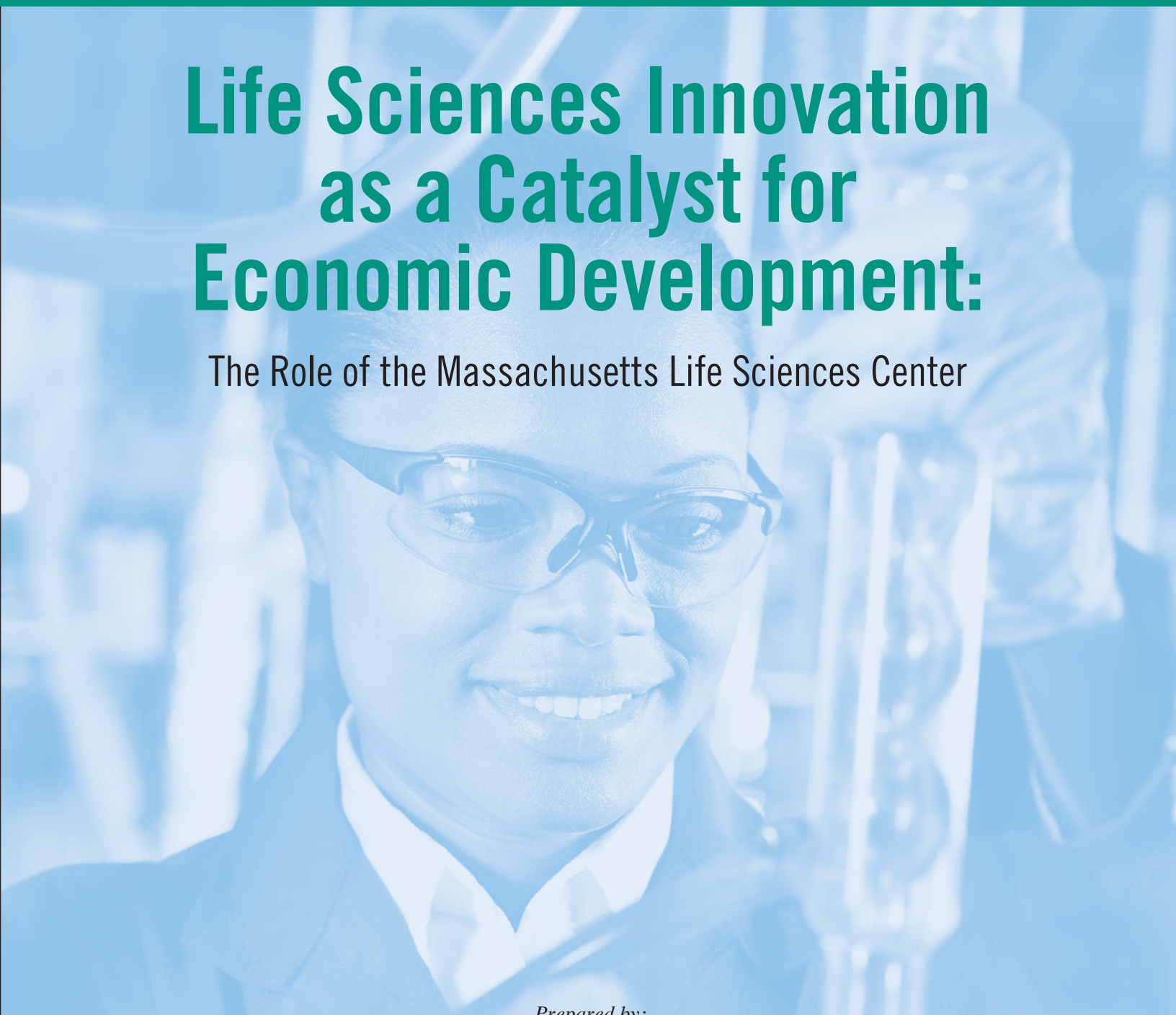
UNDERSTANDING BOSTON

Life Sciences Innovation as a Catalyst for Economic Development:

The Role of the Massachusetts Life Sciences Center



Prepared by:

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Northeastern University
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About the Authors

Barry Bluestone is a Founding Director of the Kitty and Michael Dukakis Center for Urban and Regional Policy and former Dean of the School of Public Policy and Urban Affairs at Northeastern University, where he is also the Stearns Trustee Professor of Political Economy. Previously, Professor Bluestone spent 12 years at the University of Massachusetts at Boston and 15 years at Boston College, where he directed the University's Social Welfare Research Institute. At the Dukakis Center, he has led research projects on housing, local economic development, state and local public finance, and the manufacturing sector in Massachusetts. He regularly consults with trade unions, business leaders, and serves on Gov. Deval Patrick's Economic Development Strategy Council. Professor Bluestone was raised in Detroit and attended the University of Michigan, where he received his Ph.D. in economics.

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Preface

In 2003, a distinguished group of university leaders, educators and business representatives came together for a unique and unprecedented summit, spearheaded by Harvard Business School professor Michael Porter and hosted by the presidents of MIT and Harvard, Susan Hockfield and Drew Gilpin Faust. This was the same year those two universities played a major role in the international team that cracked the human genome.

The summit's purpose was to discuss the state's life sciences "super cluster," meaning all of the many sectors that are involved in the life sciences. Everyone attending agreed that strengthening the life sciences was not only smart and played to our state's strengths, it was crucial to our future global competitiveness. It could mean jobs for hundreds of thousands and billions added to the Massachusetts economy.

While the summit was stimulating, there was no established vehicle to build on the momentum that it generated. And so, in 2005, the Boston Foundation provided a grant of $125,000 to create the Massachusetts Life Sciences Collaborative. The Organizing Committee for the new group included the leaders of all of the Boston area's major universities, teaching hospitals, life-sciences companies and venture-capital firms.

In March of 2007, Governor Deval Patrick spoke at one of the Collaborative's meetings about the importance of the life sciences to the Commonwealth. He previewed an announcement he would make publicly later that year about the creation of a new Massachusetts Life Sciences Initiative, which represented a 10-year, $1 billion investment to enhance and strengthen the state's leadership in the life sciences.

The Boston Foundation was honored to play a major convening role in bringing together the stakeholders for those early discussions. And now we are proud to publish this first report on the Massachusetts Life Sciences Initiative and the work of the quasi-public agency charged with carrying out its mission.

We have published many reports researched by the lead author of this report, Barry Bluestone, Director of the Kitty and Michael Dukakis Center for Urban Affairs at Northeastern. Reports from the Dukakis Center are always thorough and compelling, but not all of them carry good news. This one does, especially when it comes to economic impact. The $56.6 million Massachusetts awarded in tax incentives to life sciences firms between 2009 and 2011 has created 2,500 jobs, which should generate more than $266 million in wages and salaries during the next five years. In fact, the Commonwealth's life sciences super cluster has risen to number one in the nation in terms of per capita employment, with close to 14,300 jobs for every one million residents.

These jobs are not just for workers with advanced degrees: at least one in five require no more than a two-year associate's degree and another 48 percent require just a bachelor's degree. For the Boston Foundation, this confirms our deep investment in supporting the full education pipeline and the importance of preparing college students for well-paying jobs in a field that will only grow.

Estimating the economic impact of this life sciences super cluster is within our grasp. Evaluating its broader value to society is daunting because of the almost limitless potential it has for improving the lives and well-being of people here in Massachusetts and around the world.

Paul S. Grogan
President & CEO

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Executive Summary

This report provides an up-to-date, independent evaluation of the $1 billion, 10-year Massachusetts Life Sciences Initiative and the Massachusetts Life Sciences Center (MLSC) charged with the responsibility of carrying out its mission. The initiative was established in July 2008 by Governor Deval Patrick's Administration and the Legislature to encourage the growth of discovery and production in the life sciences, including biotechnology, pharmaceuticals, medical diagnostics, medical devices and bioinformatics in the Commonwealth. Based on the region's existing comparative advantage in life sciences research and development (R&D) emanating from the laboratories of its leading universities and medical institutions, this substantial infusion of public funds was undertaken with the ambitious goal of making this cluster of industry sectors the most successful in the world.

This evaluation comes at a propitious time, given the state of fiscal affairs in the Commonwealth and the nation. Virtually every unit of government is scrutinizing the use of each tax dollar to ensure that public revenue is being spent effectively and efficiently. Put simply, our goal in this evaluation was to gather as much data as possible to assess whether the Commonwealth's sizeable commitment of public resources is paying off in the form of a life sciences "super cluster" capable of attracting massive amounts of investment dollars, generating well-paying jobs for Massachusetts residents and yielding additional tax revenue for the Commonwealth.

The Life Sciences Super Cluster and the MLSC

After it was created, the MLSC sought to develop as a key element of its strategy the creation of a collaborative "ecosystem" encompassing all aspects of the state's life sciences. It would do this by encouraging the development of a dense, highly connected community of scholars, entrepreneurs, industry leaders, venture capitalists and government officials who were all dedicated to the success of this sector. Unlike many narrowly focused state economic development initiatives, the Center has chosen to guide its investments with a broad range of strategic priorities geared to enhance all aspects of the life sciences cluster. These include:

- funding translational research that converts new discoveries into marketable products and services
- investing in promising new technologies
- ensuring worker skill acquisition that aligns with the needs of life sciences industries
- creating new infrastructure with shared resources to accelerate life sciences innovation
- building partnerships among segments of the local and international life sciences communities

To accomplish these goals, the Center relies on a portfolio of seven distinct programs. These include:

Cooperative Research Grants to support industry-sponsored research at universities in order to facilitate scientific discoveries that lead to medical applications. These grants match industry contributions dollar for dollar.

Internship Challenge Program to provide funds for interns working at start-up and smaller Massachusetts life sciences companies.

New Investigator Grants to spur innovative research and advance the careers of new investigators working on cutting-edge research at academic research centers in Massachusetts.

Life Sciences Accelerator Loan Program to make loans available to early-stage companies and help leverage additional sources of capital.

Small Business Matching Grant (SBMG) Program to provide matching support to firms on the verge of commercializing new technologies developed with Phase II or Post-Phase II federal Small Business Innovation Research (SBIR) awards or federal Small Business Technology Transfer (STTR) grants.

Life Sciences Tax Incentive Program to offer a combination of 10 competitively awarded tax incentives available to companies that meet specified hiring goals.

TABLE 1

Distribution of MLSC Investments by Dollar Amount (June 2008–June 2012)

Capital Projects (12)	$186,950,000
Company Grants and Accelerator Loans (31)	$22,907,000
Academic Research Grants (35)	$23,346,344
Tax Incentives (56)	$56,595,093
Interns Funded for Workforce Development (884)	$6,903,164
Equipment and Supply Grants for Schools (32)	$3,333,675
Other Grants/Business Plan Competitions	$1,540,000
TOTAL	$301,575,276

Source: Massachusetts Life Sciences Center, 2013

Capital Projects Fund to provide capital for equipment and supplies for high schools in Gateway Cities, vocational/technical schools, and community colleges; and for capital projects at academic/research institutions, business incubators, and other not-for-profit organizations.

Between 2008 and June 30, 2012, the Center directly invested or committed more than $300 million in state funds that have leveraged more than $1 billion in third-party investments by private businesses, the federal government and foundations, according to the MLSC *FY2012 Report*. **Table 1** provides a breakdown of these investments.

Special Features of the Massachusetts Life Sciences Center

Our analysis revealed that, aside from its extraordinarily broad mandate, there are other factors that make the MLSC quite different from most government subsidy programs.

First, the MLSC operates under a Board of Directors that includes state government officials, but also industry CEOs, leaders from academia and medicine, bioscience researchers and others who have great knowledge of the life sciences.

Second, MLSC accelerator loans and other investments are reviewed by a panel of more than 200 specialists who advise the Center's Scientific Advisory Board (SAB), which itself is dominated by academic researchers, industry scientists, and private venture-capital experts who together can judge both the scientific and economic potential of an MLSC investment. Accelerator loans are also reviewed by private venture-capital experts who can assess the economic potential of recipient firms.

And third, the Center insists on accountability in terms of private sector investment matches. The Center also retains the power (and has utilized it) to "claw back" tax incentives if and when specific job creation goals are not reached by grant recipients.

We discovered from our interviews with life sciences executives, trade association leaders and members of the MSLC Scientific Advisory Board that the high level of professionalism associated with the Center's expert-based review process has resulted in MLSC investments that appear to have a high rate of return for the Commonwealth. We will return to this point, but must first touch upon a finding even more important than the measured rates of return to specific MLSC programs.

New vs. Old Growth Theory

To properly assess the value of the Life Sciences Initiative and the MLSC, it is useful to place its activities in the context of economic growth theory. What is now known as the "old growth theory" suggests that economic prosperity springs from the accumulation of ever greater stocks of the fundamental ingredients of production: capital, labor and natural resources. Those countries that find ways of increasing investment in plant and equipment, adding to labor supply and extracting more natural resources are the ones that will become more affluent.

While not completely discounting this approach to growth, a "new growth theory" has evolved that places technological progress at the very epicenter of growth dynamics—even more important than capital, labor and resource inputs. Advances in technology and interdependencies between new ideas and new investment provide the basis for entire new industries and products that generate additional wealth and raise living standards.

Innovation-based growth is so powerful because it avoids the classic problem of diminishing returns on any given investment. With this type of growth, once the fixed cost of creating a new technology has been incurred, the formula can be used over and over again at little or no cost. As such, there can be increasing returns paying enormous dividends to society.

Moreover, the new innovation-based growth theory

posits a strong reciprocity among the rate of skill acquisition by workers, investments in new capital and new inventions. Thus, programs that combine incentives for innovation along with resources to augment human capital should fuel rapid economic growth more than anything else society can do to promote prosperity.

What is special about the Massachusetts Life Sciences Initiative is that it focuses explicitly on increasing the rate of innovation by encouraging more research and development (R&D) in the life sciences and helping small firms in this super cluster convert basic research into marketable products and services. New growth theory posits that this activity is the very fountain of economic growth.

Has the MLSC Been Successful?

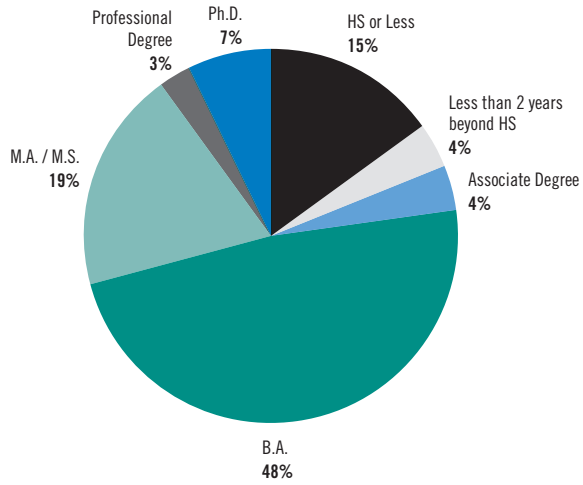
Unfortunately, keeping score on the success of innovation is difficult. Instead of a more-or-less certain return to a given infusion of capital under the old growth theory, under the new growth theory, innovation tends to deliver stronger long-term growth but it is "lumpy, discontinuous, and nonlinear." There can be a long gap between the time a new innovation is first incorporated into production and the time that it pays off in terms of increased productivity, output and jobs. In the short term, it can be discouraging, as investments in fundamental innovation usually have little immediate payoff. It will take decades to realize the full benefits to humanity and the economy from the advances now being made in drug discovery, medical diagnostics and medical devices.

What we can do is measure the short-term direct benefits of MLSC investments and consider the views of experts as to whether the Center has indeed played a critical role in creating a life sciences "ecosystem" that attracts investment and generates jobs in this sector.

Short-Term Benefits

As for the short-term benefits, we conducted a cost-benefit analysis of the Center's tax incentive program. According to our analysis based on MLSC data, the total value of tax incentives outstanding to Massachusetts life sciences firms as of June 30, 2012 was $56.6 million. Our best estimate is that a little over 2,500 jobs were created as a result of these incentives. Given the average $105,000 salary of these jobs, we predict they will generate more than $266 million in wages and salaries during the next five years. If our analysis proves correct, these workers will pay more than $93 million in state personal income and sales taxes during that period. As such, assuming all of these jobs were directly related to the tax incentives and that these jobs last at least five years, every dollar of tax incentive will repay $1.66 to state coffers, as **Table 2** reveals. This is an outstanding rate of return.

FIGURE 1
Education Distribution of New Hires by 2010 MLSC Tax Incentive Awardees



Source: Dukakis Center for Urban and Regional Policy

What is more, our analysis suggests that these jobs will go to a broad array of workers, not just those with advanced degrees. As **Figure 1** reveals, more than one in five jobs in life sciences firms require no more than a two-year associate's degree and nearly another half (48%) require no more than a bachelor's degree. Thus, the short-term benefits of MLSC tax incentives seem to have heavily outweighed the costs and the job benefits are broadly shared.

The Unique Growth Pattern of Regional Life Sciences Clusters

The most important benefits stemming from MLSC activities, however, will come in the future. This is due to the unique growth pattern of highly innovative sectors like the life sciences. The regional concentration of life-sciences companies happens in a very different manner than in other industries. In the case of traditional industrial sectors such as auto, aircraft engine, financial services and the like,

TABLE 2

Economic Return on the MLSC Tax Incentive Program

	Program Year 2009	Program Year 2010	Program Year 2011	3 Years of Incentives
Total Value of MLSC Tax Incentives ($) Outstanding	$15,245,500	$20,672,638	$20,340,884	$56,259,022
Net New Jobs Created	901	721	915	2,537
Tax Incentive per Job ($)				$22,175
Annual Tax Incentive per 5-year job ($)				$4,435
Average Salary per Job ($)				$105,037
Total Salaries Generated per Year ($)				$266,479,399
State Income Tax Revenue per Job per year ($)				$4,937
Total State Income Tax per year ($)				$12,524,532
Average Sales Tax per Job ($)				$2,404
Total State Sale Tax per year ($)				$6,099,447
Total Income+Sales Taxes per year ($)				$18,623,979
Average Income+Sales Tax/Job per year				$7,341
Total Income+Sales Taxes per 5-year Job				$36,705
Total Income+Sales Taxes over 5 years				**$93,120,585**
Tax Revenue/Incentive Ratio over 5 years				**1.66**
	Pharma	**Medical Devices**	**Scientific Research**	**Total**
Jobs	1,843	481	213	2,537
Average Salary ($)	$115,222	$66,913	$103,009	$105,037
Total Salary ($)	$212,353,256	$32,185,280	$21,940,863	$266,479,399
Share of Salary	0.7969	0.1208	0.0823	1.0000
State Income Tax By Sector ($)	$9,980,603	$1,512,708	$1,031,221	$12,524,532
Sales Tax by Sector ($)	$4,860,554	$736,689	$502,204	$6,099,447

Source: Dukakis Center for Urban and Regional Policy

a region becomes dominant in a particular cluster once a large anchor enterprise or a small number of them establish operations in that locale. Once the anchor enterprise is established, an array of smaller firms is attracted to that region to serve as part of the supply chain for the large anchor enterprise(s). Essentially, the small firms in the industry are dependent on the large ones.

For the life sciences and other highly innovative sectors, the reverse is true. The large companies that depend on the development of breakthrough innovations and sophisticated medical devices prosper by being near a concentration of small start-up firms. Even the largest of the life sciences companies, with substantial research budgets, do not have the resources to generate more than a handful of breakthroughs in the biosciences, genomics and similar fields. These big firms grow and prosper by carefully monitoring the scientific discoveries under way in university research laboratories and in the translational research carried out by small start-ups.

Those few start-ups that develop potential blockbuster drugs or devices become prime targets for acquisition by the larger firms. The secret to success in the acquisition process is being where the small firms are located. This permits the large companies to closely monitor the progress of smaller firms and buy the most promising ones before "Big Pharma" competitors or other medical device manufacturers can make a bid. To use a metaphor from nature, the large, globally important life sciences firms want to feed in the waters where the minnows are swimming.

Because Massachusetts has so many small life sciences firms, nine of the world's ten major drug companies have now set up shop in the Commonwealth. They are

investing billions in plant and equipment and creating thousands of additional jobs. These include Pfizer, Novartis, Johnson & Johnson, GlaxoSmithKline, Sanofi (which absorbed Genzyme), AstraZeneca, Abbott Laboratories, Merck and Bristol-Myers Squibb.

And here is the key to understanding the central role of the MLSC: While the large firms can easily exist without the MLSC's direct investments, the small life-sciences ventures need the Center to provide them with accelerator loans, research and development funds, and interns who can help them translate their ideas into commercially viable products. While the private venture capital market may provide some funds for this purpose, venture capitalists often demand a quicker return than can be obtained from this sector, which often has long lag times between initial research, proof of concept and a final product approved by the U.S. Food and Drug Administration.

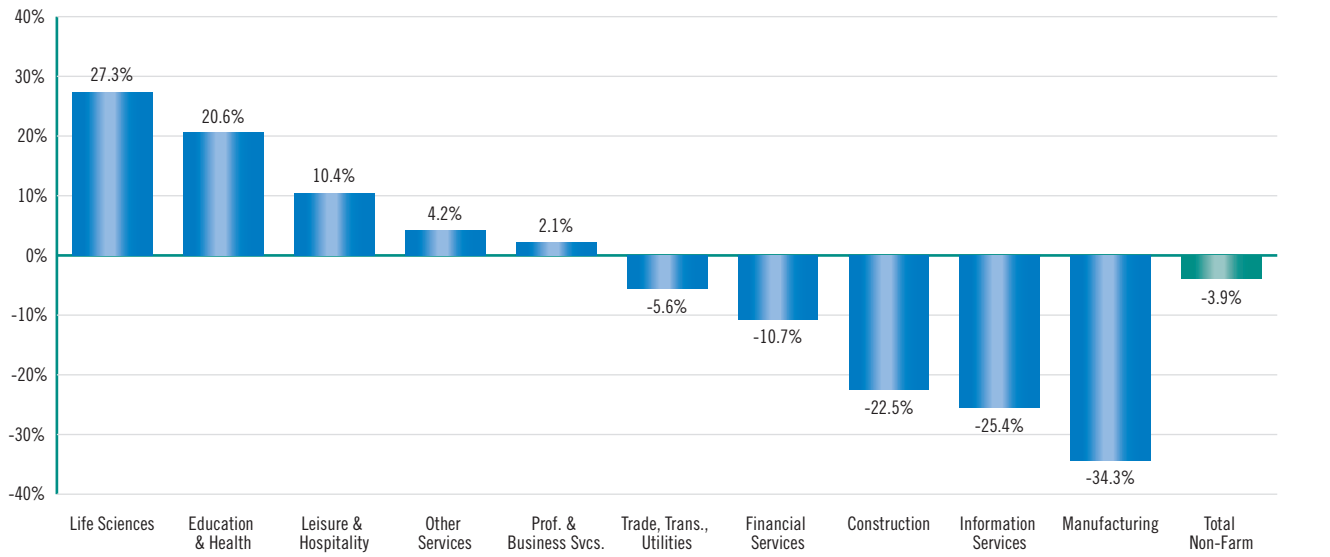
In this environment, the MLSC has become an important investment partner for smaller life sciences firms that grow out of local research universities and medical centers. By providing funds for translational research and development, the MLSC can help keep these growing companies in the Commonwealth instead of losing them to investment funds in other regions. To revert to metaphor again, it's because these minnows stay here that Big Pharma has come to swim in this pond. In addition, Big Pharma benefits from the Center's investments in workforce development, shared infrastructure resources and cooperative research projects between industry and academia. The result has been extraordinary output and employment growth.

The Massachusetts Life Sciences: A Record of Output and Employment Growth

The numbers are, indeed, impressive. As of 2012, according to the Massachusetts Biotechnology Council (MassBio), 1,198 life sciences companies were operating in New England and employing 103,006 workers. More than half of these firms are located in Massachusetts. Of all the Massachusetts firms listed in the 2012 MassBio directory, about half (514) are medical device companies; 232 are drug development firms; 147 are contract research and manufacturing enterprises and 146 produce research products and instrumentation for the life sciences.

The rapid growth in employment in the life sciences in Massachusetts provides a strong indication of how rapidly this sector is expanding. As **Figure 2** reveals, the life sciences far outpaced all other industry sectors between 2001 and 2011.

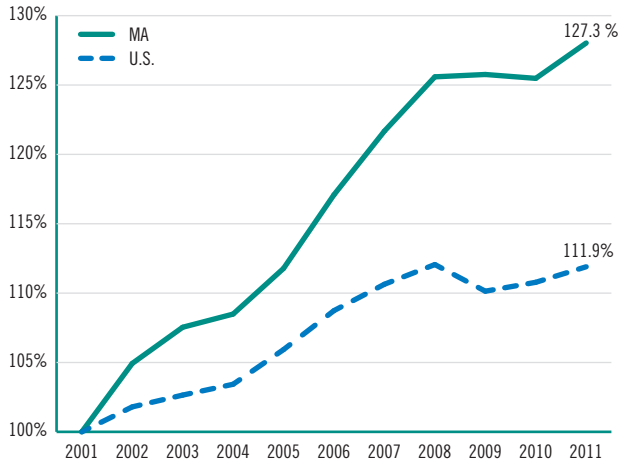
FIGURE 2
Massachusetts Employment Growth by Industry Sector 2001–2011



Source: BLS, Author's Analysis

FIGURE 3

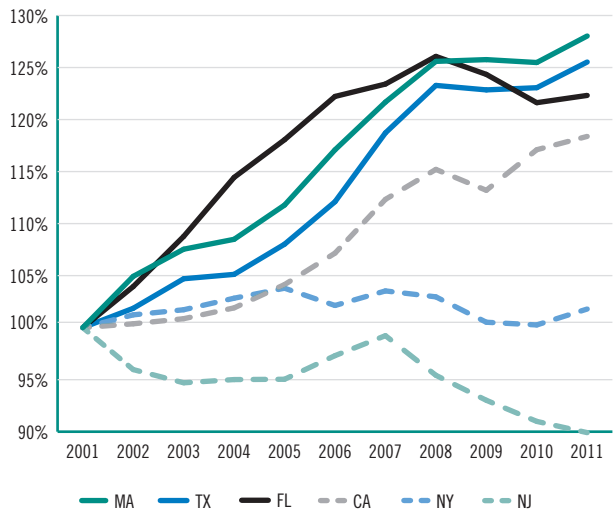
Employment in Life Sciences Indexed to 2001, Massachusetts vs. the U.S.



Source: Author's Analysis from BLS data

FIGURE 4

Employment in Life Sciences Indexed to 2001, Massachusetts vs. Big Competitor States



Source: Author's Analysis from U.S. Bureau of Labor Statistics (BLS) data

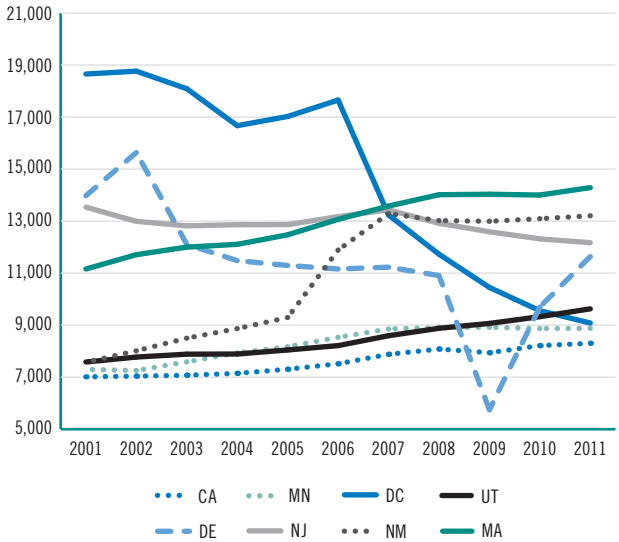
Even more impressive is the Boston-area super cluster's performance relative to the United States as a whole and to other states vying for supremacy in this rapidly evolving cluster of industries. The Commonwealth has indeed overtaken the rest of the nation in terms of employment growth in the life sciences, fulfilling an initial goal of the MLSC. **Figure 3** reveals the trend in life sciences employment in Massachusetts compared to that of the United States as a whole between 2001 and 2011. During this period, Massachusetts life sciences employment growth outperformed the nation by a factor of better than 2-to-1—growing by 27.3 percent vs. 11.9 percent for the nation.

The Commonwealth's main competitors in the life sciences are California, New Jersey, New York, Florida and Texas. But as **Figure 4** demonstrates, after 2008, the Commonwealth overtook all of these states in terms of the 2001-2011 employment growth rate.

Moreover, when we control for population size, Massachusetts is the clear winner for the entire life sciences cluster of industries. In **Figure 5**, we have controlled for the size of population of each state by measuring the number of life sciences jobs per 1 million residents. By 2011, given its rapid growth rate, the Massachusetts cluster had risen to #1 in terms of per-capita life sciences employment. With nearly 14,300 life sciences jobs for every 1 million residents, Massachusetts eclipsed all other states on this measure.

FIGURE 5

Life Sciences Jobs per 1 Million 2010 Population Top 8 States in 2011, by Year



Source: Author's Analysis from BLS data

With this growth dynamic at work, Massachusetts appears well positioned to continue to attract new investment in the life sciences super cluster. In a 2011 analysis of the established life sciences clusters worldwide, the commercial developer Jones Lang LaSalle concluded that Boston had become the #1 region for the life sciences. The report noted the Boston area's concentration of high-tech research and hospital/medical employment, its many science and engineering graduate students, its plentiful funding from the National Institutes of Health and venture capitalists, its investment in R&D as a percentage of state GDP and its research facilities. Boston had a composite score of 7, ranking it #1 overall. New York/New Jersey was #2 with a composite score of 24, followed by the Bay Area and Los Angeles in California, each with a score of 25. Boston remained #1 in the developer's 2012 report, while San Diego, the San Francisco Bay area, Raleigh-Durham, N.C., and Philadelphia overtook New York/New Jersey and Los Angeles.

Why Has the MLSC Been So Successful at Building the Life Sciences Ecosystem?

According to our interviews, the Center's successful record of investments in the life sciences is grounded in its reliance on a Scientific Advisory Board (SAB) along with a large panel of experts to guide the Center's Board of Directors in determining which firms show the greatest promise. This approach to distributing public funds has created credibility within the super cluster and its ecosystem. Over and over again, we heard adjectives like "rigorous" and "diligent" when our informants described the processes MLSC uses in selecting awardees and providing a platform for collaboration.

The interviews we carried out also suggested that the Center itself is being run quite effectively and efficiently and in a highly professional manner. Virtually all of our informants praised the management team and expressed special appreciation for the leadership's refusal to permit political considerations to trump scientific merit. Because the Scientific Advisory Board (SAB) selects awardees, "There is not an ounce of boondoggle in this agency," one informant told us. Another observed that the MLSC has "lots of moving parts" and all of them are working well. Several of the interviewees observed that the Center remains responsive to industry needs, meets its deadlines and stays focused on its mission. In its report on creating fiscally sound state tax incentives, the Pew Center on the States singled out the Massachusetts Life Sciences Tax Incentive Program for its focus on annual cost controls and its reliance on scientific merit in making awards.

Still another informant noted that the MLSC is successful because its leadership is committed to working "at the speed of business" and therefore has become a valued partner in the expansion of the industry.

Conclusions

All of our research suggests that the state will benefit from fully funding the remaining five years of the initiative in order to maintain the lead the life sciences super cluster has established in the Commonwealth. This is particularly important as other states ramp up their investments in hopes of creating their own life sciences ecosystems to entice the small and large firms Massachusetts has successfully attracted. California, Maryland, New Jersey, New York, Minnesota and Florida are not resting on their laurels, but continue to spend state funds on their own life sciences industries.

Over time, it should be possible for the Center to reach out to the private sector to help fund more of its initiatives, as it has done with the newly established Massachusetts Neuroscience Consortium. This consortium, established in September 2012, combines the efforts of the MLSC with seven global biopharmaceutical companies to jointly fund pre-clinical neuroscience research at Massachusetts academic and research institutions. Based on this model and with the plethora of larger, profitable firms coming to the state to expand their operations, one could imagine the Center funding more of its internships with private funds and having for-profit companies contribute to other programs (STEM: science, technology, engineering and math education, for example), allowing the Center to focus even more of its resources on accelerator loans and tax incentives for firms undertaking translational research.

We should also note that the success of the MLSC has lessons for other quasi-public entities in the Commonwealth. We can mention five of them here:

1. Long-term success in the use of tax incentives and business loans is most likely to occur when funds are focused on a cluster of firms and a set of technologies in a given industry, helping to create an industrial ecosystem which can attract new companies to the state.

2. The use of expert panels to determine the awarding of loans assures that these funds will be well utilized. "Claw-back" provisions protect the taxpayers by requiring firms to repay funds advanced by the Commonwealth if they fail to meet hiring goals.
3. A focus on encouraging firms in their early stage innovation activity is central to promoting economic growth and prosperity.
4. Helping fund workforce development efforts for critical industries as part of the mandate of the quasi-public entity helps ensure a pipeline of skilled workers for the industry and this itself helps attract new firms to the region.
5. Taking a "portfolio" approach to the entire range of activities in the life sciences—from investments in small innovative firms to helping train the future workforce to underwriting infrastructure—helps sustain the "ecosystem," undergirding a virtuous cycle of discovery, innovation, investment, and employment opportunity.

In the end, we applaud the Governor and the Legislature for their foresight in creating the Massachusetts Life Sciences Center and the $1 billion Life Sciences Initiative and we tip our hat to the MLSC for carrying out its public responsibilities in a most effective and efficient manner. The programs in place are fulfilling the goals set out in the original legislation and the Center's leadership has ensured that these programs work to the full benefit of the Commonwealth and its residents.

Introduction

The Massachusetts Life Sciences Initiative, conceived by Governor Deval Patrick's Administration and passed into law by the Massachusetts Legislature in July 2008, is a bold 10-year, $1 billion investment in the future of the state's economy. Based on the region's existing comparative advantage in the life sciences emanating from the laboratories of its leading universities and medical institutions, this substantial infusion of public funds was squarely aimed at making this cluster of industry sectors—including biotechnology, pharmaceuticals, medical diagnostics, medical devices, and bioinformatics—the most successful in the world. The Massachusetts Life Sciences Center (MLSC), founded two years earlier, was charged with the responsibility of implementing this bold experiment in public-private sector collaboration. If effective, the initiative was expected to boost investment and jobs in this evolving industrial sector, generating increased household income and tax revenue for the state.

In 2012, at the near halfway point of that 10-year initiative, the Dukakis Center for Urban and Regional Policy at Northeastern University was invited by the MLSC to measure the progress of the life sciences sector in Massachusetts and to carry out an evaluation of the Center's activities. We agreed to conduct such a study, but only under the condition that we would have full access to MLSC records, that our investigation would not be censored in any way by the MLSC staff, and that the staff of the Dukakis Center would have absolute control over the content of the final evaluation report. As a result, this report is being published by the Boston Foundation as part of its *Understanding Boston* series.

For the past year, Barry Bluestone, Director, and Alan Clayton-Matthews, Senior Research Associate at the Northeastern center, have carried out this evaluation. Both of us are economists who have extensive experience in industry studies and in program evaluation. Neither of us, however, was an expert on the life sciences sector when this evaluation project was first launched.

In the course of this research, we immersed ourselves in literature about the components of the life sciences industry cluster and about the role of public investment in innovation and economic growth. We analyzed existing employment data on each of the life sciences industries in the state; reviewed all of the annual reports of the MLSC; attended meetings of the MLSC Board of Directors where decisions over tax incentives and awards were made; and conducted lengthy interviews with leading executives of life sciences companies located in the state, industry trade association leaders, and members of the MLSC Scientific Advisory Board. This report is based on all of the data gathered over the year.

We began this research fully agnostic about what we might ultimately find, given the checkered record across the country of state industrial policy aimed at assisting other industries. But what we have found, based on our research, is that the Commonwealth's life sciences initiative is meeting, if not exceeding, the goals first established in 2008 by the Governor and the Legislature. Moreover, our interviews with key informants led us to the conclusion that the Massachusetts Life Sciences Center is executing its responsibilities in an effective, efficient, and professional manner. The initiative and the MLSC has performed exceptionally well in creating an *ecosystem* within which the cluster has prospered.

Moreover, we have concluded that the Center's mission, administration, and performance provide important lessons that can be applied to other state agencies charged with encouraging economic development.

This research could not have been carried out without the assistance of the staff of the MLSC and the many industry executives and experts who provided us with data and candid answers to our probing questions. We thank them all for their time and the information they afforded us.

CHAPTER ONE

About the Massachusetts Life Sciences Center

In June 2006, the Massachusetts Legislature created a new quasi-public agency, the Massachusetts Life Sciences Center (MLSC), to promote the life sciences within the Commonwealth. It was tasked with "investing in life sciences research and economic development . . . by making financial investments in public and private institutions."[1] Its mandate was broad: to encourage basic research, development, and commercialization in the biosciences; ensure the preparation of a skilled workforce to meet the needs of the state's bioscience industry cluster, and build stronger collaboration between the sectors of the local and international life sciences community.[2]

A year later, in May 2007, Governor Deval Patrick revealed an ambitious plan for a 10-year, $1 billion public initiative to enhance the Commonwealth's existing competitive advantage in this rapidly evolving and critically important sector of the U.S. economy. This would provide the funding for a major expansion in the activities of the Life Sciences Center. In June 2008, the legislature enacted the Governor's Massachusetts Life Sciences Initiative with the aspiration of building on the existing strengths of the state's research universities, its world-renowned health care sector, and its emerging private sector life sciences firms to promote the Commonwealth as the foremost center for the life sciences in the world.

With such a large commitment of state resources, how close has the Center come to meeting this goal? Has it helped attract life sciences companies to the Commonwealth, boosted R&D in the private life sciences arena, created job opportunities for Massachusetts workers and increased the state's revenue base by boosting employment, household income, and corporate profits?

This analysis of the MLSC comes at a propitious time. Massachusetts, along with most of its cities and towns—not to mention the nation as a whole—faces growing fiscal constraints. The economic recession that officially began in late 2007 and officially ended in 2009 has given way to an extended period of sluggish economic growth. This has diminished tax revenue just when the swelling cost of health care and public pensions is generating structural deficits.[3] Without additional tax revenue from more vigorous growth, these potential deficits will require either raising taxes or cutting public services, or both.

In this new economic environment, virtually every unit of government is being forced to husband its resources and scrutinize its spending to assure that every tax dollar is spent effectively and efficiently. As such, it is not surprising that the nation, the Commonwealth, and most of its municipalities are considering ways to cut "unnecessary" or "wasteful" spending. At the same time, they want to preserve essential public programs that meet critical social needs and improve the targeting of incentives to the private sector to accelerate economic growth.

A prime target in this new era of public scrutiny is the extensive set of "subsidies" and "tax expenditures" that governments have traditionally used to encourage specific types of consumption or investment. Every tax dollar that a government agency transfers to a private business or individual in the form of a *subsidy* means a dollar less that can be used in the short-term for other purposes. Every dollar that a business or individual saves on its taxes is an "uncollected" dollar—a *tax expenditure*—that could have been used to pay for one or another public service.[4] Because of the short-run "opportunity costs" attached to every dollar spent, there is a growing demand to ensure that public dollars are not being wasted on programs that have little payoff. Each program must be judged on whether the *long-term* gain from issuing a tax incentive, government grant, loan guarantee, or subsidy outweighs the *short-term* cost to the treasury.

Adding to the demand for more accountability has been a recent series of high-profile cases of "failed" government incentive programs. Solyndra, a manufacturer of solar photovoltaic systems, became the poster child for "misspent" federal funds during the last presidential campaign when it filed for bankruptcy after receiving

$535 million in U.S. Energy Department loan guarantees.[5] The same was true when A123, a manufacturer of lithium ion batteries for electric cars, went bankrupt after receiving a $130 million federal grant to build a plant in Michigan. It was, according to a series of *Washington Post* reports, the fifth clean-energy firm the current Washington administration subsidized with loans or grants that filed for bankruptcy protection. During the campaign, Republicans claimed both Solyndra and A123 were prime examples of "cronyism" in President Obama's stimulus program.[6]

Closer to home was the failure of Curt Shilling's 38 Studios video-game firm. It closed its doors and laid off all of its employees after Rhode Island lured it from Massachusetts with a $75 million loan guarantee. This case raised anew an old question. Under what circumstances should states use tax abatements, subsidies, and other inducements to encourage investment and create jobs in the private sector?[7]

As the Massachusetts Life Sciences Initiative approaches the halfway mark in its 10-year legislative life, it is altogether appropriate that this report attempt to ascertain whether, and to what extent, the Massachusetts Life Sciences Initiative has already produced tangible positive gains for the Commonwealth, and whether maintaining the initiative will likely produce even greater long-term benefits for the state's residents and taxpayers.

For the purposes of this report, we define the Life Sciences cluster as consisting of sixteen (16) specific 6-digit NAICS industry sectors as shown in **Table 1**.[8] These include two research and development industries, two laboratory industries, two medical distribution

TABLE 1
Life Sciences Sectors

Group	NAICS	Title
1	325411	Medicinal and Botanical Manufacturing
1	325412	Pharmaceutical Preparation Manufacturing
1	325413	In-Vitro Diagnostic Substance Manufacturing
1	325414	Biological Product (except Diagnostic) Manufacturing
2	334510	Electromedical and Electrotherapeutic Apparatus Manufacturing
2	334516	Analytical Laboratory Instrument Manufacturing
2	334517	Irradiation Apparatus Manufacturing
3	339112	Surgical and Medical Instrument Manufacturing
3	339113	Surgical Appliance and Supplies Manufacturing
3	339114	Dental Equipment and Supplies Manufacturing
4	423450	Medical, Dental, and Hospital Equipment and Supplies Merchant Wholesalers
4	424210	Drugs and Druggists' Sundries Merchant Wholesalers
5	541711	Research and Development in Biotechnology
5	541712	Research and Development in Physical, Engineering, and Life Sciences (except Biotechnology)
6	541380	Testing Laboratories
6	621511	Medical Laboratories

Source: Battelle and the Biotechnology Industry Organization (June 2012)

sectors, and ten different manufacturing industries.[9] The cluster also includes the life sciences departments in universities and medical institutions in the Commonwealth.[10]

As of 2012, according to the Massachusetts Biotechnology Council (MassBio), there were 1,198 life sciences companies operating in New England employing 103,006 workers, the vast majority of these firms located in Massachusetts. More than one-third of these New England firms were founded after 2004 and 80 percent are relatively small with sales under $100 million a year. More than two out of five of these firms (43%) have annual sales of less than $5 million. Of all the Massachusetts firms listed in the 2012 MassBio directory, about half (514) are medical device companies; 232 are drug development firms; 147 are contract research and manufacturing enterprises; and 146 produce research products and instrumentation for the life sciences.[11]

CHAPTER TWO

The Size and Scope of Public Tax Expenditures and Public Subsidies

To begin our assessment, it is useful to put the Commonwealth's $1 billion investment in the life sciences into perspective. According to the Congressional Research Service, at the federal level there are over 200 separate tax expenditures which taken altogether are projected to cost the U.S. Treasury more than $1.1 trillion in FY2014.[12] The bulk of these take the form of exemptions, deductions, and exclusions from the personal income tax such as the mortgage interest deduction. These tax provisions are intended to encourage such "virtuous" behavior as home ownership, charitable contributions, and family saving.[13]

While paling in comparison to these personal tax expenditures, federal corporate subsidies cost the Treasury almost $100 billion a year, according to research conducted by the Cato Institute.[14] A full quarter of these go to farmers in the form of agricultural subsidies and crop insurance, but other subsidies underwrite applied research and development under way at defense contractors, energy companies, housing developers, airlines, AMTRAK, universities and research labs, the National Institutes of Health, NASA, and small businesses.[15] In searching for ways in 2013 to cut federal spending in order to reduce federal deficits, one can be certain that some, if not many, of these tax expenditures and subsidies will be reviewed for possible modification or elimination.

States and municipalities have also provided the private sector with billions in tax expenditures and subsidies. In a recent series of articles, a trio of *New York Times* investigative reporters found that across the nation, states, counties, and cities dole out over $80 billion in "business incentives" each year.[16] The key industries receiving such tax preferences and subsidies are manufacturing; agriculture; the oil, gas, and mining industries; and the film industry. Technology companies like Twitter and Facebook, according to the *Times* report, are not far behind.

The *Times* analysts collected data on all 50 states. In their review of Massachusetts, they found 48 state programs that provide nearly 1,500 grants or incentive packages to specific companies. The total annual cost to state and municipal governments for these programs was reported to be at least $2.26 billion, equal to seven percent of the state budget or $345 per capita. Of this total, more than a third ($786 million) take the form of corporation income tax credits, rebates, or reductions. Another $130 million is paid out by the state treasury in the form of cash grants, loans, or loan guarantees.

The *Times* reporters listed a group of 94 Massachusetts companies that received nearly $165 million in grants, tax incentives, and subsidies between 1994 and 2011. Of this total, 26 were life sciences companies accounting for $48.7 million or nearly 30 percent of the total. Among the companies receiving these funds were Vertex Pharmaceuticals, Organogenesis, Shire Human Genetics Therapies, Sanofi, and Cubist Pharmaceuticals. The company receiving the largest state subsidy, however, was Liberty Mutual, an insurance company. Between 2006 and 2009 alone, the Massachusetts Film Office doled out nearly $150 million in tax credits to film companies.[17]

States like Alaska, West Virginia, Texas, and Michigan spend two to three times as much per capita as Massachusetts on such business incentives, but other states including New Hampshire ($30), North Carolina ($69), California ($112), South Carolina ($194), New York ($210), Florida ($212), Oregon ($226), Connecticut ($241), and Ohio ($281) spend less.

Obviously, in a time of tight fiscal budgets, such expenditures of tax revenue need to be carefully evaluated as elements of what is known as "industrial policy"—government support of private business.

*To assure that this assessment of the Massachusetts Life Sciences Center is placed in proper context, we need to begin by considering the ways in which government can encourage private sector economic development in an efficient and effective way. In doing this, we need to pay particular attention to understanding the role of government-induced innovation in spurring economic growth.*This foray into these theoretical issues will provide us with guidance as to what types of government tax expenditures and subsidies are more likely to yield positive benefits for society and thereby help us to assess the value of the MLSC.

CHAPTER THREE

Industrial Policy: Pros and Cons

For decades, economists have debated the role of government in the promotion of private industry. At various times in our history, the federal government has helped to establish industries that went on to be central to our economy. The growth of the nation's aircraft industry was aided by the U.S. Post Office, which subsidized airlines with lucrative air-mail contracts in the early days of air travel. In the aftermath of Sputnik, the federal government invested billions of research dollars into perfecting solid state guidance systems and software for rockets and missiles, helping to create what today is our high-tech universe of cell phones, the Internet, iPads, GPS devices, and a dizzying array of gadgets based on the integrated circuit and the software that runs them.

Yet, as a recent Center for Economic and Policy Research working paper put it, "For the past generation, the dominant view among economists was that giving businesses a free hand—that is, little regulation and low taxes—was the most important contribution governments could make to encourage productive investments. The corollary to this view was that, as much as possible, overall investments in the economy should be undertaken by the private sector, as opposed to any sort of government entity."[18]

The argument *against* a public "industrial policy" is that governments are not capable of "picking winners" and therefore too often waste tax dollars. The conservative Cato Institute claims that government subsidies inevitably distort economic activity and "create even larger failures than might have existed in the marketplace."[19] By aiding some businesses, others are placed at a disadvantage either by reason of having to pay higher taxes or having to compete with subsidized firms. Hence, diverting resources from businesses preferred by the market to those preferred by policy makers leads to losses for the overall economy."[20]

The argument *for* public investment in the private sector is that rather than "crowding out" private capital, public investments actually "crowd in" private investment and can be used to "incubate new technologies and help private businesses bring these innovations to the stage where they can be effective in the marketplace."[21] In brief, well-placed public funds in the private sector can yield large long-term gains at relatively modest short-term cost.

But what makes for "well-placed" public funds? A good part of the answer lies in whether the funds contribute significantly to a growing economy and increasing numbers of jobs.

New vs. Old Growth Theory

In economics, there are two fundamentally different views about what contributes most to growth. What is now known as the "old growth theory" suggested that economic prosperity emanates from the accumulation of ever greater stocks of the fundamental ingredients of production: capital, labor, and natural resources. Those countries that find ways of increasing investment in plant and equipment, adding to labor supply, and extracting more natural resources are the ones that will become more affluent. Just consider the United States or Saudi Arabia versus poor countries in Africa or Southeast Asia. Clearly, without capital, labor, and natural resources, output cannot be produced.

While not completely discounting this approach to growth, a "new growth theory" has evolved that "places technological progress at the very epicenter of growth dynamics, rather than capital investment per se."[22] Advances in technology and interdependencies between new ideas and new investment provide the basis for entire new industries and products that create new wealth and raise living standards. "In the new model, technology provides the engine for sustained growth in the face of the diminishing productivity associated with additions to the stock of physical and human capital."[23]

In addition to avoiding diminishing returns, innovation-based growth has an additional salutary feature relative to other ingredients in the growth equation: Once the fixed cost of creating a technology has been incurred,

the formula can be used over and over again at little or no cost. Indeed, this *spillover* property is taken to be the defining characteristic of technology. As Paul Romer, one of the founders of new growth theory puts it, "The idea behind the transistor, the principles behind internal combustion, the organizational structure of the modern corporation, the concepts of double-entry bookkeeping—all these pieces of information and many more like them have the property that it is technologically possible for everybody and every firm to make use of them at the same time without additional costs."[24] As such, instead of diminishing returns to investment, there can be increasing returns.

Moreover, the new growth theory posits a strong reciprocity between the rate of skill acquisition among workers and the growth dividend society obtains from new capital and new inventions. *Thus, programs that combine incentives for innovation along with resources to augment human capital should, according to this theory, fuel rapid economic growth more than anything else society can do to promote prosperity.*

But here is the rub. Keeping score on the success of innovation is difficult. Instead of a more or less certain return to a given infusion of capital under the old growth theory, innovation under the new growth theory tends to deliver faster and stronger long-term growth, but it is "lumpy, discontinuous, and nonlinear."[25] There can be long lags between the time a new innovation is first incorporated into production and the time that it pays off in terms of increased productivity, output, and jobs. The introduction of the steam engine in the mid-18th century did not pay off in terms of improved productivity until the early 19th century.[26] In the short term, it can be discouraging, as investments in fundamental innovation usually have little immediate payoff.

To be productive, innovation needs to be perfected and diffused, and this takes time. According to a study of 265 major and minor innovations over the past couple of centuries, it took a typical new innovation forty-one years, on average, to move from the 10 percent to the 90 percent diffusion level.[27] The diesel locomotive, for example, was clearly superior to the steam locomotive, yet twenty years after the first diesel was introduced in 1925, there were still nearly ten steam locomotives in service for every diesel-powered engine. The first integrated computer circuits were introduced in the 1960s, but it was not until the 1990s that the full productivity premium of the computer generation was finally realized.[28] It will take decades to realize the full benefits to humanity and the economy from the advances now being made in drug discovery, medical diagnostics, and medical devices.

Unfortunately, in an era of intense concern over short-term deficits, it is often hard to marshall the patience needed to invest sufficiently in technological innovation or the firms that create it. As a corollary, investments made today in research and development (R&D) are often risky propositions from the perspective of the short-term balance sheet. Yet without massive infusions in R&D, continuous breakthrough innovation cannot occur. Nowhere is this truer than in the life sciences.

Public Investment in R&D

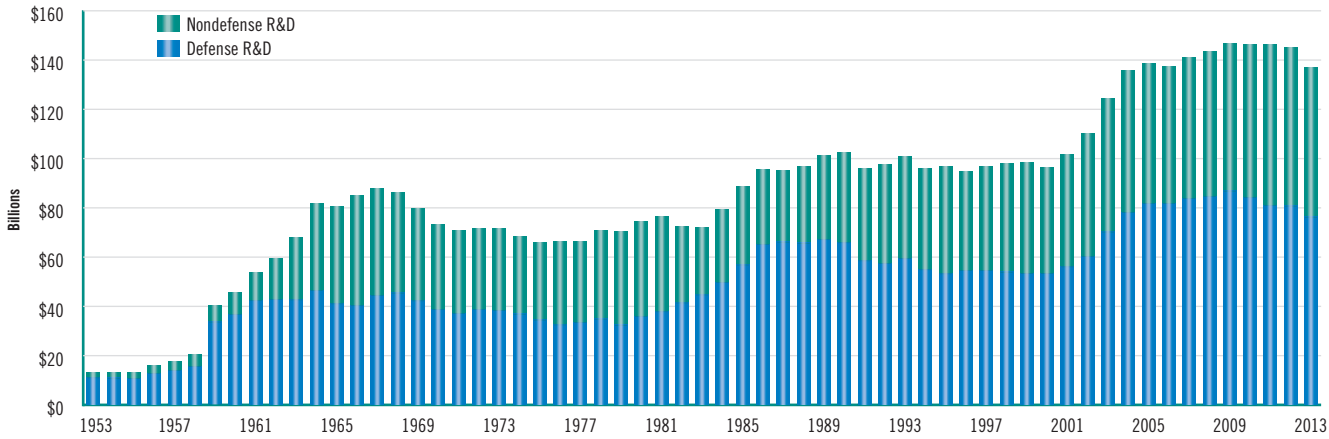
Worldwide, no country spends more than the United States on R&D, and this investment has played an important role in the nation's economic development, at least since World War II.[29] According to the Battelle Institute, total R&D spending in the U.S. reached $436 billion in 2012, of which about 29 percent ($126 billion) was supplied by the federal government while 64 percent ($280 billion) was provided by private industry. The remainder came from foundations and other non-profits ($14.5 billion), university-owned funds ($12.3 billion), and a tiny amount from state and local governments ($3.8 billion).[30]

Despite its smaller share of overall R&D funding relative to the private sector, the importance of the federal government in spurring innovation should not be underestimated. Without government investment, it is likely that private firms would underinvest in R&D, particularly basic research. The reason is that the social rate of return to investment in basic research often exceeds the private rate. Unlike investments in tangible capital such as machinery, the ideas flowing from R&D are, in the words of economists, "nonrival" and not fully "appropriable." *Nonrival* means that my learning of a new innovation does not prevent you from using it. When returns are not fully *appropriable*, the original innovator cannot gain all the profit that flows from the eventual application, especially the commercialization, of the new process or product.[31] In this case, firms will often wait for others to do the innovating. As Federal Reserve Bank Chair-

FIGURE 1

Federal Spending on Defense and Nondefense R&D

Outlays for the conduct of R&D, FY 1953–2013, billions of constant FY 2012 dollars



Source: American Association for the Advancement of Science

man Ben Bernanke recently reminded an audience at a Washington, D.C. conference, "James Watson and Francis Crick received a minute fraction of the economic benefits that have followed from their discovery of the structure of DNA."[32] Without government-sponsored basic research, society loses out on innovation.

Public sector R&D also encourages private sector R&D spending. Research reveals that there is a strong positive correlation between the trajectory of private R&D spending in a given year following public expenditures a year earlier.[33]

The Trend in Federal R&D Spending

Given (1) the importance of innovation as the prime driver of economic prosperity, (2) the role of R&D in promoting innovation, and (3) the fact that without public funding of R&D total research investment would be suboptimal because of the inability of private investors to fully appropriate its monetary benefit, how much has the federal government invested in this vital factor?

As **Figure 1** reveals, federal spending on defense and nondefense R&D (in inflation-adjusted FY2012 dollars) rose sharply between 1953 and 1965 from less than $15 billion to more than $80 billion before dipping back to just over $60 billion in 1976. Spending was back to more than $100 billion by 1989 and remained flat through 2001. It rose sharply after that, increasing to over $140 billion by 2009. In FY 2013, under pressure to reduce federal spending, total federal R&D spending once again declined.[34]

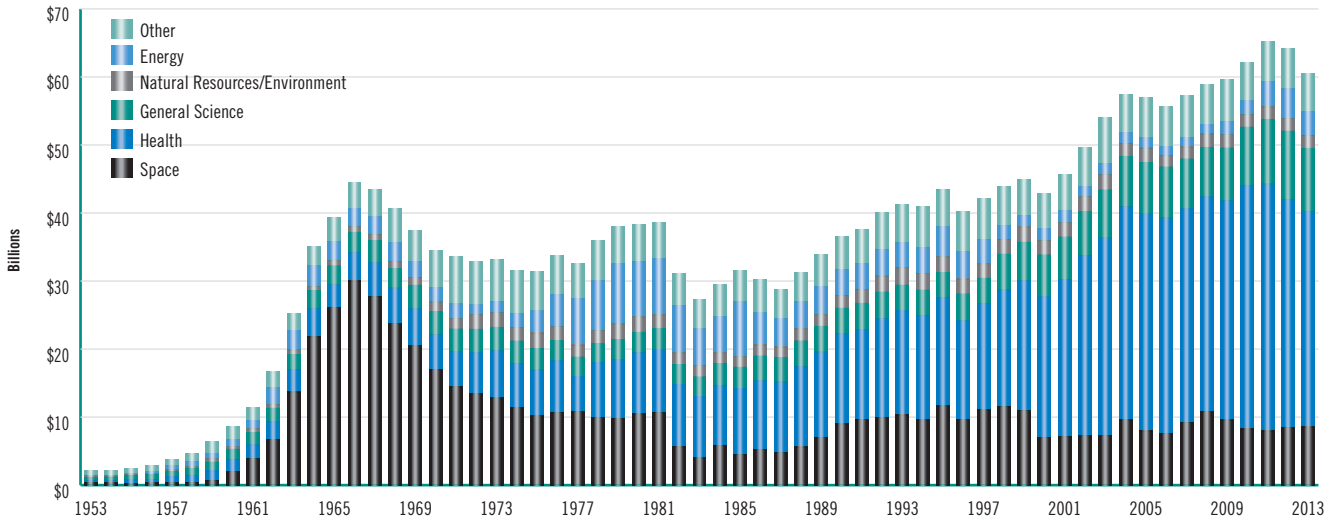
As **Figure 2** demonstrates, virtually *all* of this growth in non-defense federal R&D spending has been in the health field, mainly through the National Institutes of Health. While federally sponsored health research only accounted for about seven percent of total non-defense federal R&D spending in 1965, by 2013 it accounted for more than half (52%). Much of this basic public investment is going into the life sciences, and of all fifty states, Massachusetts trails only California in NIH funding. In 2011, California institutions received $3.5 billion in NIH funding; those in Massachusetts received $2.5 billion.[35] Yet, on a per capita basis, the Commonwealth swamps all other states in NIH funding, obtaining four times as much as the Golden State.

This growth in federally sponsored R&D seems impressive, but as a share of the nation's Gross Domestic Product (GDP), the federal government's role is roughly half of what it was in the early 1960s (**see Figure 3**). Spending rose rapidly in the 1950s and 1960s, surpassing 1.9 percent of GDP in 1964, up from just 0.7 percent in the early 1950s.[36] Much of this was in direct response to the Soviet Union's launching of Sputnik and President John F. Kennedy's goal of sending a man to the moon before 1970. After reaching its nadir of just 0.67 percent in 2000, it has slowly climbed back to 0.85 percent today.[37]

FIGURE 2

Trends in Nondefense R&D by Function, FY 1953–2013

Outlays for the conduct of R&D, billions of constant FY 2012 dollars



Source: American Association for the Advancement of Science

As we have seen, new growth theory suggests that our nation's prosperity is intimately tied to the rate of innovative activity. If innovation slows down, growth will suffer. Hence, the big question is whether the United States can maintain its rate of innovation activity into the future and thereby sustain economic prosperity and full employment.

The Role of R&D Investment at the State Level

As noted above, states have historically played a minor role in funding research and development. Their $3.8 billion spent in FY2012 amounted to less than 1 percent of total spending on R&D and no more than 3 percent of government-sponsored R&D. Indeed, given that the full benefits from basic research cannot be easily appropriated by the funder, it might seem foolish that an individual state would spend its own revenue on investments that can be appropriated by entities in other states.

So why should a state invest anything in R&D?

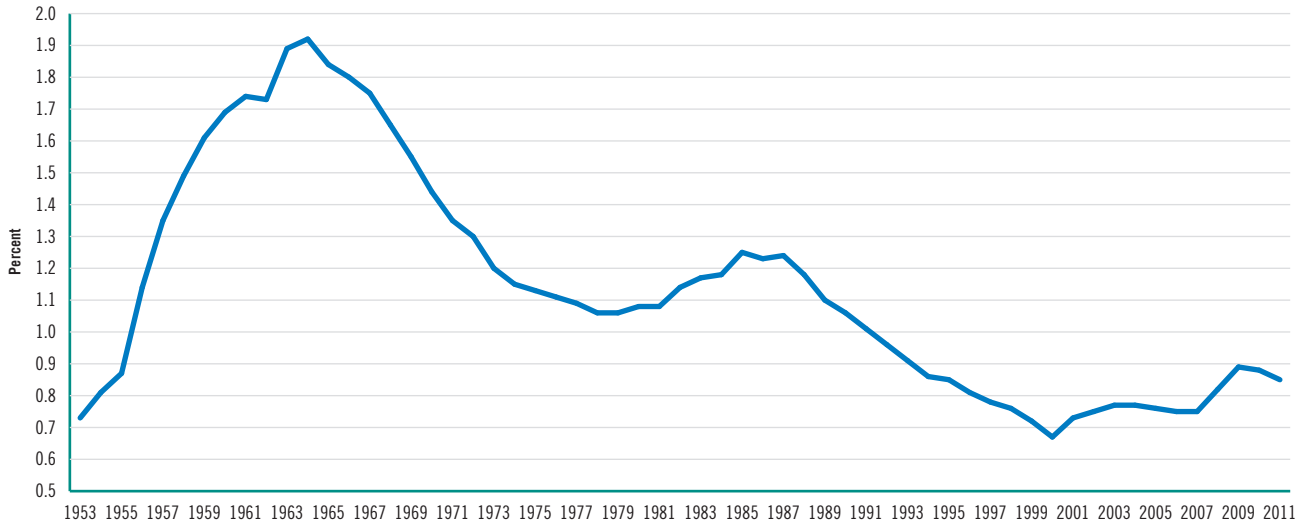
Invested in the appropriate industries, public funds can help encourage the growth of an industrial cluster in a given region that, once incubated, can maintain a self-sustaining locational advantage that provides a magnet for new private investment in the region's cluster. Such locational advantages are called *agglomeration economies* and refer to the benefits, savings, or cost reductions resulting from the clustering of economic activities.[38] The clustering of such industries can give rise to an "industrial climate" or "ecosystem" that is self-perpetuating as the result of a regional congregation of specialized facilities, labor pools, education and training institutions, and specialized legal, accounting, and financial services.

Such agglomeration economies explain the economic success of most metropolitan areas. In New York City, for example, the cluster of financial industries and advertising is responsible for much of the growth in wealth. The birth of the early auto industry in and around Detroit in the early part of the 20th century would ultimately allow Detroit to take advantage of agglomeration economies and blossom into the world's "Motor City" by the end of World War II. By 1949, the median family income of Detroiters was higher than that of any other city in America except Chicago (whose residents enjoyed a 1949 median family income exactly one dollar higher), and 29 percent above the national figure.[39] Chicago's prosperity was built on being the transportation hub for America. Seattle became the center for jet aircraft production.

In the postwar period, the most successful new indus-

FIGURE 3

Federal Spending on R&D as Percent of GDP
FY1953–FY2012



Source: National Science Foundation "Science and Engineering Indicators 2012"

trial cluster was built in Silicon Valley in and around Palo Alto, California. Beginning in 1939 with the founding of Hewlett-Packard— the brainchild of two Stanford graduate students—the valley would attract a host of firms that would ultimately build the modern computer industry and make this region one of the wealthiest in the world.[40]

In the case of Detroit, local, state, and the federal governments essentially subsidized the auto industry through the public provision of streets, roads, and highways. Chicago's prosperity was underwritten by public subsidies to the railroads. Seattle's aircraft industry has benefited not only from the early airmail contracts but from massive defense spending that provided most of the resources needed to develop both military and then commercial jet airframes and jet engines.[41] While private venture capital has played a major role in the success of Silicon Valley, the federal government has played a significant role as well. From less than $10 million in 1960, federal research funding of computer science climbed to almost $1 billion by 1995, while the U.S. expenditure on research in electrical engineering (which includes semiconductor and communications technologies) has fluctuated between $800 million and $1 billion since the 1970s. According to the National Research Council, such funding "has constituted a significant fraction of all research funds in the computing field, particularly underwriting academic research. Federal support has constituted roughly 70 percent of total university research funding in computer science and electrical engineering since 1976."[42]

The lesson is that the prosperity of many metropolitan areas has been stimulated in large measure by public investments in particular industry clusters. Given an early start in an industry, public funds can help build the agglomeration economies that in turn cement a single region's leadership in that industry nationally and globally. The Massachusetts Life Sciences Center was established precisely to this end. How successful has it been?

CHAPTER FOUR

The Emergence of the Massachusetts Biotechnology Super Cluster

In 2010, four scholars at the Massachusetts Institute of Technology (MIT) developed a schematic to explore the complement of elements needed to produce a successful American biotechnology cluster.[43] This schematic is summed up in **Table 2**. The schematic includes three innovation stages and four critical factors. Based on this matrix, the team was able to describe all of the aspects of what they called the Massachusetts Biotechnology Super Cluster.

A thriving science-based cluster must take basic research and transition it into commercial products and services. To do this requires funding, skilled labor, a legal framework that protects intellectual property (IP), and a diverse set of industries that includes both new innovative firms as well as established ones. As the authors suggest, "inadequacies in any area can threaten the cluster."[44]

As a whole, the U.S. biotechnology cluster benefits from access to both public and private sources of funding. These include, on the public side, NIH, the Department of Defense (DOD), Small Business Innovation Rewards (SBIR) to support basic research; foundation support from private nonprofits; and, on the for-profit side, angel and venture capital (VC) investors who provide funds for translating basic research into new products and services. The cluster is also supported by public and private customers for its end products, which at times are subsidized through tax expenditures and subsidies.

The talent pool for this sector ranges from creators and craftspeople who play the role of principal investigators on research grants and contracts, entrepreneurs who form new firms to commercialize the output of the sector and workers who range from those with just a high school diploma to those with Ph.Ds.

To be successful, the cluster must also enjoy a legal system that protects intellectual property through patents and licenses and IP enforcement in the courts.

Long-term success for the cluster also requires a diverse set of "tradable agglomerating" companies comprised of new innovative enterprises that can power future

TABLE 2
The Prototypical American Biotechnology Cluster

Critical Factors		Innovation Stages		
		Basic Research	Translation	Commercialization
Funding	Public	NIH	DOD, SBIR	Payers, Tax Policy
	Private	Foundations	Angel, VC, Industry	Customers
Talent	Creators	PIs	Entrepreneurs	Senior Execs
	Craftspeople	Grad Students	BA/MS/PhD	HS - PhD
Laws & Norms	Intellectual Property	Bayh-Dole	Patentability & Scope	IP Enforcement
	Experimentation	New Field Encouragement	Independence Over Security	Reinvention
Diversity	Tradable Agglomerating	Stem Cells	RNA, Interventional Imaging	Biologics
	Tradable Converging	Bio-processing	Molecular Diagnostics	Biomanufacturing
	Local Sustaining	Medical Centers	Science Parks	

Source: Trusheim, Berndt, Murray, and Stern, 2010

growth through the development of breakthrough products, "tradable converging" firms which remain globally competitive in existing products, and a set of local entities including medical centers and science parks that provide local services to the cluster.

A good deal of this requires a collaborative form of industrial policy with both the federal and state government playing major roles in the emergence of the cluster. In the 1950s, the federal government continued its funding of R&D in the biosciences as part of its Cold War strategy. The VC model was invented and the first high-tech firms founded. In the 1970s, the federal government declared a "War on Cancer" with NIH funding, while the first recombinant DNA experiments were undertaken in university laboratories and private research firms.

In 1980, the Bayh-Dole Act was adopted, giving universities IP ownership of the output from federally funded research while the first recombinant DNA products hit the market. In the Commonwealth, the Massachusetts Biotechnology Council was created in 1985, one of the first in the nation. In the 1990s, the first genomics companies were founded, led initially by Millennium Pharmaceuticals (established by a former Genentech executive).

Much of this early work came to fruition in the first decade of the 21st Century. During this period, the human genome was sequenced and the George W. Bush administration committed itself to doubling the NIH budget.

Here in the Commonwealth, a final piece of the cluster puzzle was put in place with the founding of the MLSC, followed by the state's funding of the Life Sciences Initiative to help cement the region's lead in this important cluster and maintain that lead into the future. With all of the other parts of the matrix in place in Massachusetts, the state became a magnet for Big Pharma.

By the end of the first decade of the 21st Century, Massachusetts was home to 9 of the top 10 major drug companies in America, surpassing New Jersey. Pfizer, Novartis, GlaxoSmithKline, Genzyme's successor Sanofi, AstraZeneca, Abbot Laboratories, Merck and Bristol-Myers Squibb had all committed to operations in the Bay State. The largest of these big firms, in order of employment, are Genzyme (Sanofi), Pfizer, Biogen Idec, Novartis, Shire, Thermo Fisher Scientific, EMD Millipore, Vertex, Parexel International, and Hologic.[45] Only the Swiss pharmaceutical giant, Roche—the world's third-largest biopharma firm—has not moved into Massachusetts.[46]

According to a separate comprehensive analysis of the global life sciences cluster completed in 2011, the commercial developer Jones Lang LaSalle concluded that Boston had become the #1 region for the biosciences based on its concentration of high tech research and hospital/medical employment, its number of scientific and engineering graduate students, its level of NIH and venture-capital funding, its investment in R&D as a percentage of state GDP, and its thousands of square feet of academic and research institute facilities. Boston had a composite score of 7 ranking it #1 overall. New York/New Jersey was #2 with a composite score of 24, followed by the Bay Area and Los Angeles each with a score of 25.[47]

CHAPTER FIVE

The Massachusetts Life Sciences Center

What role does the MLSC play in the MIT schematic? Beginning with its creation, the MLSC took as its strategic mission the role of pulling together all of the parts of the matrix into a life sciences ecosystem, creating a dense, highly connected community of scholars, entrepreneurs, industry leaders, venture capitalists, and government officials dedicated to the success of the life sciences super cluster in the Commonwealth. Unlike many state economic development initiatives, the Center has a broad range of strategic priorities geared to enhance all aspects of the life sciences cluster. These include:

- funding translational research—research that converts basic research into marketable products and services
- investing in promising new technologies
- ensuring worker skill acquisition that aligns with the needs of the life sciences industries
- creating new infrastructure from shared resources that accelerates innovation
- building partnerships between sectors of the local and international life sciences communities

To accomplish these goals, the Center relies on a portfolio of seven distinct programs.[48] These include:

Cooperative Research Grants—Supports industry-sponsored research at universities and facilitates scientific discoveries that lead to medical applications. These grants of $250,000 per year for up to two years match industry contributions dollar for dollar.

Internship Challenge Program—Provides up to $7,200 in funds for interns working at Massachusetts companies with fewer than 100 employees and fewer than 250 globally.

New Investigator Grants—Spurs innovative research and advances the careers of new investigators who are working on cutting-edge research at Massachusetts academic research centers with grants of $100,000 per year for up to three years.

Life Sciences Accelerator Program—Provides financing of up to $1 million for early-stage companies to help leverage additional sources of capital.

Small Business Matching Grant (SBMG) Program—Provides matching support capped at $500,000 per company to firms on the verge of commercializing new technologies developed using Phase II or Post-Phase II Small Business Innovation Research (SBIR) awards or Small Business Technology Transfer (STTR) grants from the federal government.

Life Sciences Tax-Incentive Program—Issues a combination of 10 competitively awarded tax incentives available to companies that meet specified hiring goals. These include:

- A refundable 10% investment tax credit[49]
- A refundable in-state research tax credit
- A refundable job creation tax credit (50+ jobs)
- A refundable FDA user fee credit
- Extension of net operating losses to 15 years
- Deduction of orphan drug clinical testing
- Elimination of the sales factor throwback provision
- Special sales tax exemption
- Life sciences research credit for out-of-state costs
- Construction sales tax exemption

Capital Projects Fund—Provides capital for equipment and supplies for high schools in Gateway Cities, vocational/technical schools, and community colleges; and for capital projects in academic/research institutions, business incubators, and other not-for-profit organizations in the Commonwealth.

Between 2008 and June 30, 2012, the Center had directly invested or committed over $300 million that has leveraged more than $1 billion in third-party investment, according to the MLSC's report for fiscal year 2012. If none of that investment would have been made in Massachusetts in the absence of the MLSC commit-

ments, each dollar of taxpayer money spent by the Center resulted in the attraction of $3.40 in additional, outside investment creating a public-private investment fund of more than $1.3 billion.[50]

There are four factors that make the MLSC quite different from most government subsidy programs:

- Instead of simply providing tax benefits to a few private firms to lure them to the Commonwealth, the MLSC has a portfolio of investment tools that include direct investments in life sciences companies; grants to academic organizations and medical centers and grants for "shovel ready" public and non-profit sector capital projects that help influence the location decisions of life sciences companies.
- The MLSC operates under a Board of Directors that includes state government officials, industry CEOs, leaders from academia and medicine, bioscience researchers and others who have great knowledge of the life sciences.
- Investments are reviewed by a panel of more than 200 experts who send their recommendations to the Center's Scientific Advisory Board, which itself is dominated by academic researchers, industry scientists and private venture capital experts who together can judge the scientific and economic potential of an MLSC investment.
- The Center insists on accountability in terms of private sector investment matches and specific job creation goals and retains the power to "claw back" tax incentives and other investments when these goals are not reached by grant recipients.[51]

In the four-year period between June 2008 and June 2012, the Center invested nearly $190 million in 12 capital projects, provided 31 company grants and loans worth nearly $23 million, issued 35 academic research grants with a value in excess of $23 million and 56 tax incentives (still outstanding) valued at close to $57 million, invested $7 million to fund 884 interns as part of the Center's mission to help develop the life sciences workforce, provided more than $3.3 million in equipment and supply grants to schools and spent $1.5 million on other grants including the funding of business plan competitions. As of June 30, 2012 the Center was managing a portfolio of approximately 200 grants, loans, and tax incentives.[52]

Examples of *infrastructure activity* as listed in MLSC's FY2012 report include:

- $5 million in support of the construction of the Joslin Center's Translational Center for the Cure of Diabetes
- $10 million to the Dana Farber Cancer Institute to support the expansion of its $20 million Molecular Cancer Imaging Facility
- $5 million to the Boston Museum of Science for the construction of its "Hall of Human Life," which helped leverage $11 million in private financing
- $14.6 million to the University of Massachusetts Dartmouth to build its new Massachusetts Biomanufacturing Center in Fall River
- $10 million to UMass Lowell to equip laboratories within its new Emerging Technologies and Innovation Center
- $14.3 million to help build the Framingham Wastewater and Pumping Station that will allow bioscience firms to operate in that community

Examples of accelerator loans awarded in FY2012 to provide working capital to early stage life sciences companies include:

- $750,000 to Allurion of Wellesley for developing a novel medical device for inducing weight loss in obese patients
- $750,000 to Alcyone Lifesciences, Inc. for the development of a micro-catheter for treating neurological conditions
- $245,000 to Strohl Medical for the creation of a medical device for accelerating the treatment of stroke victims

Subsequent to receiving accelerator loans, early stage firm recipients have raised more than $100 million in either private or public funding to grow their firms or in acquisition proceeds. Already six firms that have received accelerator loans have paid them off early, permitting the MLSC to construct a revolving fund, thus expanding the resources the Center has for this purpose.

In addition to the accelerator loans, the MLSC has begun a Small Business Matching Grant Program (SBMG), which complements funds received by firms from NIH, the National Science Foundation (NSF), and DOD. In 2012, the Center awarded a $500,000 grant to Firefly BioWorks, Inc. of Cambridge after full review by the

MLSC Scientific Advisory Board. The company has already been able to launch its first commercially viable product for help in diagnosing cancer, neurological disorders, and other diseases.

Examples of matching grants for academic research include:

- $5.1 million in grants to early career investigators working in research institutions within the Commonwealth which have in turn helped generate over $13 million in federal government, foundation, and private company research grants
- $4.8 million in cooperative research grants (between 2008 and 2011) to encourage industry-sponsored research at Massachusetts institutions, resulting in more than $8.6 million in research grants from other sources

Examples of the $20.6 million in 2011 program tax incentives to 26 life sciences companies include $3 million to Shire HGT, Inc.; $2.45 million to Vertex; $2.3 million to AVEO Pharmaceuticals; and $1.84 million to Biogen Idec MA, Inc. Smaller tax incentives of less than $500,000 went to such firms as Blueprint Medicines Corporation in Cambridge and T2 Biosystems, Inc. in Lexington. Under the Life Sciences Act, the Department of Revenue has the authority to "claw back" incentives from companies that the Center determines have not met the minimum job creation thresholds in their tax-incentive agreements.

In addition, the MLSC Internship Challenge Program has placed more than 1,000 interns in more than 290 companies across the state where host companies provide dedicated mentors to help expand the pool of prospective life sciences workers for the future. Those college students receiving MLSC internships are majoring in biology, engineering, chemistry, business, computer science and physics and end up interning in companies that produce medical devices, pharmaceutical products, diagnostic services, and biotechnology research. In FY2012, the Center also awarded $180,000 to four programs to encourage science, technology, engineering and math (STEM) education, especially for women and minorities.

Table 3 provides a summary of the investments made by the MLSC between June 2008, when the Life Sciences Initiative funding first became available, and June 2012.

TABLE 3

Distribution of MLSC Investments by Dollar Amount June 2008–June 2012

Capital Projects (12)	$186,950,000
Company Grants and Accelerator Loans (31)	$22,907,000
Academic Research Grants (35)	$23,346,344
Tax Incentives (56)	$56,595,093
Interns Funded for Workforce Development (884)	$6,903,164
Equipment and Supply Grants or Schools (32)	$3,333,675
Other Grants/Business Plan Competitions	$1,540,000
Total	**$301,575,276**

Source: Massachusetts Life Sciences Center, 2013

This comprehensive approach to an entire industry cluster differs significantly from other federal, state, and local incentive programs that target a single company or, at best, a single industry.

We can now ask: "*Has this approach, and the investments made through the MLSC, paid off?*"

We begin to answer this question by tracking output and employment in the life sciences cluster and consider the results in terms of the creation of the Center in 2006.

But given what we have learned about the role of innovation in spurring economic growth, we can ask a more fundamental question. "Has the creation of the Center and the Life Sciences Initiative paid off in terms of nurturing a rich 'ecosystem' within which the entire life sciences super cluster can flourish now and in the future, providing a platform for further growth in economic opportunity for Massachusetts residents?"

CHAPTER SIX

Output and Employment in the Massachusetts Life Sciences Super Cluster

The life sciences super cluster began to benefit the Commonwealth by the middle of the last decade, even before the MLSC was established. By 2006, publicly traded companies in Massachusetts were already generating $30 billion in sales, an increase of nearly 50 percent in just four years. With $7.5 billion in exports, the Massachusetts life sciences sector accounted for 30 percent of total state exports.[53] Between 2001 and 2006, employment in Massachusetts life sciences industries increased by 13,000—more than 16 percent. The life sciences were generating jobs during a period when total non-farm employment in Massachusetts was actually *declining* by 2.8 percent. While total employment in the life sciences in 2006 accounted for just 26 out of every 1,000 jobs in the state, this sector was growing faster than any other, including education and health services (See **Figure 4**).

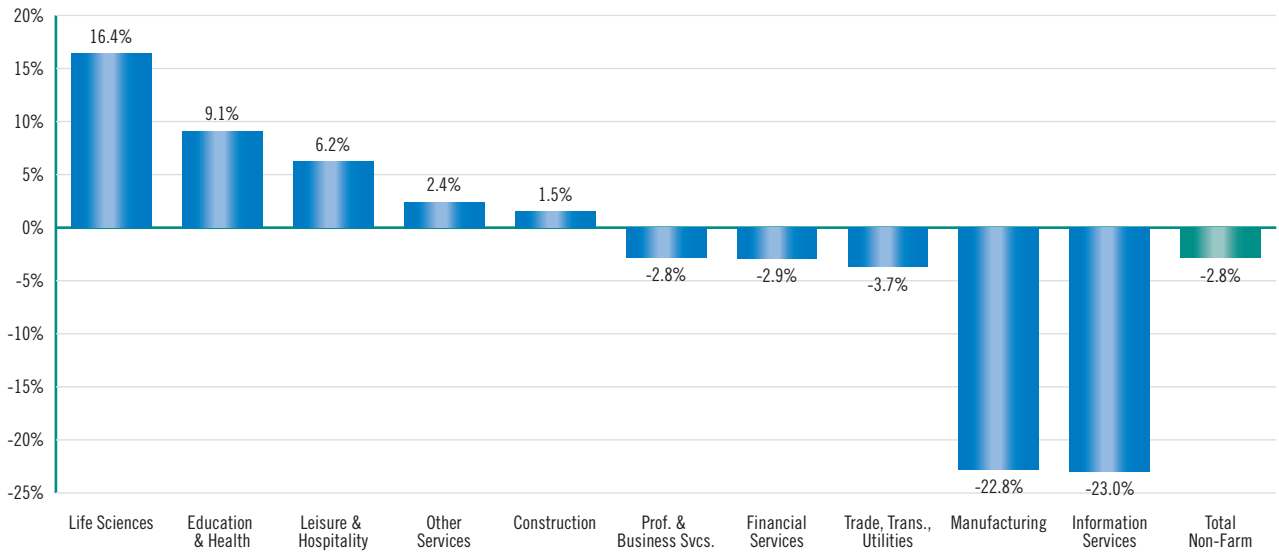
As **Figure 5** reveals, the life sciences cluster continued to generate jobs between 2006 and 2011, but not quite as rapidly as during the previous five years. However, it was still faster than every other sector save education and health services. The national recession that began at the end of 2007 weighed on the life sciences sector, as it did most other industries. Life sciences remained a small sector in terms of overall non-farm state employment, but given its faster growth, accounted for nearly 30 jobs out of every 1,000 in the Commonwealth by 2011.

Taking the entire decade (2001–2011) as a whole, the life sciences far outpaced all other industry sectors in terms of its employment growth rate as shown in **Figure 6**.

Within the cluster, however, the growth in employment has varied greatly across individual industry segments as shown in **Table 4**. During the entire period between 2001 and 2011, employment in research, testing, and medical laboratories increased by more than 50 percent, nearly twice as fast as the life sciences cluster as a whole (and 2½ times as fast as education and health services). Yet the production of medical devices—the

FIGURE 4

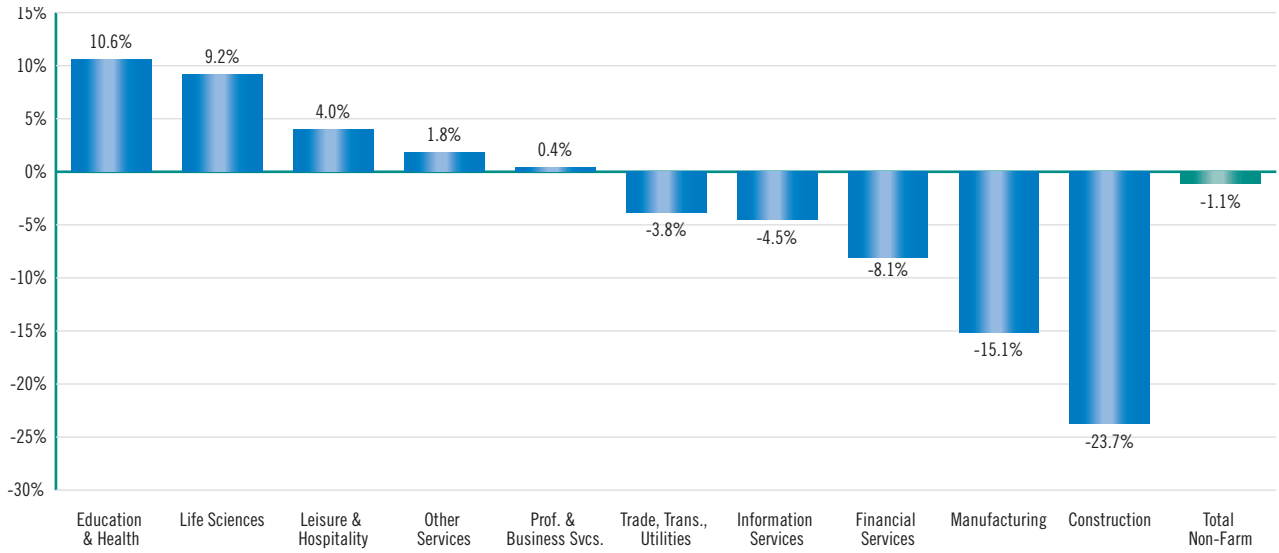
Massachusetts Employment Growth by Industry Sector 2001–2006



Source: Bureau of Labor Statistics, Author's Analysis

FIGURE 5

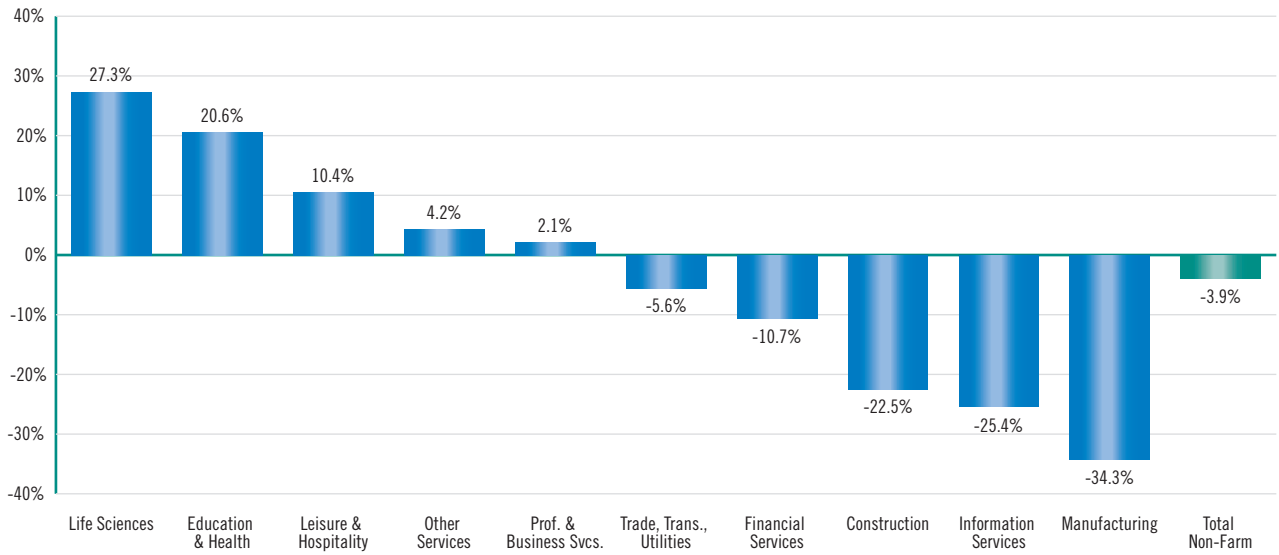
Masssachusetts Employment Growth by Industry Sector 2006–2011



Source: Bureau of Labor Statistics, Author's Analysis

FIGURE 6

Massachusetts Employment Growth by Industry Sector 2001–2011



Source: Bureau of Labor Statistics, Author's Analysis

key *manufacturing* segment of the life sciences cluster —remained nearly constant over this period, increasing by just 0.2 percent.

What is notable, however, is that the employment growth rate actually *increased* in the second period (2006–2011) for both the pharmaceutical industry and

TABLE 4
Employment Change by Life Sciences Cluster Segment

	2001	2006	2011	% Δ2001–2006	% Δ2006–2011	% Δ2001–2011
Drugs & Pharma	7,794	7,944	8,537	1.9%	7.5%	9.5%
Medical Devices & Equipment	22,835	21,645	22,882	–5.2%	5.7%	0.2%
Research, Testing, & Medical Labs	34,849	47,072	52,819	35.1%	12.2%	51.6%
Bioscience-Related Distribution	9,607	10,877	11,377	13.2%	4.6%	18.4%
Total	**75,085**	**87,538**	**95,615**	**16.6%**	**9.2%**	**27.3%**

Source: Bureau of Labor Statistics, Author's Analysis

medical device manufacturing, despite recession conditions nationally and regionally. Indeed, all four sectors in **Table 4** exhibited increased employment during this difficult economic period.

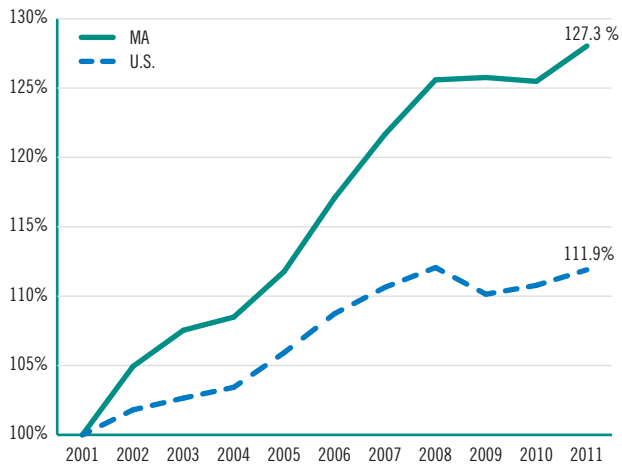
Life Sciences Employment Trends: Massachusetts vs. the United States

The capacity of the Commonwealth's life sciences to create jobs at a faster pace during the past decade than all other major Massachusetts industries is one indicator of the successful development of this sector. Even more important is how the state's life sciences have performed relative to the country as a whole and other states vying for supremacy in this rapidly evolving cluster of industries. The data we have gathered on employment trends reveal that the Commonwealth has indeed overtaken the rest of the nation in terms of employment growth in the life sciences, fulfilling the initial goal of the MLSC.

Figure 7 reveals the trend in life sciences employment in Massachusetts compared to that of the nation as a whole between 2001 and 2011. During this period, Massachusetts life sciences employment growth outperformed the nation by a factor of better than 2-to-1—growing by 27.3 percent vs. 11.9 percent for the nation.

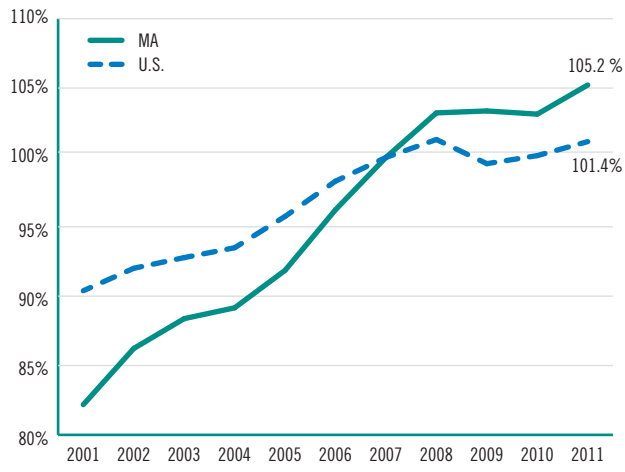
Figure 8, which indexes employment growth to 2007, reveals how the Commonwealth's life sciences cluster grew at a faster clip than the nation's, surpassing the nation and now remaining firmly ahead of it in terms of employment growth.

FIGURE 7
Employment in Life Sciences Indexed to 2001, Massachusetts vs. the U.S.



Source: Author's Analysis from BLS data

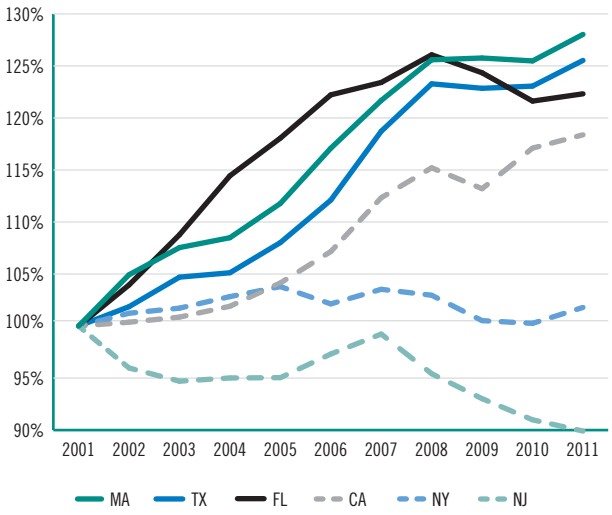
FIGURE 8
Employment in Life Sciences Indexed to 2007, Massachusetts vs. the U.S.



Source: Author's Analysis from BLS data

FIGURE 9

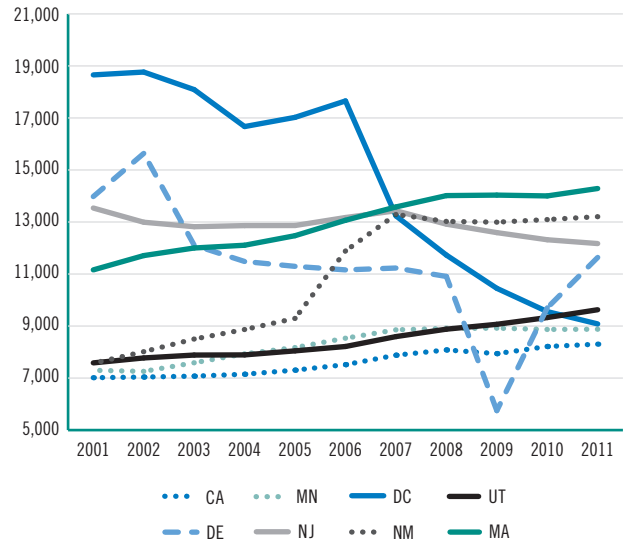
Employment in Life Sciences Indexed to 2001, Massachusetts vs. Big Competitor States



Source: Author's Analysis from BLS data

FIGURE 10

Life Sciences Jobs per 1 Million 2010 Population Top 8 States in 2011, by Year



Source: Author's Analysis from BLS data

The Commonwealth's main competitors in the life sciences include California, New Jersey, New York, Florida, and Texas. But as **Figure 9** demonstrates, after 2008 the Commonwealth overtook all of these states in terms of its 2001–2011 employment growth rate. Florida's nascent life sciences sector had been growing faster, but has fallen behind the Bay State during the past four years. Texas has been trying to catch up, but still trails Massachusetts. Over the decade, California's life sciences employment grew by just 18.4 percent compared with the Commonwealth's 27.3 percent. The growth rate in New York has been anemic, adding only 2 percent to its life sciences workforce while New Jersey, once the pharmaceutical capital of the nation, has seen its life sciences cluster decline sharply since 2007.

Even with Massachusetts's #1 position in the life sciences employment growth rate, it is not surprising that other states still have a larger absolute number of life sciences jobs. Of the top six states, Massachusetts ranked 5th in 2011, as **Table 5** reveals. California leads the pack with nearly 310,000 life sciences jobs.

Yet even as a much smaller state in total population, Massachusetts now leads all other states in the number of jobs in the vital biotechnology R&D sector within the life sciences super cluster. In 2011, the Commonwealth boasted more than 28,000 jobs, exceeding second place California (22,600) and third place Pennsylvania (11,200).[54] Since 2007, this particular sector grew faster in the Commonwealth than in any other state, adding more than 3,500 jobs.

When we control for population size, Massachusetts is the clear winner for the entire life sciences cluster of industries. In **Figure 10**, we have controlled for the size of population of each state by measuring the number of life sciences jobs per 1 million residents. In 2001, the District of Columbia actually had the highest per capita number of life sciences jobs, presumably because of the physical presence of the National Institutes of Health. Delaware ranked second followed by New Jersey. California actually lagged Minnesota, Utah, and New Mexico on this measure. Massachusetts ranked #4.

But by 2011, given its rapid growth rate, the Massachusetts cluster had risen to #1 in terms of per capita life sciences employment. With nearly 14,300 life sciences jobs per 1 million people, Massachusetts had eclipsed New Jersey (12,171) and continued to far outstrip California (8,300).

TABLE 5

States with Largest Life Sciences Employment (2011)

California	309,344
New York	109,750
New Jersey	107,007
Texas	96,969
Massachusetts	95,615
Florida	83,836

Source: Author's Analysis from BLS data

Clearly, the life sciences cluster has enjoyed stellar growth in the Commonwealth over the past decade, and it appears that after the MLSC was created, the pace of growth outdistanced all of Massachusetts's rivals.

Clearly, the life sciences are flourishing in Massachusetts and the timing of the sector's employment growth suggests at least a correlation between the creation of the MLSC and the ability of the state's life sciences super cluster to overtake the rest of the nation.

But what evidence do we have of causation rather than simply correlation? What role has the MLSC played in the stellar growth of this set of industries? Here we find the interviews we conducted with key informants provided additional information on the role MLSC has played in this 21st-Century story of industrial success.

CHAPTER SEVEN

The Key Role of the MLSC: What We Learned from the Interview Data

To obtain a firsthand view of what part the MLSC may have played in the emergence of the Commonwealth's life sciences ecosystem, we conducted a series of "key informant interviews" with executives in the industry, with leaders of related trade associations, and with a number of scientists who have an intimate knowledge of the range of activities of the Center. In order to obtain an honest and unbiased assessment of the $1 billion initiative itself and the functioning of the Center, we assured each of our informants strict confidentiality. Interviews were carried out with executives in both large and small companies in the industry, with those mostly devoted to research and development, and with those whose companies are now involved with the manufacture of scientific and medical products.

While we probed on many fronts, we asked each informant to consider a fundamental "counterfactual": *Would the life sciences in Massachusetts be much different from what they are today if the MLSC had never been created and the state had not committed long-term funding to assist the array of universities, research institutes, and companies that make up the life sciences super cluster?* What we learned provided us with a vital and deeper understanding of the critical role the MLSC has played.

Here are our key findings.

The Development of the Life Sciences "Ecosystem"

The leaders of large firms told us that given the scale of their operations, the MLSC plays at best a *minor direct role* in their own development, but an *immense indirect role* that helped to attract them to Massachusetts. The term that surfaced in virtually all of our interviews is "ecosystem," and that the MLSC has been central to the creation of the life sciences ecosystem that has made the Commonwealth more attractive than competing regions.

According to our interviews, the MLSC has indeed been instrumental in bringing together a tight-knit community of life sciences institutions including universities, research hospitals, small start-up bioscience firms, medical device manufacturers, and Big Pharma. These stakeholders all interact on a regular basis to assist each other in the promotion of their activities. The ecosystem includes the nurturing of small firms through the MLSC's accelerator-loan and tax-incentive programs, assistance to the life sciences research labs in the state's public higher education system, the provision of funds for student interns in relevant fields, and countless opportunities for executives, scientists, and industry employees to meet and explore opportunities for expanding the life sciences super cluster in the Commonwealth. The Center has been critical, according to our key informants, in helping to build a "platform" for the entire sector and cultivate a "collaborative gene" among all of its separate parts.

As one recent example of this role, the MLSC helped create the Massachusetts Neuroscience Consortium, announced at the 2012 BIO International Convention in Boston. With charter sponsors including Abbott Labs, Biogen Idec, EMD Serono, Janssen Research & Development LLC, Merck, Pfizer, and Sunovion Pharmaceuticals, Inc., the consortium provides an arrangement whereby companies that normally compete with each other collaborate on funding preclinical neuroscience research under way at academic and research institutions throughout the state. With leadership provided by the MLSC, each of the founding sponsors has pledged $250,000 toward this effort, and the Center will administer the funds.[55] The research results will be shared with all participants and all companies and academic researchers will have access to any tools developed as a result of these investigations. Without the Center playing this convening role, it is unlikely that such a consortium would have come into existence.

The Center has also been responsible for helping to nurture international cooperation among life sciences firms and academic institutions. The Center provided a $300,000 grant to the Northern Ireland Massachusetts Connection (NIMAC) for a new multinational research

study on non-invasive procedures to detect pre-malignant lesions. Finland and Catalonia have joined NIMAC as well. MLSC is also helping to develop alliances between Massachusetts companies and Israeli firms through the Massachusetts-Israel Innovation Partnership (MIIP). The Center has contributed $300,000 to this effort so far, funding two Massachusetts firms working in partnership with Israeli firms. A second round of funding for this program is pending.

All of these efforts are part of building an ever larger life sciences ecosystem based in the Commonwealth.

The Unique Growth Pattern of Regional Life Sciences Clusters

The most important lesson we derived from our interviews, however, was the unique growth pattern of the life sciences cluster. The regional concentration of life-sciences companies happens in a very different manner than in other industries. In the case of traditional industrial sectors such as auto, aircraft engine, financial services and the like, a region becomes dominant in a particular cluster once a large anchor enterprise or a small number of them establish operations in that locale. Once the anchor enterprise is established, an array of smaller firms is attracted to that region to serve as part of the supply chain for the large anchor enterprise(s).

Once Detroit became home to Henry Ford's car company and General Motors and Chrysler built huge auto assembly facilities in Michigan, hundreds of small parts plants, design studios, and small engineering facilities opened their doors nearby in order to easily serve the industry's "Big Three." The same is true of the aircraft engine industry in New England dominated by Pratt & Whitney in East Hartford, Connecticut, and General Electric's Aircraft Engine facility in Lynn-Everett, Massachusetts. These massive facilities attracted hundreds of aircraft engine parts suppliers to New England, making the region one of the core jet-engine manufacturing centers in the United States. *Essentially, the small firms in the industry are dependent on the large ones.*

For the life sciences, the reverse is true. For companies that crucially depend on the development of breakthrough innovations and sophisticated medical devices, *the large firms prosper by reason of being proximate to a panoply of small start-up firms*. The reason for this is that despite their substantial research budgets, even the largest of the life sciences companies do not have the resources to generate more than a handful of breakthrough innovations in the biosciences, genomics, and other sophisticated fields. These large firms grow and prosper by carefully monitoring the scientific discoveries under way in university research laboratories and in the translational research carried out by small start-up firms. Those few start-ups that end up with potential blockbuster drugs or devices become prime targets for acquisition by the larger firms. Only a fraction of the long-term revenue generated by Big Pharma and the largest biotech and medical device companies has its origin in their own research labs. The majority comes from the absorption of successful smaller firms.

The secret to success in the acquisition process is being where the small firms are located. This permits the large firms to closely monitor the progress of smaller firms and buy the most promising ones before other Big Pharma or other competitors can make a bid. To use a metaphor from nature, the large, globally important life sciences firms want to feed in the waters where the minnows are swimming.

Pfizer, for one, has moved operations into Cambridge from other locations for this purpose.[56] In 2010, it announced that Cambridge would become one of Pfizer's worldwide research and development hubs, and it relocated approximately half of the current employees from its BioTherapeutics R&D organization to Kendall Square. A year later, Pfizer announced plans to move two existing research units, Cardiovascular Medicine (CVMed) and Neuroscience from Groton, Connecticut, to Cambridge, leasing 180,000 square feet of lab and office space from MIT to house these two research units.

In June 2011, Pfizer opened the Boston Centers for Therapeutic Innovation (CTI), an entrepreneurial network of partnerships with leading academic medical centers. According to the company, "these partnerships reduce the time and cost of drug discovery and development by accessing leading translational researchers."[57] Boston is also the global headquarters for the CTI network, which has established partnerships in New York City and San Francisco. The richness of the Massachusetts life sciences ecosystem prompted Pfizer to expand still further in the Commonwealth, with the company's newest building in Cambridge scheduled to be completed in 2013.

Over the past three years, Massachusetts is the only state where Pfizer has added jobs, not California, Connecticut, New Jersey, or New York. As an executive of this company told us in one interview, "Innovation between the big, the small, and the in-between is what makes the industry succeed." Another Pfizer executive noted that while his company has not taken a dollar from the MLSC, the Center has helped the firm by creating a "mentality" about the life sciences that has permeated the state right down to the local level, making it possible to speed local permitting and rezoning where necessary.

Executives at Sanofi-Aventis SA, which acquired Genzyme in 2011 in a $20 billion deal, have relied on the MLSC to "act as a bridge" between the company and such research institutions as the Cummings School of Veterinary Medicine at Tufts University and the University of Massachusetts Medical Complex in Worcester. Like Pfizer, Sanofi is expanding in Cambridge in order to have a "front row seat" for acquisitions.[58]

And here is the key to understanding the central role of the MLSC. *While the large firms can easily exist without the MLSC, the small life sciences firms need the Center to provide them with accelerator loans, research and development funds, and interns who can help them translate their ideas into what could be commercially viable products. While the private venture capital market may provide some funds for this purpose, venture capital often requires a quicker return than can be obtained from this industry, which often has long lag times between initial research, proof of concept, and a final FDA-approved product.*

In 2012, according to data gathered by PricewaterhouseCoopers, venture capital investments in biotech and health-care startups fell to their lowest level since 1995.[59] Investment in biotech firms in the Boston area dropped to $869 million in 2012, a 24 percent reduction from 2011 levels. Regulatory uncertainty facing the health-care industry is making this "a more challenging time for life sciences companies to raise money," according to Terry McGuire, general partner of Polaris Venture Partners, a Waltham-based VC firm with about half its portfolio invested in health-care companies.[60] Another reason biotech investments may be dwindling is that new software companies are on the rise and the return on investments in these firms tends to be much more "capital-efficient," paying off relatively rapidly.

The lack of easy access to VC funds has worried small life sciences firms about the "valley of death"—the gap in funding needed to move basic research into commercial products. In this environment, the MLSC has become an important investment partner for smaller life sciences firms, providing them with funds for translational research and development. These smaller firms may grow out of local research universities and medical complexes, but they can then turn to the MLSC for investment assistance. This tends to help keep them in the Commonwealth instead of losing them to investment funds in other regions.

In a number of cases, we found that smaller companies were being lured to relocate to other states, but according to their executives, the MLSC moved quickly to narrow the interregional cost differential and keep these firms in the Commonwealth. They did this through tax incentives and investment credits. And because these "minnows" stay here, Big Pharma has come from all over the world to swim in this pond. By helping to attract small life sciences companies to Massachusetts as well as incubating new ones begun in the state, the MLSC has created a well-stocked fishing ground for Big Pharma. In 2012 alone, a large array of small- and medium-sized domestic and international firms chose to establish operations in Massachusetts, including Era7 Bioinformatics, Algeta U.S., QServe, Scivax USA, ReproCELL, Inc., Human Metabolome Technologies, Inc., Alacrita, Arrayjet, ARGO Medical Technologies, BioAxone, BioSurplus, Promedior, and KeraFAST.

By the end of 2012, nine of the ten major drug companies in the world had set up shop in Massachusetts.[61] To house these firms, 3.4 million square feet of biotech-related office and laboratory space is now under construction across Massachusetts with massive buildings now being completed for Pfizer and Novartis. This adds to the 2.4 million square feet of commercial lab space erected between 2007 and 2011.[62] The other Big Pharma firms with major investments in Massachusetts are Johnson & Johnson, GlaxoSmithKline, Sanofi (which absorbed Genzyme), AstraZeneca, Abbott Laboratories, Merck, and Bristol-Myers Squibb. A decade ago, none of these global firms had a significant presence or any presence at all in the state, according to Mass Bio, the state's life sciences trade group.[63] Only Roche, the Swiss company and third largest biopharmaceutical firm in the world, has yet to establish a presence in the Commonwealth.

With this growth dynamic at work, Massachusetts appears well positioned to continue to attract new investment in the life sciences cluster.

The MLSC "Modus Operandi"

In the course of this study, many of those interviewed commented on the protocols that the MLSC follows in carrying out its activities. According to these sources, the Center's success in funding firms is grounded in its reliance on a Scientific Advisory Board (SAB) to guide the Center's Board of Directors in determining which firms show the greatest promise of economic and scientific success. The Center has established a competitive process for securing assistance and the SAB has made certain that the process is transparent. Over and over again, we heard in our interviews words like "rigorous" and "diligent" when describing the processes MLSC uses in selecting awardees.

It should be noted that other states that have created similar life sciences initiatives have had a less-than-stellar record of maintaining a process free of political considerations. In early 2013, the Texas Legislature essentially defunded the state's Cancer Prevention and Research Institute (CPRIT), which had been established by referendum in 2007. This followed the resignation of the agency's chief scientific officer, along with many of the institute's high-profile grant reviewers, in protest over how the independent peer review system had been disrespected.[64] According to the chair of the MLSC's Scientific Advisory Board, here in the Commonwealth the Center has been scrupulous in following the recommendations of the Center's Board of Directors and the SAB.

This has apparently contributed to the Center's exceptional record of assisting firms that ultimately succeed and grow. Accountability measures implemented by the Center have also contributed to the success of the Center's tax program. As **Table 6** reveals, the Center had

TABLE 6

Firms Receiving Tax Incentive Funding (Program Years 2009-2011)—Active Awards

		Hiring Goal	Hiring Actual	% of Goal	Hiring Potential
2009	Shire	150	153	102%	153
2009	Cubist	58	60	103%	60
2009	Biogen	50	235	470%	235
2009	Merrimack	50	53	106%	53
2009	Lightlab	29	32	110%	32
2009	Constellation	26	21	81%	26
2009	Sepracor	25	108	432%	108
2009	InfraReDX	21	25	119%	25
2009	OmniGuide	18	10	56%	18
2009	Organogenesis	15	26	73%	26
2009	Dyax	15	23	153%	23
2009	Still River	10	18	180%	18
2009	Nova	10	25	250%	25
2009	Infinity	18	14	78%	18
2009	STD Med	10	54	540%	54
2010	Shire	150	141	94%	150
2010	Sanofil	100	101	101%	101
2010	Vertex	90	136	151%	136
2010	NX Stage	50	27	54%	50
2010	Merrimack	50	37	74%	50

TABLE 6

Firms Receiving Tax Incentive Funding (Program Years 2009-2011)—Active Awards *(continued)*

		Hiring Goal	Hiring Actual	% of Goal	Hiring Potential
2010	Ironwood	37	56	151%	56
2010	Instrumentation Laboratory	30	30	100%	30
2010	Valeritas	18	10	56%	18
2010	Organogenesis	17	44	259%	44
2010	Bluebird	10	13	130%	13
2010	Bind	10	8	80%	10
2010	NormOxys	10	–5	–50%	10
2010	LeMaitre	19	43	226%	43
2010	Foundation Medicine	40	25	63%	40
2010	Lightlab	14	45	321%	45
2010	Nova	10	10	100%	10
2011	Shire	100			100
2011	Vertex	100			100
2011	AVEO Pharma	94			94
2011	Biogen Idec	75			75
2011	Ironwood	75			75
2011	DePuy Othopaedics	50			50
2011	Momenta Pharma	50			50
2011	PerkinElmer	50			50
2011	Organogenesis	35			35
2011	Aegerion Pharma	27			27
2011	Lightlab	26			26
2011	Cell Signaling Tech	20			20
2011	Quanterix Corp	19			19
2011	NinePoint Medical	15			15
2011	Pharmalucence	12			12
2011	Metamark Genetics	11			11
2011	New England Biolabs	10			10
2011	Nova	10			10
2011	T2Biosystems	10			10
2011	Boston Heart Diagnostics	31			31
2011	Ra Pharma	10			10
2011	Blueprint Medicines	15			15
2011	PAREXEL International	32			32
2011	Moderna Therapeutics	13			13
2011	Courtagen Life Sciences	13			13
2011	Knome	12			12
	2009–2011 Awardees	**1,160**	**1,578**	**136%***	**2,639****

Source: Massachusetts Life Sciences Center

* Proportion of hiring goal for 2009–2010 active awardees only; no data available on 2011 awardees at this time

** Minimum total jobs created if, on average, all firms meet or exceed hiring

31 outstanding tax incentive packages from the 2009 and 2010 programs as of June 30, 2012.

In a number of cases, hiring targets were exceeded by a factor of four or greater. In only one case did a firm receiving an award actually reduce its staff. As of June 30, 2012, the currently active 31 awards from the 2009/2010 program have produced 1,578 new jobs, exceeding the aggregate hiring goal of 1,160 by 36 percent. Adding in the 2011 program awards for which we do not yet have data on hiring, the potential number of new hires could exceed 2,600 if all firms, on average, meet or exceed hiring goals.

As noted above, the accelerator loan program is also meeting with success, with six of the 20 firms that received such loans already repaying them in full.

Table 7 provides additional data on the outstanding awards to firms from the 2009 program, the first year of the program. The outstanding amount of the tax incentive awards as of June 30, 2012 amounts to $15.25 million. Fifteen firms received tax incentive awards in that year totaling $15.25 million. They ranged in size from $6.3 million to Shire Human Genetic Therapies to $121,000 to STD Med, Inc. In 2009, these firms had a base headcount of 5,427. The target headcount associated with these awards was 5,932—an increase of 505 hires. By the end of 2011, 12 of these firms had met or exceeded their hiring targets.

What adds to the efficiency of these awards is a "claw-back" feature requiring firms that fail to meet their approved hiring goals to return to the Center the funds they were provided. A number of firms have done just that when they were unable to meet their specified minimum job-creation targets.

TABLE 7

Annual Report: 2009 Tax Incentive Program Results—for annual reporting period ending December 31, 2011

			Per Agreement			Actual	2011	Actual	
		$ Award Provided	Base Hdct	Adds	Targeted	12/31/2011 Hdct	Actual Growth (from base)	% of Adds (from base)	Achieved or exceeded target
	COMPANY								
	Active awards								
1	Shire Human Genetic Therapies, Inc.	$6,277,057	986	150	1136	1280	294	196%	Yes
2	Cubist Pharmaceuticals, Inc.	$1,740,000	355	58	413	415	60	103%	Yes
3	Biogen Idec MA, Inc.	$1,500,000	1899	50	1949	2134	235	470%	Yes
4	Merrimack Pharmaceuticals, Inc.	$1,500,000	124	50	174	214	90	180%	Yes
5	LightLab Imaging, Inc.	$188,951	64	29	93	141	77	266%	Yes
6	Constellation Pharmaceuticals, Inc.	$513,252	41	26	67	62	21	81%	No
7	Sepracor Inc. / Sunovion	$750,000	601	25	626	709	108	432%	Yes
8	Infraredx, Inc.	$630,000	60	21	81	85	25	119%	Yes
9	OmniGuide, Inc.	$ 540,000	62	18	80	72	10	56%	No
10	Infinity Pharmaceuticals, Inc.	$ 540,000	172	18	190	186	14	78%	No
11	Organogenesis Inc.	$ 245,240	241	15	256	311	70	467%	Yes
12	Dyax Corp.	$ 100,000	94	15	109	117	23	153%	Yes
13	Mevion (formerly Still River Systems), Inc.	$ 300,000	73	10	83	91	18	180%	Yes
14	Nova Biomedical Corporation	$ 300,000	498	10	508	533	35	350%	Yes
15	STD Med, Inc.	$ 121,000	157	10	167	211	54	540%	Yes
	TOTALS	$ 15,245,500	5427	505	5932	6,561	1,134		

Source: Massachusetts Life Sciences Center

Based on wage and salary data from the companies receiving tax-incentive awards between 2009 and 2011, we carried out an economic analysis of the cost and benefit of this MLSC program. The results are found in **Table 8**. Our analysis suggests that as of June 30, 2012, the Center had $56.3 million in outstanding tax incentives. Altogether, the firms receiving these incentives added more than 2,500 jobs by 2012. The vast majority (1,843) of these were in pharmaceutical firms with the remainder generated by medical device companies (481) and scientific research enterprises (213). The average annual salary of these jobs exceeded $105,000. As such, these new jobs generated a total of over $266 million in wages and salaries each year.

Based on estimates from the Massachusetts Department of Revenue, we estimate that, on average, the added workers employed by these firms paid more than $4,900 in income taxes to the Commonwealth and $2,400 in sales taxes.[65] Assuming that each of these jobs lasts on average just five years, the added state revenue generated by these workers over that period is close to $37,000 per worker or a total of $93 million in tax revenue.

Compared with the total cost of the incentive program, each dollar in awards will generate $1.66 to the state in added tax revenue. This represents an extraordinary rate of return on this public investment.

TABLE 8
Economic Return on the MLSC Tax Incentive Program

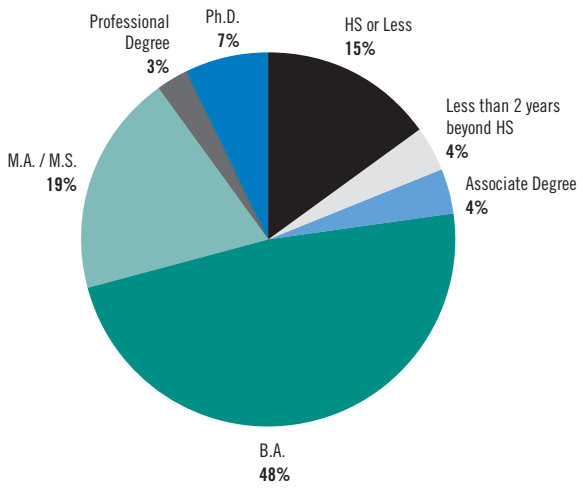
	Program Year 2009	Program Year 2010	Program Year 2011	3 Years of Incentives
Total Value of MLSC Tax Incentives ($)	$15,245,500	$20,672,638	$20,340,884	$56,259,022
Net New Jobs Created	901	721	915	2,537
Tax Incentive per Job ($)				$22,175
Annual Tax Incentive per 5-year job ($)				$4,435
Average Salary per Job ($)				$105,037
Total Salaries Generated per Year ($)				$266,479,399
State Income Tax Revenue per Job per year ($)				$4,937
Total State Income Tax per year ($)				$12,524,532
Average Sales Tax per Job ($)				$2,404
Total State Sale Tax per year ($)				$6,099,447
Total Income+Sales Taxes per year ($)				$18,623,979
Average Income+Sales Tax/Job per year				$7,341
Total Income+Sales Taxes per 5-year Job				$36,705
Total Income+Sales Taxes over 5 years				$93,120,585
Net State Revenue Gain (5 years) ($)				$36,860,872
Ratio of Tax Revenue/Incentive over 5 years				1.66

	Pharma	Medical Devices	Scientific Research	Total
Jobs	1,843	481	213	2,537
Average Salary ($)	$115,222	$66,913	$103,009	$105,037
Total Salary ($)	$212,353,256	$32,185,280	$21,940,863	$266,479,399
Share of Salary	0.7969	0.1208	0.0823	1.0000
State Income Tax By Sector ($)	$9,980,603	$1,512,708	$1,031,221	$12,524,532
Sales Tax by Sector ($)	$4,860,554	$736,689	$502,204	$6,099,447

Source: Dukakis Center for Urban and Regional Policy

FIGURE 11

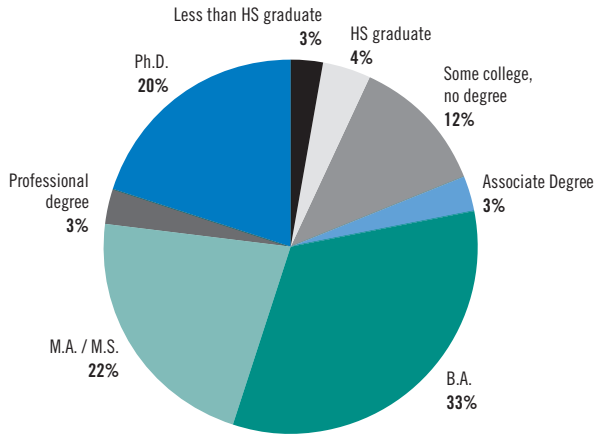
Education Distribution of New Hires by 2010 MLSC Tax Incentive Awardees



Source: Dukakis Center for Urban and Regional Policy

FIGURE 12

Education Distribution—Pharma

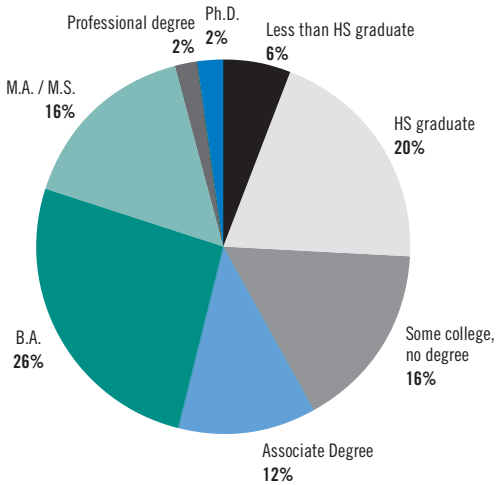


Less than B.A.: 22%

Source: Dukakis Center for Urban and Regional Policy

FIGURE 13

Education Distribution—Medical Devices

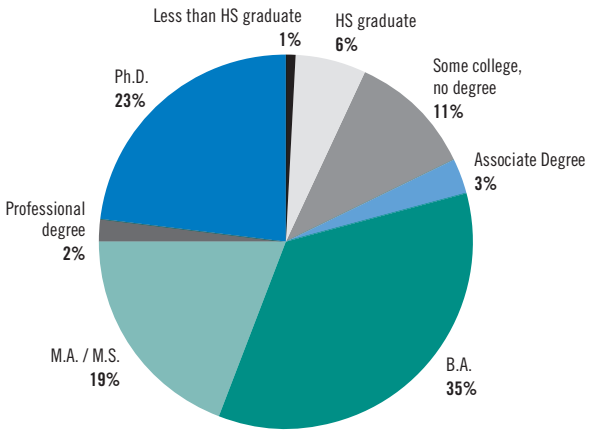


Less than B.A.: 54%

Source: Dukakis Center for Urban and Regional Policy

FIGURE 14

Education Distribution—Diagnostics, Tools, and Related Products and Services



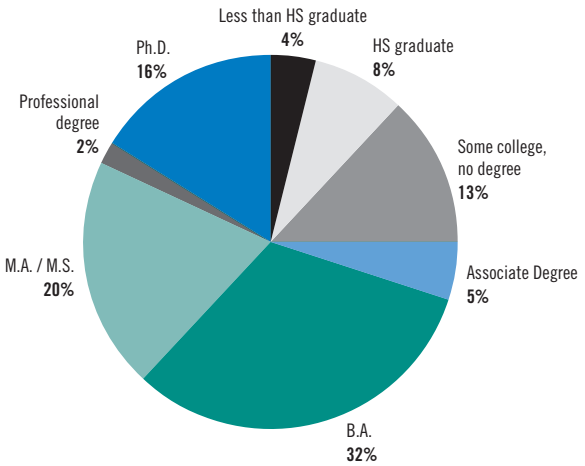
Less than B.A.: 21%

Source: Dukakis Center for Urban and Regional Policy

Of course, it is possible that these firms would have generated some or perhaps even many of these jobs without the MLSC award. But given the importance of the life-sciences ecosystem created in the Commonwealth, at least partly as a result of Center activity, it is reasonable to suggest that many of these jobs and their associated tax revenue would not have been created without the help of the Center. Moreover, our estimates do not consider any "multiplier" effects. The added spending of these new hires in the Commonwealth helped generate additional jobs as these workers spent money in the state, creating jobs in a wide range of industries.

FIGURE 15

Education Distribution—Life Sciences Cluster Pharma/Medical Devices/Diagnostics, Tools, and Related Products and Services



Less than B.A.: 30%

Source: Dukakis Center for Urban and Regional Policy

A concern that one might have about the employment generated by the life sciences super cluster is that the jobs created all go to the most educated workers in the state, leaving behind those who have not had the benefit of a college degree or post-graduate education. But based on the hiring records of a number of firms in the industry, it turns out that like other industries, life sciences firms need to hire workers who have a range of skills. In addition to Ph.D. scientists and other highly educated workers, these firms need laboratory technicians and clerical staff, and they employ a range of other workers in occupations that require a good deal less education. **Figure 11**, based on these hiring data, reveals that less than a third (29%) of those working in the life sciences have a Master's degree, professional degree, or Ph.D. Nearly half (48%) have the B.A. or B.S. as their highest level of education, while nearly a quarter (23%) of the workforce has no more than an associate's degree, often from a community college.

Using national data from the 2010 *American Community Survey* (ACS) available from the U.S. Census Bureau, we were able to estimate the education distribution for the individual sectors within the life sciences super cluster. As **Figures 12–15** demonstrate, the proportion of workers in each of the cluster segments needing less than a B.A. (or B.S.) ranges from 21 percent in diagnostics, tools, and related products and services and 22 percent in pharmaceutical firms to more than half in medical devices. According to these national estimates, the total workforce in the super cluster requiring less than a 4-year college degree is 30 percent, a bit higher than the 23 percent in Massachusetts. Essentially, with such a highly educated workforce in the Commonwealth, firms here are able to insist on somewhat higher educational credentials for their employees.

What adds to the value of the life sciences labor market in the Commonwealth are the high wages paid in this sector. As **Table 9** reveals, based on an analysis of Census data, the average annual wage in the state's

TABLE 9

Estimated Annual Earnings for Life Sciences Workers (2006–2010)

	Pharma	Medical Devices	Scientific R&D	Total
Less than High School graduate		$35,142	$51,685	$36,702
HS graduate	$42,966	$33,250	$71,418	$44,225
Some college, no degree	$62,745	$46,684	$61,816	$55,386
Associate's degree	$96,171	$61,400	$53,712	$61,285
Bachelor's	$95,147	$98,853	$85,080	$92,033
Master's	$102,851	$114,019	$102,045	$105,143
Professional school degree	$150,264	$118,399	$182,999	$161,195
Doctorate	$171,596	$249,332	$112,626	$134,195
Total	$102,961	$78,498	$96,379	$91,805

Source: Dukakis Center Analysis of American Community Survey (Census) data

life sciences varies from $78,500 in medical devices to nearly $103,000 in the pharmaceutical industry.[66] Those with a Ph.D. earn, on average, nearly $250,000 in the medical-device sector and well over $100,000 in other sectors within the cluster. But even those who have not completed high school average nearly $37,000 a year, the equivalent of more than $18.00 an hour. High school graduates average more than $44,000 and those with an associate's degree, more than $61,000.

Compared with other industries, the life sciences provide some of the highest paying jobs in the Commonwealth. With an average annual salary of nearly $92,000, this sector rewards its workforce with higher pay than those who work in manufacturing as a whole, construction, real estate, education, government, health care, and transportation. The average salary in the life sciences industries in the Commonwealth exceeds the all-industry Massachusetts average by 68 percent.[67]

The Long-Term Impact of the Commonwealth's Life Sciences Initiative

Based on all of the data we collected about the MLSC and its activities, the analysis we conducted on the expansion of the life sciences industries in the Commonwealth, and the information we gleaned from the interviews, our overall conclusion is that because of its unique comprehensive approach to an entire industry super cluster and its reliance on scientific peer-reviewed procedures for awarding grants, the Commonwealth has reaped a substantial return on its life sciences initiative investment. Moreover, given the number of firms that have been attracted to the state, in large measure because of the ecosystem the Center has helped nurture, the benefits from the state's investment in this initiative are likely to pay off bountifully in the years to come.

Many of our informants for this report noted that by 2018, when the $1 billion Life Sciences Initiative sunsets, the state will still need an agency that encourages innovation among smaller life sciences firms. Innovation, they note, must be a continuous process for the region to remain prosperous. This will be particularly important as China, India, Singapore, and other foreign countries compete for a share of this expanding super cluster by offering massive incentives to life sciences start-ups.

The big question is whether Massachusetts can continue to lead the nation in the evolution of this critical industry or whether other regions of the country will be able to capture this industry and the jobs that go with it. Massachusetts was once the premier textile center of the nation until the south captured much of the industry in the early part of the 20th century. The Commonwealth led in the development of the commercial computer industry in the 1970s and 1980s with the growth of Digital Equipment Corporation (DEC), Data General, Prime Computer, and Wang, but lost out to Silicon Valley in California and companies like Dell in Texas. Today, other states including New Jersey, California, New Mexico, Utah, and Minnesota are all vying to expand their life sciences clusters.The state's concentration of globally prominent "eds and meds" has clearly been critical to the evolution of the life sciences in the Commonwealth.

One area where the MLSC might wish to pay more attention in the years to come is the medical-device industry. As noted earlier in this report, employment in this component of the life sciences cluster has been stagnant. According to our interviews, other states including Indiana, Michigan and Minnesota are targeting this sector with state funding. Unlike Big Pharma, which can be more patient in the marketplace and worry less about cost pressures, medical-device firms need to move quickly in the market to commercialize their products and they need to be vigilant about reducing costs. To the extent that the MLSC can assist these firms, Massachusetts could remain a center for this sector and employment growth could ensue.

But overall, based on the state's continued commitment to the life sciences, we fully expect to see further growth in the size of private-sector investments in the state's life sciences industries and further increases in employment opportunity.

Assessment of the MLSC Staff

The interviews we carried out also suggested that the Center itself is being run quite effectively and efficiently and in a highly professional manner. Virtually all of our informants praised the management team and especially appreciated the leadership's reliance on peer review and its refusal to permit political considerations to trump scientific merit. As one expert informant noted, the MLSC has "lots of moving parts" and all of them are working well and the Center remains responsive to

industry needs, meeting deadlines, and staying focused on its mission. As another informant put it, with the reliance on the Scientific Advisory Board (SAB) to select awardees, "there is not an ounce of boondoggle in this agency." In its report on creating fiscally sound state tax incentives, the Pew Center on the States singled out the Massachusetts Life Sciences Tax Incentive Program for its focus on annual cost controls and its reliance on scientific merit in making awards.[68]

Still another informant noted that the MLSC is successful because its leadership is committed to working "at the speed of business" and therefore has become a valued partner in the expansion of the industry.

Conclusions

All of our research suggests that the state will benefit from fully funding the remaining five years of the initiative in order to maintain the lead the life sciences have established in the Commonwealth. This is particularly important as other states ramp up their investments in hopes of creating their own life-sciences ecosystems to entice the small and large firms Massachusetts has successfully attracted. California, Maryland, New Jersey, New York, Minnesota, and Florida are not resting on their laurels, but continue to spend state funds on their own life-sciences industries.

Over time, it should be possible for the Center to reach out to the private sector to help fund more of its initiatives, as it has done with the Massachusetts Neuroscience Consortium. With the plethora of larger, profitable firms coming to the state to expand their operations, one could imagine the Center funding more of its internships with private funds and having private firms contribute to other programs (STEM education, for example), allowing the Center to focus even more of its funding on accelerator loans and tax incentives for firms undertaking translational research.

We should also note that the success of the MLSC has lessons for other quasi-public entities in the Commonwealth. We can mention five of them here:

1. Long-term success in the use of tax incentives and business loans is most likely to occur when funds are focused on a cluster of firms and a set of technologies in a given industry, helping to create an industrial ecosystem which can attract new companies to the state.
2. The use of expert panels to determine the awarding of loans assures that these funds will be well utilized. "Claw-back" provisions protect the taxpayers by requiring firms to repay funds advanced by the Commonwealth if they fail to meet hiring goals.
3. The focus on encouraging firms in their early-stage innovation activity is central to promoting economic growth and prosperity.
4. Helping fund workforce development efforts for critical industries as part of the mandate of the quasi-public helps assure a pipeline of skilled workers for the industry and this itself helps attract new firms to the region.
5. Taking a "portfolio" approach to the entire range of activities in the life sciences—from investments in small innovative firms to helping train the future workforce to underwriting infrastructure—helps sustain the "ecosystem," undergirding a virtuous cycle of discovery, innovation, investment, and employment opportunity.

In the end, we applaud the Governor and the Legislature for their foresight in creating the Massachusetts Life Sciences Center and the $1 billion Life Sciences Initiative. The structure put in place is fulfilling the goals set out in the original legislation and the Center's leadership has continually assured that the structure works effectively and efficiently.

Endnotes

Chapter One

1. The Massachusetts Life Sciences Center, "About the Center," www.masslifesciences.com/mission.html.

2. Massachusetts Life Sciences Center, *Fiscal Year (FY) 2012 Annual Report*, "Outpacing the Competition," Cover Letter, September 28, 2012.

3. According to an analysis prepared by the Massachusetts Budget and Policy Center, the Commonwealth faces at least a $1.2 billion deficit in FY2014. This is based on current tax rates and expected spending. See Massachusetts Budget and Policy Center, "A Preview of the FY2014 Budget," January 10, 2013.

4. Following on the early work of Stanley Surrey who served as Assistant Secretary of the U.S. Treasury for Tax Policy, the Congressional Budget and Impoundment Act of 1974 (CBA) defines *tax expenditures* as "those revenue losses attributable to provisions of the Federal tax laws which allow a special credit, a preferential rate of tax, or a deferral of tax liability." See Stanley Surrey, Pathways to Tax Reform: The Concept of Tax Expenditures (Cambridge, MA.: Harvard University Press, 1974); U.S. Congress, Congressional Budget Act of 1974.

5. Joe Stephens and Carol D. Leonnig, "Solyndra: Politics Infused Obama Energy Program," *Washington Post*, December 25, 2011.

6. Carol D. Leonnig, "Battery Firm backed by Federal Stimulus Money files for Bankruptcy," *Washington Post*, October 16, 2012.

7. Jason Schwartz, "End Game," *Boston Magazine*, August 2012.

8. The specific life sciences industry sectors used in this report are based on the non-agricultural 6-digit NAICS (North American Industry Classification System) as reported in the *Battelle/Bio State Bioscience Industry Development 2012 Report* produced jointly by the Battelle Institute, the Biotechnology Industry Organization (BIO), and MPM Public Affairs Consulting, Inc. (June 2012).

9. This set of NAICS industries omits perhaps 50 percent of the growth in life sciences jobs in Massachusetts because it omits life sciences in research in hospitals and universities. These jobs are not counted in the Battelle report because the NAICS industrial coding system cannot distinguish between research jobs in hospitals and other jobs in hospitals such as physicians and nurses, and life sciences research jobs in universities and other jobs such as English and social science professors.

10. It is important to note that because we could not break out faculty, staff, and students involved in the life sciences departments and research institutes from all others employed at universities and hospitals, this report does not include an analysis of the educational attainment, earnings, and occupations for those working in these institutions. Clearly, if we could have done this, our estimates of the number of those employed in the life sciences in Massachusetts would be much greater.

11. Massachusetts Biotechnology Council, "The Complete Guide to the 2012 New England Life Sciences Industry," p. 4.

12. Jane G. Gravelle and Thomas L. Hungerford, "The Challenge of Individual Income Tax Reform: An Economic Analysis of Tax Base Broadening," Congressional Research Service, 7-5700, March 22, 2012.

Chapter Two

13. The largest of these include the exclusion from taxable income of employer contributions for medical insurance premiums and medical care; the net exclusion of contributions to 401(k) pension plans, Individual Retirement Accounts (IRAs), and Keogh plans; the deductibility of home mortgage interest on owner-occupied homes, the deductibility of charitable contributions, and the preferential tax rates on long-term capital gains.

14. Tad DeHaven, "Corporate Welfare in the Federal Budget," Policy Analysis No. 703, Cato Institute, July 25, 2012.

15. Ibid., Table 1, pp. 3–5.

16. See Louise Story, Tiff Fehr and Derek Watkins "As Companies Seek Tax Deals, Governments Pay High Price," *New York Times*, December 1, 2012, p. 1; "Lines Blur as Texas Gives Industries a Bonanza," New York Times, December 2, p. 2; "Michigan Town Woos Hollywood, but End Up with a Bit Part," *New York Times*, December 3, p. 1.

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20. DeHaven, op.cit., p. 6

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31. Bluestone and Harrison, op.cit., p. 216.

32. Ben S. Bernanke, "Promoting Research and Development: The Government's Role," Remarks before the Conference on New Building Blocks for Jobs and Economic Growth," Washington, D.C., May 16, 2011.

33. See Martin Bailey, "Trends in Productivity Growth," in Jeffrey C. Fuhrer and Jane Sneddon (eds.), *Technology and Growth: Conference Proceedings*, Federal Reserve Bank of Boston, Conference Series No. 40, June 1996.

34. Matt Hourihan, "The Federal R&D Budget: Process and Perspectives," Presentation before the AAAS Leadership Seminar in Science and Technology Policy, American Association for the Advancement of Science, November 12, 2012.

35. MassBio "Biopharma Industry Snapshot, 2012," p. 22 based on data from the National Institutes of Health and the U.S. Census.

36. Congressional Budget Office, "Federal Support for Research and Development," June 2007.

37. National Science Board, *Science and Engineering Indicators 2012* (Washington, D.C.: National Science Foundation, January 2012).

38. See Economic Geography Glossary, http://faculty.washington.edu/krumme/gloss/a.html.

39. Steven J. K. Walters, "Unions and the Decline of U.S. Cities, *Cato Journal*, Vol. 30, No. 1 (Winter 2010), p. 119.

40. For a fascinating history of Silicon Valley, see the three-part series on National Public Radio, *The Birth of Silicon Valley* produced by Laura Sydell. These include "A Rare Mix Created Silicon Valley's Startup Culture" (April 4, 2012); "America's Magnet for Innovation and Investments" (April 5, 2012); and "Intel Legends Moore and Grove: Making It Last" (April 6, 2012).

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42. See National Research Council, Funding a Revolution: Government Support for Computing Research, (Washington, D.C. 1999), pp. 2–3.

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43. This section is based on Mark R. Trusheim, Ernst R. Berndt, Fiona Murray, and Scott Stern, "American Entrepreneurial Chaos or Collaborative Industrial Policy: The Emergence of the Massachusetts Biotechnology Super-Cluster," Contributed Paper for the 2nd Conference on Corporate R&D (European Commission, 2010).

44. Trustheim, Berndt, Murray, and Stern, op.cit., p. 13.

45. MassBio "Biopharma Industry Snapshot, 2012," p. 23 based on MassBio membership reports and the *Boston Business Journal Book of Lists, 2012.*

46. See Greg Turner, "Boston is a Big Force in Pharma, *Boston Herald*, December 14, 2012.

47. Jones, Long LaSalle, "Life Sciences Cluster Report: Global 2011," p. 16. Boston ranked #1 on each component of the composite score with the exception of venture capital funding where it ranked #2.

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48. MassBio, "Massachusetts Life Sciences Incentives," Fact Sheet, September 2012.

49. "Refundable" tax credits are payments made to a taxpayer by the Internal Revenue Service or the Commonwealth's Department of Revenue. Such payments can offset other tax liabilities or in the case of no tax liability are a form of "negative" tax.

50. Massachusetts Life Sciences Center, *Fiscal Year (FY) 2012 Annual Report*, p. 4.

51. According to an MLSC memo to the Secretary of Administration and Finance, "The MLSC Tax Incentive Program has enforcement mechanisms, including strict monitoring and reporting requirements for recipient companies. Within 30 days of the end of each calendar year following the award, awardees are required to provide an annual report to the Center that permits the Center to determine whether the awardee's job targets have been met. The statute provides for 'clawback' provisions for companies that are found not to be fulfilling their job creation commitments to the state. Companies that fail to achieve at least 70% of their job targets at the end of any annual reporting period are subject to an investigation to determine the cause of this 'material variance.'" In cases where it is found that the company cannot meet its requirements, the Center

notifies the Massachusetts Department of Revenue so that the department can initiate claw-back procedures to recover the tax value any award provided. If a company has met at least 70% of its goal, the Center may permit the company a second year to fully meet this requirement before notifying the DOR. See memo to Jay Gonzales, Secretary, Executive Office for Administration and Finance from Susan Windham-Bannister, President and CEO of the Massachusetts Life Sciences Center, August 27, 2012.

52. Massachusetts *Life Sciences Center, Fiscal Year (FY) Annual Report*, op. cit., p. 6.

53. UMass Donahue Institute, *Growing Talent: Meeting the Evolving Needs of the Massachusetts Life Sciences Industry* (Cambridge, MA.: Massachusetts Life Sciences Center and Massachusetts Biotechnology Council, 2008), p. 15.

54. U.S. Bureau of Statistics, *Quarterly Census of Employment and Wages* as reported in MassBio "Biopharma Industry Snapshot, 2012," p. 4. These statistics are for NAICS Code 541711.

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55. See D.C. Denison, "Drugmakers, Mass. Form Consortium," *The Boston Globe*, June 20, 2012, p. B1.

56. Pfizer: Science at our Core, "R&D Locations: Cambridge, MA." http://www.pfizer.com/research/rd_works/cambridge.jsp.

57. Pfizer: Science at our Core, op. cit.

58. See Jeanne Whalen and Mimosa Spencer, "Sanofi wins Long-Sought Biotech Deal," *Wall Street Journal*, February 17, 2011.

As a case in point, on January 29th, 2013 Sanofi announced the launch of LeGoo, a biopolymer gel that allows surgeons to temporarily stop blood flow during surgery without the use of clamps, elastic loops or other conventional occlusion devices that may risk trauma to blood vessels. LeGoo was developed by Pluromed, a young company that was one of the first to receive a loan through the Center's Accelerator Loan Program in 2009. The Accelerator Loan provided support for Pluromed at a critical stage in the development of LeGoo. Pluromed repaid its loan with interest to the Center following its acquisition by Sanofi.

59. See Michael B. Farrell, "Startup Funding Declines Across US," *The Boston Globe*, January 18, 2013, p. B5.

60. Michael B. Farrell, "Startup Funding Declines Across US," op. cit., p. B9.

61. See Greg Turner, "Boston is a Big Force in Pharma," *Boston Herald*, December 13, 2012.

62. MassBio "Biopharma Industry Snapshot," 2012, p. 9.

63. Greg Turner, "Boston is a Big Force in Pharma," op.cit.

64. Monya Baker, "Texas Cancer Institute gets no Funds for new Grants in Proposed Budget," *Nature.com*, January 16, 2013.

65. According to estimates prepared by the Mass DOR from recent annualized tax revenue data, state income tax revenues in the Commonwealth average 4.7% of wage and salary income and sales tax revenues average 48.7% of income tax revenues.

66. These estimates are based on data for 2010 from the American Community Survey (ACS).

67. See Barry Bluestone, et. al, *Staying Power II: A Report Card on Manufacturing in Massachusetts 2012*, Dukakis Center for Urban and Regional Policy, September 2012, Table 1.10, p. 32 based on data from the U.S. Bureau of Labor Statistics, Quarterly Census of Employment and Wages.

68. "Avoiding Blank Checks: Creating Fiscally Sound State Tax Incentives, Pew Center on the States, December 2012, Table 1, p. 5 and p. 14.