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The Economic, Labor Market, and Fiscal Performance and Impacts of the Biopharmaceutical Industries of Massachusetts (Research Summary)

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The Economic, Labor Market, and Fiscal Performance and Impacts of the Biopharmaceutical Industries of Massachusetts (Research Summary)

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Note: This executive summary provides a brief overview of findings from a comprehensive series of research papers on a wide array of analyses of the employment, output, research and development expenditures, profitability, and multiplier effects of biopharmaceutical industries as well as the demographic characteristics of their workforce, their occupations, earnings, and net fiscal contributions to national, state, and local governments.

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Introduction

During the past 14 months, the Center for Labor Market Studies at Northeastern University has been conducting a comprehensive analysis of the economic, labor market, earnings and income, and fiscal impacts of the operations of the industries of firms belonging to the PhRMA Association of Massachusetts. Our study has examined a wide array of issues on the past, current and projected future job creation activities of these industries, their direct and indirect impacts on jobs in the entire state economy, the types of jobs generated by these industries, the output levels of these industries, their research and development activities, the characteristics of the workers and their occupations, the earnings of workers employed by these industries, and the net fiscal impacts of the workers employed in these industries. In many cases, findings for the biopharmaceutical-related industries in Massachusetts were compared to those of all other industries in the state and to the same industries in other states or across the entire nation. The analyses included both cross-sectional and time series findings.

One of the key distinguishing characteristics of many of the pharmaceutical production and research/development activities of PhRMA members is their export base orientation. The bulk of the products and the research and development activities of these firms are either sold outside of the state or financed by government agencies and private sector firms located outside of Massachusetts. These industries, thus, form part of the state's export base, which had been suffering steep job losses in recent years, particularly as a result of job declines in the manufacturing sector. In urban economics, firms in the export base generate an array of output, earnings, and employment multipliers from their activities. These multiplier effects result from their purchases of goods and services from local firms and the consumption expenditures of their workers, managers, and owners. The multiplier effects from pharmaceutical firms, especially employment multipliers, can be quite substantial due to the high productivity and annual earnings of their workers and strong linkages with other state industries.

Our research activities have gone well beyond the standard analyses of employment and output developments and multiplier impacts. We have used data from a wide array of national, state, local, and private sources to conduct the above analyses.

Data were combined from a variety of surveys to estimate and examine growth in the numbers of economic establishments in biopharmaceutical-related industries, the number of workers per establishment, the demographic and socioeconomic traits of biopharmaceutical industry workers, the occupational characteristics of their job, quality of jobs issues, comparative annual earnings of workers in these industries, the determinants of the annual earnings of workers, fiscal impacts of workers in biopharmaceutical industries, and, inter-industry output and employment linkages via multiplier analysis. Fourteen individual research papers were prepared by CLMS research staff. A detailed summary of the findings of these papers is presented below.

Defining the Industrial Content of Biopharmaceutical-Related Industries

The first major set of research tasks undertaken by CLMS staff involved the identification of the specific industries in which PhRMA member companies operate in Massachusetts. The primary purpose of this research was to identify the NAICS industry codes to which PhRMA member companies were assigned. The PhRMA group provided CLMS staff with a listing of PhRMA member companies that operated in Massachusetts. The staff at CLMS obtained North American Industry Classification (NAICS) codes for PhRMA member companies from multiple sources- Analysts Resource Center's (ARC) 2006 Employer Database, Thompson Financial, and HooversTM based on companies' Securities and Exchange Commission filings. In addition, CLMS staff interviewed labor market economists at state agencies in charge of disseminating company data and also visited each PhRMA member company's web site to determine the exact nature of their actual business and assign an appropriate NAICS code to each PhRMA member company with operations in Massachusetts. Both public and private data sources for companies are based on NAICS codes. Data on employment, earnings, outputs, wages, R&D expenditures, sales etc. are available under the NAICS codes. After a comprehensive research review, we determined that all of the PhRMA member companies in Massachusetts fall under one of the following three NAICS codes:

1. **3254-** Pharmaceutical preparation manufacturing (includes pharmaceutical preparation manufacturing, in-vitro diagnostic substance manufacturing, and biological products except diagnostic manufacturing)

2. **3391** - Surgical and medical instrument manufacturing (includes laboratory apparatus and furniture manufacturing, surgical and medical instrument manufacturing, surgical appliance and supplies manufacturing, dental equipment and supplies manufacturing, ophthalmic goods manufacturing and dental laboratories).
3. **54171** – Physical, engineering and biological research (includes only physical, engineering and biological research).

These NAICS codes are not only restricted to PhRMA member companies in Massachusetts, but they also apply to all other companies operating a similar line of businesses. Table 1 displays a listing of 16 PhRMA member companies with operations in Massachusetts and their assigned four digit NAICS codes.

Table 1:
A Listing of 16 PhRMA Companies and Their NAICS Codes in Massachusetts

Company	Location	NAICS- Line of Business/Description
Abbott	Worcester	5417 - Physical, engineering and biological research 3254 - Other biological product mfg.
Alkermes	Cambridge	3254- Pharmaceutical preparation mfg.
Astra Zeneca	Westborough	3254- Medicinal and botanical mfg 3391 - Surgical & medical instrument/appliances mfg
Astra Zeneca	Waltham	5417 - Physical, engineering and biological research
Bayer	E Walpole	3391 - Surgical and medical instrument mfg.
Bristol-Myers Squibb	Billerica	3254 - Pharmaceutical preparation mfg.
Genzyme	Cambridge	3254 - Pharmaceutical preparation mfg. 5417 - Physical, engineering and biological research
Johnson & Johnson	Lexington	5417 - Physical, engineering and biological research
Idenix	Cambridge	3254 - Pharmaceutical preparation mfg.
Merck	Boston	5417 - Physical, engineering and biological research
Millennium	Cambridge	3254 - Pharmaceutical preparation mfg. 5417 - Physical, engineering and biological research
Pfizer	Cambridge	5417 - Physical, engineering and biological research
Sanofi-Aventis	Cambridge	5417 - Physical, engineering and biological research
Schering-Plough	Cambridge	5417 - Physical, engineering and biological research
Serono	Rockland	3254 - Pharmaceutical preparation mfg.

Table 1: (Continued)

Company	Location	NAICS- Line of Business/Description
Sepracor	Marlborough	3254 - Pharmaceutical preparation mfg. 5417 - Physical, engineering and biological research
Wyeth	Andover	3254 - Pharmaceutical Preparation Manufacturing
Wyeth	Cambridge	5417 - Physical, engineering and biological research

The definitions of the biotechnology and pharmaceutical industries are overlapping over time as a result of changes in product mixes of industries and inter-industry linkages between them. In the past, biotechnology industries pursued R&D based largely on biological processes to develop drugs whereas the pharmaceutical industry primarily used chemical syntheses to develop new drugs. However, over the years, pharmaceutical companies are increasingly using biological processes and biotechnology companies also are using synthesis chemistry to develop new drugs. In addition, the big pharmaceutical firms have acquired many biotechnology firms. For these reasons, the distinctions between the biotechnology industries and pharmaceutical industries have blurred over time.¹ Since, PhRMA member companies cut across both of these two types of drug development industries, we will use the term “biopharmaceutical” industry in all of our research papers to refer to PhRMA-related companies.

Data Sources for the Study

In conducting the economic, financial, labor market and research and development analyses of biopharmaceutical-related industries in Massachusetts and the U.S., research staff of the Center for Labor Market Studies used data from a diverse array of sources. All of the data sources and statistical analyses underlying the findings in our research papers are documented clearly in the main body of these papers. Any well-trained economic analyst would be able to replicate our findings. These sources were:

1. The 2000 Decennial Census of Population and Housing public use data files of the U.S. Census Bureau

¹ For discussion of this issue, see: Gary P. Pisano, Science Business: The Promise and the Reality of the Future of Biotech, Harvard Business School Press, Boston, Massachusetts, 2006.

2. 2004 and 2005 American Community Surveys of the U.S. Census Bureau
3. 1997 and 2002 Economic Censuses of the U.S. Census Bureau
4. County Business Patterns (CBP), U.S. Census Bureau
5. Quarterly Census of Employment and Wages (QCEW), U.S. Bureau of Labor Statistics and Massachusetts Department of Workforce Development
6. Public use files from the Monthly Current Population Surveys (CPS), a household survey conducted by the U.S. Census Bureau for the U.S. Bureau of Labor Statistics
7. The Occupational Employment Statistics program (OES), U.S. Bureau of Labor Statistics and Massachusetts Department of Workforce Development
8. The Gross Domestic Product (GDP) and Gross State Product data of the Bureau of Economic Analysis (BEA), U.S. Department of Commerce
9. National Science Foundation
10. U.S. Securities and Exchange Commission (SEC)
11. Thompson Financial
12. HooversTM

Recent Trends in Payroll Employment in Massachusetts in the Pharmaceutical and Medicine Manufacturing, Surgical and Medical Instrument Manufacturing Industries, and Physical, Engineering, and Biological Research Service Industries of Massachusetts: A Comparative Perspective

Over the past two decades, the state of Massachusetts has experienced both substantial cyclical swings in the number of nonfarm wage and salary jobs in the state and a substantial shift in the mix of industries that employ wage and salary workers in the state.² From 1979 to 1989, the state experienced a major jobs boom that added 505,000 net new wage and salary jobs, a near 20% rate of job growth that matched the national payroll jobs growth rate over that decade. Over the 1988-1992 period, however, the state would see its wage and salary job base substantially diminished, with a 10% decline in payroll employment over this four year period. It would take nearly six years of steady

² For a comprehensive overview of job developments in Massachusetts during the decade of the 1980's and 1990's, see: Andrew Sum, Paul Harrington, et.al., The State of the American Dream in Massachusetts, 2002, Massachusetts Institute For a New Commonwealth, Boston, May 2002.

job growth from 1992 to 1998 to restore the previous job level peak that prevailed in 1988.

A number of important structural shifts in the industrial composition of employment in the state also took place over the past 20 some years. In particular, since the mid-to-late 1980s, Massachusetts has experienced a major deindustrialization, losing over one-half of its manufacturing jobs. In 1983, the state had 629,000 manufacturing jobs. By 2005, this number had dwindled to 305,500. The manufacturing sector produces a number of important labor market and economic benefits for the state's economy. During the 1970's and 1980's, the manufacturing sector created a broad base of mid-to-high wage jobs that helped many of the state's blue collar workers without post-secondary schooling as well as professional, technical, and managerial workers earn middle class incomes. Manufacturing jobs paying mid-level wages were available to residents with only a high school education or one to two years of postsecondary schooling. In addition to the important labor market benefits of having a large manufacturing job base, there are also substantial economic output and employment multiplier benefits. As a main component of the export base of the Massachusetts economy, manufacturing industries helped generate large, favorable multiplier effects that produced economic benefits for suppliers and for local industries supplying residents with goods and services. Thus, the substantial decline in manufacturing jobs over the past two decades has created unfavorable labor market conditions in the state for male workers without a college degree and produced negative multiplier effects that compounded the problem of job loss in that sector. Given the broad decline in manufacturing activities in the state, Massachusetts has become increasingly dependent on other industries especially professional and technical services, health and educational services, finance, and leisure and hospitality industries to create jobs for the state's residents in recent years.

Employment Trends in Biopharmaceutical-Related Industries, 2000-2005

To identify job trends in biopharmaceutical-related industries in Massachusetts, we analyzed payroll employment data from the Quarterly Wage and Employment Survey

for three North American Industry Classification System (NAICS) industries. They are represented by the following three NAICS codes: 3254, 3391 and 54171. Employment trends were analyzed for each industry separately and for the three industries combined. Employment in the pharmaceutical preparation manufacturing industry (NAICS 3254) in Massachusetts grew steadily from 2000 to 2003 while many other industries in the state were shrinking. This sector added 1,166 jobs between 2000 and 2003, representing a 15.2% increase in employment from 2000. The pharmaceutical preparation manufacturing industry, however, shed 1,845 jobs between 2003 and 2004, before recovering some of these job losses between 2004 and 2005. Over the five year period from 2000 to 2005, there was an overall increase of 115 jobs in pharmaceutical preparation manufacturing. It was one of the few manufacturing industries in the state to add jobs over this time period (Table 2).

Employment in the Physical, Engineering, and Biological Research industry in our state has been one of the star performers in job creation over the past five years. Payroll employment in this sector increased by 8,823 or 33% between 2000 and 2005 (Table 2). The strong growth in jobs in this key research-oriented industry enabled total employment in all biopharmaceutical-related industries to rise over the 2000-2005 period.

Employment in the Surgical and Medical Instrument manufacturing industries (NAICS code 3391) did not fare as well over the past 5 years. Overall wage and salary employment in this sector declined from 14,821 in 2000 to 11,981 in 2005, a loss of more than 2,800 jobs or 19%. This rate of job loss was still below the 25% decline in overall manufacturing employment in the state between 2000 and 2005.

In 2005, there were nearly 55,000 private sector wage and salary jobs in biopharmaceutical-related industries of Massachusetts. The number of payroll employment positions in these industries during 2005 surpassed the previous employment peak that occurred in 2002 when there were 54,044 jobs in these industries. Between 2000 and 2005, over 6,000 net new jobs were added in these three industries, representing a 12.5% growth rate over this five year period. In comparison, total private sector wage and salary employment in Massachusetts fell by 100,000 or 3.5% over the same five-year period.

Table 2:
Changes in Payroll Employment Levels in Biopharmaceutical-Related
Industries of Massachusetts, 2000-2005

Industrial Sector	2000	2005	Absolute Change	Percent Change
Pharmaceutical Preparation Manufacturing	7,656	7,771	115	1.5%
Surgical and Medical Instrument Manufacturing	14,821	11,981	-2,840	-19.1%
Physical, Engineering, and Biological Research	26,369	35,192	8,823	33.4%
Total, Above 3 Industries	48,846	54,944	6,098	12.4%
All Manufacturing Industries	408,532	305,518	-103,014	-25.2%
Total, All Private Sector Industries	2,858,008	2,757,402	-100,606	-3.5%

Source: Quarterly Wage and Employment Surveys, U.S. Bureau of Labor Statistics, tabulations by CLMS.

Trends in Employment, the Number of Establishments, and Workers Per Establishment in Biopharmaceutical-Related Industries of Massachusetts and the U.S.

Knowledge of the magnitude and sources of employment change in a state's industries over time is critical for both economic development and workforce development policymaking and program planning. Employment in an industry can grow over time due to an increase in the number of economic establishments within the industry, to a rise in average employment per establishment, or to some combination of the above two factors. Annual data from the U.S. Census Bureau's County Business Patterns (CBP) allow us to identify trends in employment, payrolls, and the number of establishments within industrial sectors. The CBP published data cover all major and sub-sector NAICS industries at the national, state and local level.³ An economic establishment is defined by the U.S. Census Bureau as a physical facility producing goods and services that is located in a fixed geographic location.⁴ For each industry, information on the number of establishments by employment size class is also provided.

³ The NAICS acronym refers to the North American Industry Classification System that is used by the U.S. Department of Commerce and the U.S. Bureau of Labor Statistics to assign industry codes to each economic establishment.

⁴ Many of the large and medium-sized firms in the biopharmaceutical industry have multiple economic establishments across and within states.

The CBP data were used to identify and assess trends in both the number of establishments and in average employment per establishment for each biopharmaceutical-related industry in Massachusetts and to compare the state's trends for each of these variables with those for the U.S. over the 1998 to 2004 period.

Our definition of biopharmaceutical-related industries includes the following set of industries: pharmaceutical and medicine manufacturing, medical instruments and supplies manufacturing, and research and development in physical, scientific, and biological services. There were 1,142 biopharmaceutical-related industry establishments in Massachusetts in 2004, representing an increase from 1,020 in 1998 and 1,062 in 2001. In relative terms, the number of establishments in biopharmaceutical-related industries increased by 12 percent between 1998 and 2004 (Table 3). The growth rate of economic establishment in these industries in Massachusetts was above average for the state as a whole, but was only three-fourths as high as that for the entire nation during the same time period (16%).⁵ Between 2001 and 2004, biopharmaceutical-related industries in Massachusetts experienced a 7.5 percent increase in the number of establishments versus a growth rate of nearly 10 percent for the entire nation. Massachusetts' share of the national number of establishments in biopharmaceutical-related industries declined modestly from 4.3% to 4.1% over this six-year period.

⁵ According to estimates from Country Business Patterns, the number of private, economic establishments in the state increased by 8,000 or slightly under 5% between 1998 and 2004.

Table 3:
Trends in the Number of Economic Establishments in Biopharmaceutical-Related Industries of Massachusetts and the U.S., 1998-2004

Area	Number of Establishments			Percent Change		
	1998	2001	2004	1998-2001	2001-2004	1998-2004
Massachusetts						
Pharmaceutical and Medicine Manufacturing	70	82	72	17.1	-12.2	2.9
Medical Instrument and Supplies Manufacturing	357	339	312	-5.0	-8.0	-12.6
Research and Development in Physical, Engineering, and Biological Services	593	641	758	8.1	18.3	27.8
All Biopharmaceutical-Related Industries	1,020	1,062	1,142	4.1	7.5	12.0
United States						
Pharmaceutical and Medicine Manufacturing	1,812	1,825	1,833	0.7	0.4	1.2
Medical Instrument and Supplies Manufacturing	12,469	12,151	12,139	-2.6	-0.1	-2.6
Research and Development in Physical, Scientific, and Biological Services	9,650	11,299	13,780	17.1	22.0	42.8
All Biopharmaceutical-Related Industries	23,931	25,275	27,752	5.6	9.8	16.0

Source: County Business Patterns (CBP), U.S. Census Bureau, authors' tabulations.

Growth patterns in the number of economic establishments over the 1998-2004 period varied widely across key industrial segments of the biopharmaceutical sector. The medical instrument and supplies manufacturing industries were the only biopharmaceutical-related sector in Massachusetts experiencing a substantial decline in the number of establishments over the six-year period. A similar growth pattern for this industry prevailed in the U.S. too, but the decline in the number of national establishments in the medical instruments and supplies industry took place at a much more modest pace. The number of establishments involved in medical instrument and supplies manufacturing in Massachusetts declined from 357 in 1998 to 339 in 2001 and even further to 312 in 2004, an overall decline of 13 percent between 1998-2004. The national number of establishments in this industry declined by only 2.6 percent over the

same time period. The number of establishments in pharmaceutical and medicine manufacturing industries in Massachusetts increased from 70 to 72 between 1998 and 2004. The number of establishments in this particular industry in our state grew by 17% over the 1998-2001 period, but then declined by 12% between 2001 and 2004. However, the Massachusetts' establishment growth rate of nearly 3% in pharmaceutical and medicine manufacturing industries over the six year time period was slightly higher than that of the nation (1.2%).

The largest increase in the number of establishments in biopharmaceutical-related industries in Massachusetts occurred in research and development in physical, engineering and biological services' industries. The number of establishments in this research and development services industry increased substantially from 593 in 1998 to 758 in 2004, an absolute gain of 165 establishments, representing a relative increase of 28 percent. However, the growth rate in the number of establishments in Massachusetts in this biopharmaceutical-related sector was lower than the growth rate of establishments in the same set of industries in the U.S. (43% versus 28%).

The Average Number of Workers Per Establishment in Biopharmaceutical-Related Industries of Massachusetts

Estimates of the number of employed workers, both full-time and part-time, in biopharmaceutical-related industries of Massachusetts can be combined with data on the number of economic establishments to estimate the mean number of workers per establishment for all biopharmaceutical-related industries combined and for individual industries.⁶ The following types of questions can be answered with these data.

What was the average level of employment per establishment in biopharmaceutical-related industries of Massachusetts and how did the average employment levels of biopharmaceutical-related firms compare with those of establishments in other major industries in our state? Has average employment in these establishments experienced any growth in Massachusetts over the 1998-2004 period?

⁶ The employment counts from the CBP surveys include corporate executives on the payrolls of these firms and persons on paid vacation/sick leave.

How has the growth of average employment in biopharmaceutical-related establishments in Massachusetts compared with that of other industries across the state?

Table 4 displays the rankings of major industries by average employment per establishment in Massachusetts in 2004. The average employment size of establishments in Massachusetts' biopharmaceutical-related industries was 45 in 2004. For all private sector industries in the state, average employment per establishment was only 17. To place these findings in comparative perspective, we also compared biopharmaceutical-related industries' average employment per establishment with those of 19 other major industries in Massachusetts in 2004. Among the 20 major industries, the average employment per establishment in Massachusetts was third highest in biopharmaceutical-related industries (Table 4). The two industrial sectors with a higher average employment per establishment were management of companies & enterprises with 83 employees per establishment and educational services with 74 employees per establishment.

Table 4:
Rankings of Major Private Sector Industries by Their Average
Employment Per Establishment in Massachusetts, 2004

Rank	Industry	Average Employment Per Establishment
1	Management of companies & enterprises	83
2	Educational services	74
3	<i>Biopharmaceutical-Related Industries</i>	45
4	Utilities	43
5	Manufacturing	36
6	Health care and social assistance	28
7	Information	27
8	Finance & insurance	22
9	Transportation & warehousing	22
10	Admin, support, waste management, remediation services	20
11	Wholesale trade	16
12	Accommodation & food services	16
13	Arts, entertainment & recreation	15
14	Retail trade	14
15	Mining	13
16	Professional, scientific & technical services	11
17	Real estate & rental & leasing	7
18	Other services (except public administration)	7
19	Construction	7
20	Forestry, fishing, hunting, and agriculture support	3
	All Industries	17

Source: County Business Patterns (CBP), U.S. Census Bureau, authors' tabulations.

Average (mean) employment in biopharmaceutical-related establishments in Massachusetts has been trending upward in recent years, rising from 40 workers per establishment in 1998 to 41 in 2001 and to 45 in 2004, an increase of 5 workers per establishment or 12.5%. Massachusetts' trends in average establishment employment in biopharmaceutical-related industries were in close accord with those for the entire U.S. over the same time period. Average employment per establishment in the U.S. increased from 33 to 41 over this six year period, a relative gain of 24%. Average employment per establishment grew in both time periods in the U.S.

The three biopharmaceutical-related industries in Massachusetts were characterized by large differences in average employment per establishment and in

growth rates of average employment per establishment over the 1998-2004 period. The pharmaceutical/medicine manufacturing industries were characterized by a considerably higher average number of workers per establishment in both 1998 and 2004. Average employment during 2004 in establishments in pharmaceutical and medicine manufacturing industries of Massachusetts was 122 versus only a mean of 42 workers in research and development service industries and 36 workers per establishment in medical instruments and supplies manufacturing. A similar set of average employment size patterns prevailed for these industries in the U.S., with pharmaceutical manufacturing establishments employing more than five times as many workers as establishments in medical instrument and supplies manufacturing (134 vs. 25).

Massachusetts' Competitive Ranking Among the 50 States with Respect to Employment, Payrolls, and Other Key Characteristics of Biopharmaceutical-Related Industries in the State

Our study of biopharmaceutical-related industries in Massachusetts identified the levels of employment in these industries in Massachusetts, growth in employment in these industries over the past decade, the export-orientation of these industries in the Commonwealth, and compared Massachusetts' findings with those for the nation.⁷ It is equally important to identify how well Massachusetts fares in comparison to all other states on an array of measures of the economic performance of biopharmaceutical industries and economic competitiveness factors that would be expected to influence the state's ability to attract and retain firms in biopharmaceutical-related industries in the future.

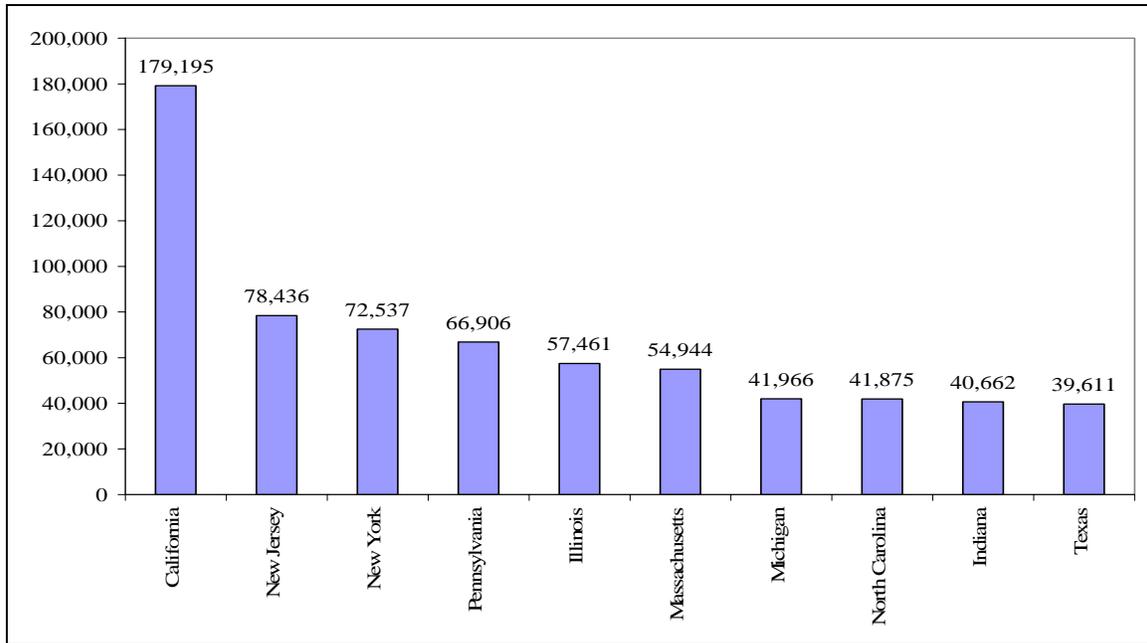
Biopharmaceutical-Related Employment Levels Across States in 2005

To identify Massachusetts' comparative ability to generate jobs in biopharmaceutical-related industries, we analyzed wage and salary employment data for such industries in all 50 states and the District of Columbia. The findings of the Quarterly

⁷ See: (i) Andrew Sum, Ishwar Khatiwada and Joseph McLaughlin, Employment Trends in Biopharmaceutical-Related Industries in Massachusetts and the U.S., Research Brief # 1, Report prepared for PhRMA by the Center for Labor Market Studies, Northeastern University, December 2006; (ii) Ishwar Khatiwada and Andrew Sum, Export Orientation of Jobs in Biopharmaceutical-Related Industries in Massachusetts and the U.S., Research Brief # 2, Report prepared for PhRMA by the Center for Labor Market Studies, Northeastern University, December 2006.

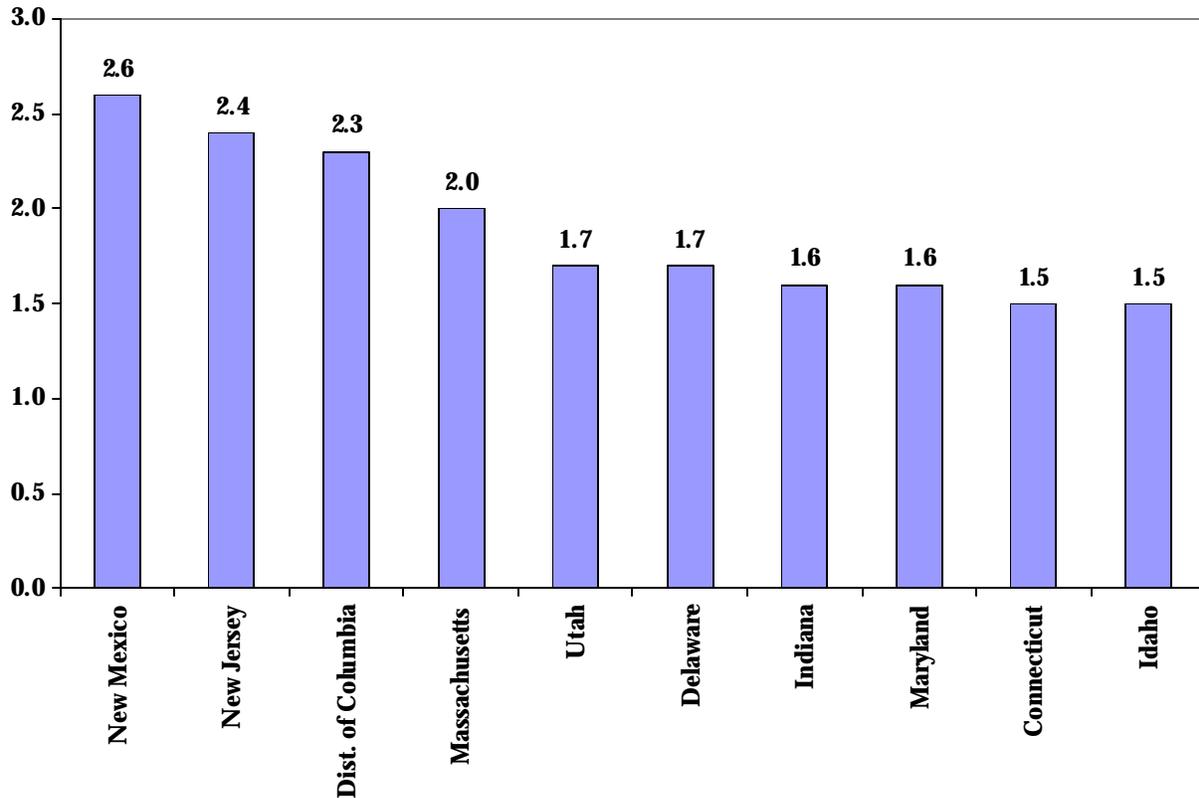
Census of Employment and Wages (QCEW) revealed that nearly 55,000 wage and salary workers in Massachusetts were employed in biopharmaceutical-related industries in 2005. Among all 50 states and the District of Columbia, Massachusetts' ranking with respect to the total number of biopharmaceutical-related jobs was 6th highest in 2005 (Chart 1). The five states in 2005 with a higher number of wage and salary jobs in biopharmaceutical-related industries were California (176,361), New Jersey (81,719), New York (70,202), Pennsylvania (66,888) and Illinois (68,870). Massachusetts' ranking on this jobs measure in 2005 was the same as it was in 2001. Given its far greater economic size, the state of California clearly dominated Massachusetts in terms of the absolute number of biopharmaceutical jobs with three times as many such jobs as Massachusetts. As will be revealed below, however, Massachusetts outperforms California in terms of the share of all wage and salary jobs in biopharmaceutical-related industries. Among the three major such industries, Massachusetts ranking in 2005 in terms of the absolute number of biopharmaceutical jobs was 11th highest in pharmaceutical and medicine manufacturing, 8th highest in medical equipment and supplies manufacturing, and second highest in physical, engineering and biological research service industry employment.

Chart 1:
Top 10 States with the Highest Number of Biopharmaceutical-Related
Wage and Salary Jobs in 2005



Since states vary considerably with respect to the aggregate number of wage and salary jobs and residents, a more appropriate comparison would rank states on the number of biopharmaceutical jobs as a percent of total jobs. The number of biopharmaceutical-related industry jobs in Massachusetts accounted for approximately 2 percent of all private sector wage and salary jobs in 2005, and the state ranked 4th highest among the 50 states in 2005 on this jobs measure (Chart 2). The share of jobs generated by biopharmaceutical-related industries in Massachusetts rose from 1.8% in 2001 to 2.0% in 2005. New Mexico had the highest share of biopharmaceutical-related industry jobs (2.6%) followed by New Jersey (2.4%) and the District of Columbia (2.3%). Among the three major biopharmaceutical-related industries, Massachusetts' ranking on this jobs measure was 11th highest in pharmaceutical and medicine manufacturing industries, 8th highest in medical instrument and supplies manufacturing, and 4th highest in physical, engineering and biological research service industries. Clearly, Massachusetts is a national leader in its ability to generate biopharmaceutical industry jobs.

Chart 2:
Top 10 States Ranked by Their Biopharmaceutical-Related Industries’
Share of Total Private Sector Wage and Salary Jobs in 2005

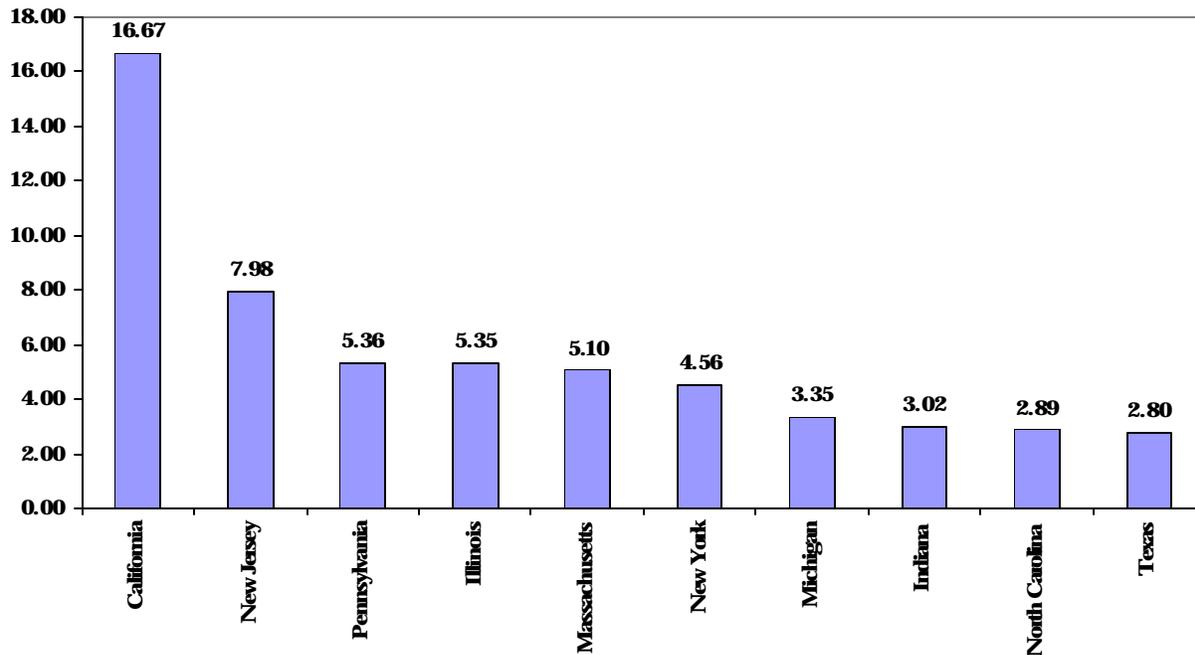


Payroll Measures of Economic Performance For Biopharmaceutical-Related Industries Across States

Another important measure of an industry’s contribution to a state’s economy is the size of its annual payroll. The QCEW data base provides information on wage and salary payments of industries. The payments represent the aggregate payroll for wage and salary workers on the formal payrolls of the firms in these industries. The annual payroll of \$5.10 billion in 2005 in biopharmaceutical-related industries in Massachusetts was the 5th highest among the 50 states and the District of Columbia. (Chart 3). On this performance measure, Massachusetts was only outpaced by California (\$16.67 billion), New Jersey (\$7.38 billion), Pennsylvania (\$5.36 billion), and Illinois (\$5.35 billion). The high payroll per worker in the state’s biopharmaceutical industries is also important since it will be a key determinant of the multiplier impacts of the industry by generating spending by workers on local goods and services. Within the three major biopharmaceutical industries, Massachusetts’ payroll ranking was 10th highest in pharmaceutical

and medicine manufacturing, 8th highest in medical equipment and supplies manufacturing, and biological research service industries.

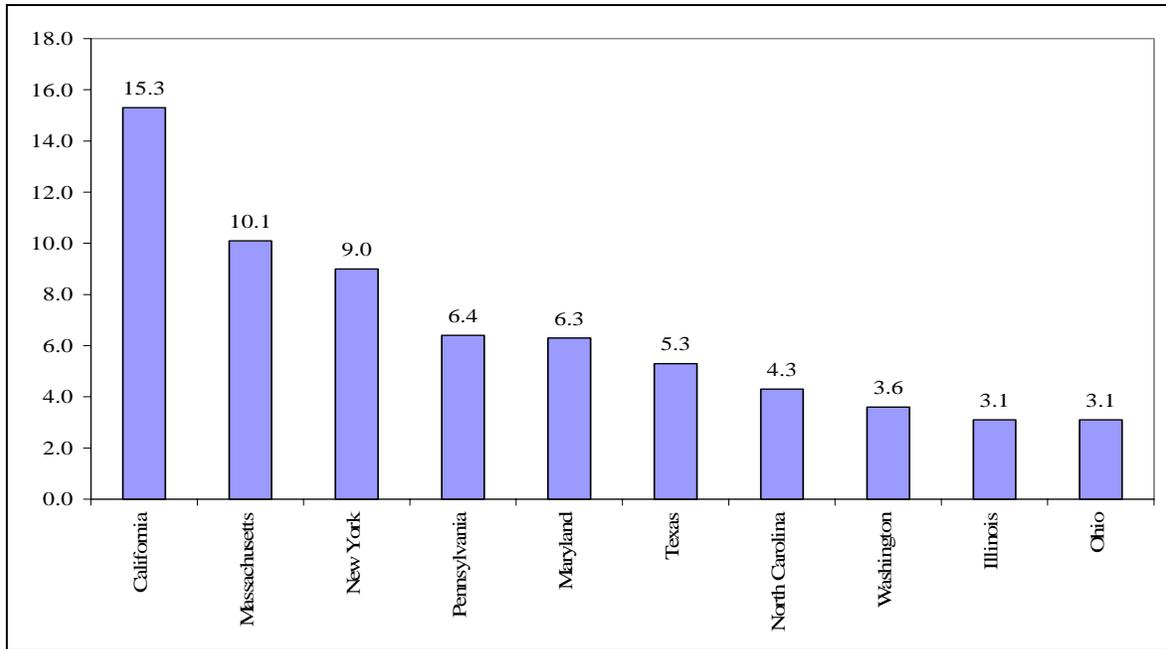
Chart 3:
Ten States With the Largest Aggregate Payrolls in Biopharmaceutical-Related Industries, 2005
(In Billions of Dollars)



Massachusetts’ Share of NIH Research Grants and New Patents Awarded to Biopharmaceutical-Related Industries, 2000-2005

Two additional measures of economic competitiveness are a state’s ability to attract national research monies and to obtain patents for inventions. Massachusetts obtains a large chunk of National Institute of Health (NIH) funding grants for research and development. These grants include research grants, training grants, fellowship grants, R&D contracts, and other grants. Between 2000 and 2005, Massachusetts obtained a total of \$11.8 billion dollars in such grants. In 2005, the value of these grants from NIH to Massachusetts was equal to \$2.27 billion, accounting for 9.8% of all total grants disbursed by the NIH across the country. Massachusetts’ ranking on the share of NIH grants received by states was second highest among the 50 states. Only California obtained a level of NIH funding that was higher than Massachusetts’ NIH grants. In per worker and per capita terms, Massachusetts substantially outperformed the other states across the nation on this measure (Chart 4).

Chart 4:
Top Ten States with the Largest Percentage Share of
NIH Grants Obtained Between 2000-2005



The U.S. Patent and Trademark Office (USPTO) keeps records of the number of patents for inventions that were granted during a calendar year for each state. The patents data are classified under the U.S. Patent Classification System (USPCS), which according to USPTO contains 470 total classes and 155,000 total subclasses. Data from USPTO can be analyzed to identify the states that generate new inventions from their R&D sector. It can be reasonably hypothesized that states, such as Massachusetts, with relatively higher human capital endowments combined with a supportive infrastructure will spew forth a larger number of inventions.

How has Massachusetts fared in comparisons to other states in obtaining patents for its inventions? Of all awarded patents for inventions, what share of patents for inventions were from biopharmaceutical-related industries? To answer these questions, we aggregated 12 categories of patents data for each state that closely matched the products of our biopharmaceutical-related industries. Table 5 displays our definition of biopharmaceutical-related industry patents.

Table 5:
CLMS Listing of Biopharmaceutical-Related Industries' Products Patents Classification

- | |
|---|
| <ol style="list-style-type: none">1. Class 128 - Surgery2. Class 422- Chemical Apparatus and Process Disinfecting, Deodorizing, Preserving, or Sterilizing3. Class 424 - Drug, Bio-Affecting and Body Treating Compositions (includes Class 514)4. Class 430- Radiation Imagery Chemistry: Process, Composition, or Product Thereof5. Class 435- Chemistry: Molecular Biology and Microbiology6. Class 436- Chemistry: Analytical and Immunological Testing7. Class 601- Surgery: Kinesitherapy8. Class 602- Surgery: Splint, Brace, or Bandage9. Class 604- Surgery (Medicators and Receptors)10. Class 606- Surgery (instruments)11. Class 607- Surgery: Light, Thermal, and Electrical Application12. Class 623- Prosthesis (i.e., Artificial Body Members), Parts Thereof, or Aids and Accessories Therefore |
|---|

Source: The U.S. Patent and Trademark Office, authors' classifications for biopharmaceutical-related industries.

Massachusetts obtained a total of 17,970 patents between 2001 and 2005, ranking 5th highest among all 50 states and the District of Columbia on this aggregate patents measure. Of these total patents, 4,483 involved biopharmaceutical-related industry patents. Nearly 8 percent of all such industry invention patents were obtained by the state during the 2001-2005 period (Table 6). California had the highest share of biopharmaceutical-related industry patents (25.4%) followed by Massachusetts (7.9%), New York (6.6%), New Jersey (5.7%) and Minnesota (5.3%).

Table 6:
Top Ten States with the Highest National Share of Invention Patents Obtained in
Biopharmaceutical-Related Industries, 2001-2005

Rank	State	Biopharmaceutical- Related Industries' Patents	Percent Share of All Such Patents
1	California	14,474	25.4%
2	Massachusetts	4,483	7.9%
3	New York	3,781	6.6%
4	New Jersey	3,230	5.7%
5	Minnesota	3,045	5.3%
6	Pennsylvania	2,891	5.1%
7	Maryland	2,124	3.7%
8	Texas	2,001	3.5%
9	Florida	1,779	3.1%
10	Ohio	1,647	2.9%
	All 50 States and the D.C.	56,840	100.0%

Source: The U.S. Patent and Trademark Office, tabulations by authors.

The total number of invention patents awarded over the 2001-2005 period was 421,254. Patents in biopharmaceutical-related industries accounted for 56,840 or 13% of all such patents. The share of a state's patents that were biopharmaceutical-related varied considerably by state, with Massachusetts being a national leader in this area. One quarter of the total number of invention patents received by Massachusetts were in this industrial category. Massachusetts ranked second highest among the 50 states on this patent measure. Only the state of Maryland had a share of invention patents in biopharmaceutical-related industries that was higher than that of Massachusetts (31% versus 25%).

Employment Projections for Biopharmaceutical-Related Industries and Occupations in Massachusetts, 2004-2014

To better understand the potential future employment impacts of biopharmaceutical-related industries in the Commonwealth of Massachusetts, we have analyzed findings of state employment projections from the Massachusetts Department of

Workforce Development for the 2004 to 2014 period by industry and occupation.⁸ Overall, the Massachusetts economy is expected to add 247,210 net new nonfarm wage and salary jobs between 2004 and 2014, representing an employment growth rate of just under 8 percent (Table 7).

Table 7:
Wage and Salary Employment Projections by Major Industry Sector,
Massachusetts, 2004-2014

Industry Sector	2004	2014	New jobs	Growth Rate (in %)
Total Non-Farm	3,181,120	3,428,330	247,210	7.8
Natural Resources and Mining	1,900	1,810	-90	-4.7
Construction	138,400	134,480	-3,920	-2.8
Manufacturing	312,930	281,210	-31,720	-10.1
Trade, Transportation, and Utilities	572,110	597,510	25,400	4.4
Information	87,440	97,820	10,380	11.9
Financial Activities	219,730	230,590	10,860	4.9
Professional and Business Services	451,080	538,190	87,110	19.3
Educational and Health Services	582,210	676,660	94,450	16.2
Leisure and Hospitality	290,800	325,450	34,650	11.9
Other Services	116,820	128,230	11,410	9.8
Government	407,700	416,380	8,680	2.1

Source: Massachusetts Department of Workforce Development.

Projected employment growth in Massachusetts varies quite widely across major industrial sectors of the state. Wage and salary employment declines are expected to occur in industries such as natural resources and mining, construction, and manufacturing. Unfortunately, the state's manufacturing industries will account for a dominant share (89%) of the gross number of employment losses in the state. About 31,720 manufacturing jobs are projected to disappear between 2004 and 2014, a decline of 10.1%, further eroding an important element of the state's export base. The construction industry, a source of strong job growth in the 1990s, is projected to experience a decline of 3,920 jobs or 2.8% between 2004 and 2014.

⁸ See: Massachusetts Department of Workforce Development, Massachusetts Employment Projections Through 2014 by Industry and Occupation, Boston, 2006.

Each of the state's other major industrial sectors are expected to expand their employment base over the decade although projected growth rates vary quite considerably across major industries. Professional and business services and the educational and health services industries are projected to grow at 19.3% and 16.2%, respectively, growth rates well above the state average. Information, leisure and hospitality, and other service industries are projected to experience employment growth rates between 10% and 12%.

A more detailed analysis of employment projections for specific biopharmaceutical-related industries in Massachusetts is presented in Table 8. The biopharmaceutical-related industries, which include the scientific research and development services, medical equipment and supplies manufacturing, and pharmaceutical and medicine manufacturing industries, are expected to generate 12,011 net new jobs between 2004 and 2014, representing a growth rate of slightly above 21%, three times the projected growth rate of total nonfarm employment in the state.

The scientific research and development sector alone is expected to create 9,790 new jobs, accounting for 80% of the new jobs in the biopharmaceutical-related sector.⁹ Employment growth in this sector will be primarily driven by the biotechnology and academic sector which is heavily dependent on government and private sector research grants. The pharmaceutical and medicine manufacturing industries are projected to add over 1,700 jobs, representing a growth rate of 25.2 percent between 2004 and 2014. Employment in medical equipment and supplies manufacturing industries will grow at a much more modest 3.7 percent pace, generating only 470 new jobs by 2014, but this would represent an improvement over their job creation performance in recent years.

⁹ Because of limitations on disaggregations of the industry employment projections data, we were unable to separate the Scientific Research and Development Services industry sector into the two subsectors that constitute this industry: Research and Development in the Physical, Engineering, and Life Sciences and Research and Development in the Social Sciences and Humanities. The latter subsector contains jobs that are not related to the bio-pharmaceutical sector.

Table 8:
Projected Wage and Salary Employment Growth in Biopharmaceutical-Related
Industries in Massachusetts, 2004-2014

Industry Sector	2004	2014	Net New jobs	Growth Rate (in %)
Scientific research and development services	36,600	46,390	9,790	26.7
Medical equipment and supplies manufacturing	12,800	13,270	470	3.7
Pharmaceutical and medicine manufacturing	6,949	8,700	1,751	25.2
Total Above 3 Biopharmaceutical-Related Industries	56,349	68,360	12,011	21.3
Manufacturing, All	312,930	281,210	-31,720	-10.1
Total NonFarm	3,181,120	3,428,330	247,210	7.8

Source: Massachusetts Employment Projections through 2014, Massachusetts Department of Workforce Development, 2006.

We also conducted an analysis of employment projections for selected occupations in Massachusetts to identify the employment outlook for those occupations that accounted for a very high share of employment in the state's biopharmaceutical-related industries. Using data from the 2005 American Community Surveys (ACS), we have identified the top 16 individual occupations that accounted for 50 percent of total employment in the biopharmaceutical-related industries of Massachusetts in 2005 (Table 9).

Table 9:
Occupational Distribution of Jobs in Massachusetts' Biopharmaceutical-Related Industries, Selected Top Sixteen Occupations, 2005

Occupation	Number of Jobs	% of Total Employment in Biopharmaceutical Industries
Physical Scientists, all other	3,746	6.0
Managers, All Other	3,693	5.9
Medical Scientists, Except Epidemiologists	3,223	5.1
Miscellaneous Assemblers and Fabricators	2,916	4.6
Miscellaneous Engineers	1,927	3.1
First-Line Supervisors/Managers of Production and Operating Workers	1,782	2.8
Inspectors, Testers, Sorters, Samplers, and Weighters	1,774	2.8
Chemist and material scientists	1,731	2.8
Life, Physical, and Social Science Technicians, Other	1,594	2.5
Biological Scientists	1,540	2.5
Marketing and sales Managers	1,447	2.3
Chemical Technicians	1,367	2.2
Engineering Technicians, Except Drafters	1,286	2.1
Secretaries and Administrative Assistants	1,259	2.0
Sales Representatives, wholesale and manufacturing	1,063	1.7
Computer Software Engineers	988	1.5

Source: American Community Surveys (ACS) 2005, U.S. Census Bureau, tabulations by authors.

Given the levels of employment and educational characteristics of workers in these 16 individual occupations which accounted for 50 percent of all jobs in biopharmaceutical-related industries, we can see that employment in these industries is dominated by occupations that require a relatively high level of education and training. With the exception of the two production occupations (assemblers and fabricators; inspectors, testers, sorters, samplers) and two office related occupations, (secretaries and administrative assistants), the rest of the occupations are in fields in which a four year college degree and/or significant work experience is required for entry into employment.

We also have analyzed the projected employment outlook for the above sixteen occupations for the entire state of Massachusetts for the 2004-2014 period. This analysis is based on employment projections by occupation for the state provided by the Massachusetts Department of Workforce Development. The projected employment

growth rates for the above occupations vary quite widely, ranging from projected declines of -10% and -4% in production-related occupations to highs well above the state average of 8%. Engineering and life, physical and social science occupations are projected to grow at rates between 10 percent and 31 percent. Medical scientists are projected to grow at a 31% rate between 2004 and 2014, the highest growth rate across all biopharmaceutical-related occupations, followed by biological scientists with a projected growth rate of 23 percent. A total net increase of 25,590 new jobs in all industries of the state will be created by the sixteen occupations presented in Table 9. An additional 40,000 job openings in all industries are expected in these same 16 occupations due to the need for companies to replace workers that are expected to retire, die or change careers.

Job Vacancies in Biopharmaceutical-Related Occupations in Massachusetts, 2006 II Quarter

The availability of information on the numbers, characteristics, and geographic locations of available job openings by industry and occupational area across the state is crucial to help identify the degree of labor shortage or surplus in industries and occupational groups at a given point in time and over time. The Commonwealth of Massachusetts' Department of Workforce Development has been conducting a semi-annual job vacancy survey since 2002.¹⁰ The Massachusetts job vacancy survey provides data on the estimated number of job vacancies and job vacancy rates for the state as a whole and for major industrial sectors and major occupational groups in the state. Job vacancies represent currently available job openings in the firm for which the employer is making an active effort to recruit applicants from outside the firm. Positions for consultants, independent contractors, and other non-employee positions are excluded from the count of job vacancies.¹¹ The job vacancy rate for a given occupational group is calculated by taking the ratio of the number of job vacancies in a given occupation to the total number of employed persons in that occupation (V/E).

¹⁰ For a review of job vacancy concepts, measures, and their uses at the national level in the JOLTS survey, See: Kelly A. Clark and Rosemary Hyson, "New Tools for Labor Market Analysis: JOLTS," Monthly Labor Review, December 2001, pp. 32-37.

¹¹ The Massachusetts job vacancy survey is conducted during the second and fourth quarters of each calendar year. For details on the design features and outputs of the job vacancy survey, see the website of the Massachusetts Department of Workforce Development.

While the job vacancy survey does provide estimates of job vacancies for major industries, it does not provide published estimates for industries at a fine enough level of industrial detail to estimate vacancies for biopharmaceutical-related industries. As an alternative, we have selected a set of individual occupations closely related to the biopharmaceutical sector and analyzed data on job vacancy levels and rates for those occupations provided by the Massachusetts Department of Workforce Development for the second quarter of 2006. Estimates are presented in Table 10. Total job vacancies across all occupations in the second quarter of 2006 were estimated to be over 86,000, representing an overall job vacancy rate of 3.0%. The vacancy rate has risen steadily over the past three years as employment growth resumed across the state and the resident labor force failed to grow.

Table 10:
Job Vacancy Levels and Vacancy Rates for Selected Biopharmaceutical-Intensive Occupations in Massachusetts, 2006 II

	Vacancies	Vacancy Rate (in %)
All Occupations	86,296	3.0
Medical Scientists, excluding epidemiologists	574	12.0
Biochemists and Biophysicists	157	10.3
Chemists	222	7.8
Marketing Managers	457	6.6
Industrial Engineers	392	6.2
Computer Software Engineers, Applications	1,197	5.6
Biomedical Engineers	55	4.1
Sales Managers	422	3.9
Computer Systems Analysts	575	3.5
Exec. Secretaries & Admin. Assistants	1,311	3.0
Sales Reps, Wholesale & Manufacturing, Technical & Scientific	235	1.3
Biological Technicians	37	1.0
Chemical Technicians	16	0.8

Job vacancy rates varied quite considerably across occupational category during the second quarter of 2006. Medical scientists registered a considerably above average job vacancy rate in the 2nd quarter of 2006 at 12.0%, followed closely by biochemists and biophysicists with a job vacancy rate of 10.3%. These two occupations registered job vacancy rates that were three to four times as high as the state average. Other occupations

closely related to the biopharmaceutical sector with relatively high job vacancy rates were the following: chemists (7.8%), marketing managers (6.6%), industrial engineers (6.2%), computer software engineers (5.6%), and biomedical engineers (4.1%). Each of these occupations had job vacancy rates that were between 1 and 3 percentage points higher than the state average for all occupations.

The existence of high vacancy rates for a number of occupations that are closely linked to the state's biopharmaceutical-related industries suggests that there are important opportunities for workforce development programs to boost employment and output in these industries. Available evidence on unemployment rates for workers in these same occupations indicates that there are relatively few unemployed workers with skills in these occupations in the state. An expansion of job training programs and post-secondary educational programs aimed at preparing currently unemployed and future workers for these occupations could help expand employment and output levels in these key export-based industries of the state. Future research on the educational and skill requirements for workers in these occupations and institutional constraints on future supply is needed.

The Geographic Concentration and Export Orientation of Biopharmaceutical-Related Industries in Massachusetts

In accord with the core elements of export base theory, the economic impact of an industry on a state or local economy is highly dependent on whether it is an "export-based" industry selling its goods or services outside of the state or a "local industry" serving the needs of resident households and businesses in local markets in the state. To identify the degree of the export base orientation of the state's biopharmaceutical-related industries, we estimated the concentration of these related industries in Massachusetts compared to the nation as a whole. Do biopharmaceutical-related industries in Massachusetts employ a greater share of the state's workforce than the nation does? Alternatively, is employment of biopharmaceutical-related industries in Massachusetts "basic" or export based or is it primarily "local" industry? To answer these key questions, we have used the location quotient (LQ) technique in conducting our analysis. The LQ technique in urban economics is widely used in economic geography and locational analysis. The value of a location quotient represents the ratio of an industry's share of

state employment to the industry's share of national employment. With the findings from the location quotient analysis, we will be able to identify the comparative degree of specialization in Massachusetts' biopharmaceutical industries and to determine whether these industries in Massachusetts accounted for a greater share of employment in the state's economy than they did in the U.S. economy.

Table 11 displays our estimates of the values of the location quotients for the three individual biopharmaceutical-related Massachusetts industries and for all three industries combined during 2001 and 2005. The share of employment in all biopharmaceutical industries combined in Massachusetts was higher than the national share in both years. The state's share of national employment in two of the three biopharmaceutical industries were rising over this time period. Controlling for brand differences in the mix of products in these industries would raise the location quotient for each of them. The share of pharmaceutical and medicine manufacturing industry employment in Massachusetts was 8.2% higher than the national share. The relatively low value of the location quotient for pharmaceutical and medicine manufacturing industries in Massachusetts is somewhat puzzling given the significant worldwide importance of this industry in Massachusetts. A high share of the output of these industries is exported outside the state, suggesting the importance of brand differences in classifying exports. Employment in medical instruments and supplies manufacturing in Massachusetts was nearly 59% higher than the national share in 2005. Employment in medical instrument and supplies manufacturing industries in Massachusetts, however, has declined somewhat in recent years. Despite the declining employment in this sector nationwide, experts are optimistic that this sector has substantial growth potential and will continue to exist as an important industry in Massachusetts similar to expectations for the other two biopharmaceutical industries. Given the steep deterioration in employment in the state's manufacturing sector over the 2000-2005 period, the medical instrument device and supplies manufacturing sector has experienced only modest declines in employment in Massachusetts.

Table 11:
Location Quotients (LQ) for Biopharmaceutical-Related
Industries in Massachusetts, 2001 and 2005

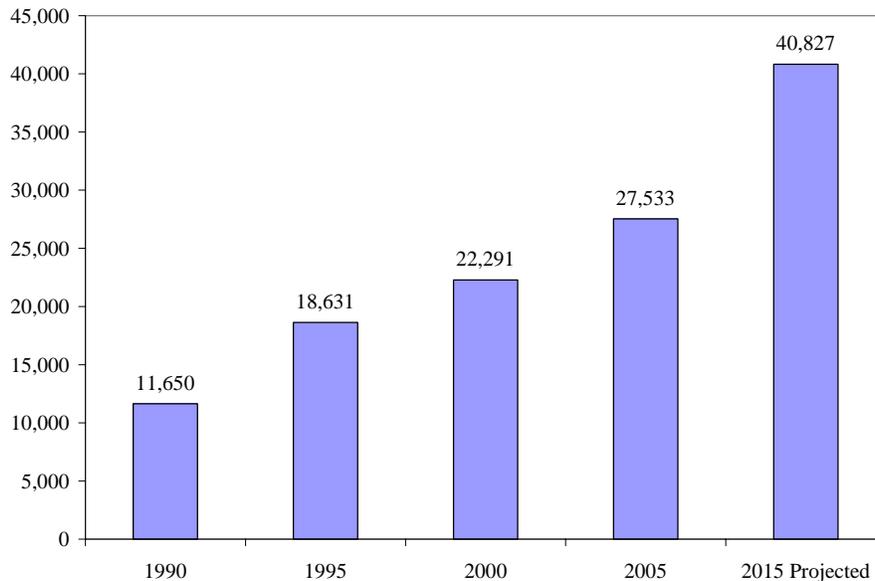
Industry	2001	2005
Pharmaceutical and Medicine Mfg. Industry (NAICS 3254)	1.061	1.082
Medical Instrument and Supplies Mfg. Industry (NAICS 3391)	1.834	1.587
Research and Development in the Physical, Engineering and Life Sciences (NAICS 54171)	2.417	2.775
All Biopharmaceutical-Related Industries Combined	1.883	2.004

Note: Data sources for these estimates are the Quarterly Census of Employment and Wages (QCEW). Only private sector employment is included in the LQ analysis.

For all biopharmaceutical industries combined in Massachusetts, the value of the location quotient was consistently much greater than 1. When the location quotient is greater than 1, we can estimate the number of jobs that were “export” based in such industries in Massachusetts. The number of biopharmaceutical industry jobs in Massachusetts over and above the expected number of jobs in the same industry in the state based on national ratios are considered to be basic or “export” jobs. These export jobs in bio-pharmaceutical industries produce goods and services for sale to other states or other countries around the world.

Basic employment in biopharmaceutical-related industries in Massachusetts has been growing at an annual rate of nearly 6% since 1990. CLMS analysis indicates that there were 11,650 export-based jobs in such industries in Massachusetts in 1990, but the number had increased to 27,533 in 2005, an absolute gain of nearly 16,000 basic sector jobs, representing a relative increase of 137% (Chart 5). No other major industry in Massachusetts has experienced such an impressive growth rate in basic sector jobs during this time period. The annual growth rate of employment in bio-pharmaceutical-related industries in Massachusetts between 2000-2005 was 4%. If this industry maintains the same growth rate over the next 10 years, the biopharmaceutical industry in Massachusetts will have nearly 41,000 export jobs in 2015. The gain in export-based employment in Massachusetts’ biopharmaceutical industries was partly attributable to the relocation of global biopharmaceutical companies to articulate and the establishment of new biopharmaceutical-related companies in Massachusetts.

Chart 5:
Trends in Basic or “Export” Wage and Salary Employment in Biopharmaceutical-Related Industries in Massachusetts, 1990-2005 and Projected 2015



Source: NAICS based Quarterly Census of Employment and Wages (QCEW), U.S. Bureau of Labor Statistics, tabulations by authors.

Trends in the Value of Shipments/Receipts of Biopharmaceutical-Related Industries in Massachusetts and the U.S. Over the 1997-2002 Period

Another key indicator for gauging the economic performance of biopharmaceutical-related industries in Massachusetts involves trends in the value of shipments/receipts generated by these industries with those of all other industries in the state and with similar industries in the nation and all other states across the country.¹² How much growth took place in the value of shipments/receipts in biopharmaceutical-

¹² The value of shipments, according to the U.S. Census Bureau’s definition, includes, “the received or receivable net selling values, Free on Board (FOB) plant (exclusive of freight and taxes), of all products shipped, both primary and secondary, as well as all miscellaneous receipts, such as receipts for contract work performed for others, installation and repair, sales of scrap, and sales of products bought and sold without further processing. Included are all items made by or for the establishments from material owned by it, whether sold, transferred to other plants of the same company, or shipped on consignment. The net selling value of products made in one plant on a contract basis from materials owned by another was reported by the plant providing the materials”. For the professional, scientific, and technical services industry, sales revenue means “receipts/revenue”, which, according to the Census Bureau’s definition, “includes gross receipts from customers or clients for services provided, from the use of facilities, and from merchandise sold in 2002 whether or not payment was received in 2002. Receipts do not include sales and other taxes collected directly from customers and paid directly to a local, state, or federal tax agency.

related industries in our state and across the country between 1997 and 2002? How did growth rates in the value of shipments/receipts in the state's biopharmaceutical-related industries compare to those of other major industrial sectors across the state? To provide answers to these key questions, we analyzed shipments/receipts data for biopharmaceutical related industries in Massachusetts and the U.S. that were produced by the U.S. Census Bureau's Economic Censuses of 1997 and 2002.

Table 12 displays the nominal value of the shipments/receipts of biopharmaceutical-related industries operating in Massachusetts during the 1997-2002 period. The nominal value of shipments in these industries of Massachusetts increased from \$6.7 billion in 1997 to \$11.2 billion in 2002, an increase of \$4.47 billion or 66.5%. Growth in the nominal value of shipments of all biopharmaceutical-related industries combined in Massachusetts outpaced the U.S. growth rate in these three same industries over the same time period (66.5% versus 52.9%). In Massachusetts, the growth rates of the value of shipments over the 1997-2002 period ranged from 53% in medical instrument and supplies manufacturing, to 71% in pharmaceutical and medicine manufacturing, to a high of 73% in research and development in the physical, engineering and life sciences service industry.

Table 12:
Trends in the Nominal Value of Shipments/Receipts in Biopharmaceutical Related Industries in Massachusetts and the U.S., 1997-2002 (In 1,000)

	1997	2002	Absolute Change	% Change
Massachusetts				
Pharmaceutical and Medicine Mfg. Industry (NAICS 3254)	\$2,124,000	\$3,632,725	\$1,508,725	71.0
Medical Instruments and Supplies Mfg. Industry (NAICS 3391)	\$2,008,850	\$3,072,093	\$1,063,243	52.9
Research and Development in the Physical, Engineering and Life Sciences (NAICS 54171)	\$2,595,285	\$4,496,928	\$1,901,643	73.3
All Biopharmaceutical Industries Combined	\$6,728,135	\$11,201,746	\$4,473,611	66.5
United States				
Pharmaceutical and Medicine Mfg. Industry (NAICS 3254)	\$92,932,786	\$140,557,276	\$47,624,490	51.2
Medical Instruments and Supplies Mfg. Industry (NAICS 3391)	\$44,893,840	\$61,928,760	\$17,034,920	37.9
Research and Development in the Physical, Engineering and Life Sciences (NAICS 54171)	\$34,145,927	\$60,453,069	\$26,307,142	77.0
All Biopharmaceutical Industries Combined	\$171,972,553	\$262,939,105	\$90,966,552	52.9

Source: 1997 and 2002 Economic Censuses, U.S. Census Bureau, tabulations by authors.

Biopharmaceutical-related industries in Massachusetts were the fastest growing industries in terms of the value of shipments. No other Massachusetts industry experienced a growth rate in the value of shipments over the 1997-2002 period that surpassed the growth rate of biopharmaceutical-related industries on this key economic measure in Massachusetts (Table 13). Despite the absence of aggregate nominal revenue growth in the overall manufacturing sector, both the pharmaceutical/medicine manufacturing industry and the medical instrument and supplies manufacturing industry experienced high rates of increase in the nominal value of their shipments/receipts¹³. Thus, biopharmaceutical-related manufacturing industries' performance on this output

¹³ Due to declining prices for a number of manufactured products, the real value of the output produced by the state's manufacturing industries rose between 1997 and 2002.

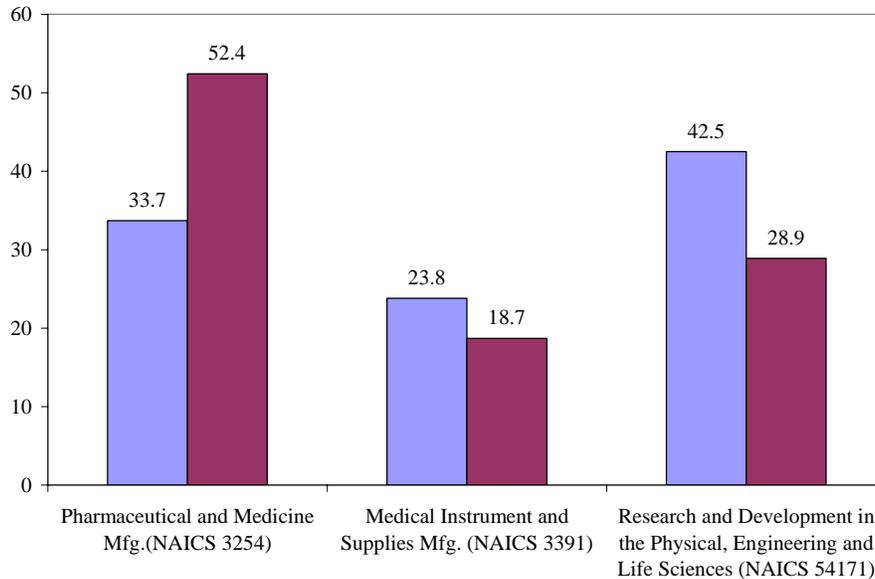
measure was considerably above the average for all manufacturing industries in the state. Massachusetts' trend was consistent with that of the U.S. economy.

Table 13:
Growth Rates of the Nominal Value of Shipments/Receipts by Major Private Sector
Industries in Massachusetts and the U.S., 1997-2002

Industry	MA	U.S.
Biopharmaceutical-Related Industries	66.5	52.9
Construction	52.6	40.6
Manufacturing	0.1	2.1
Wholesale trade	12.8	14.2
Retail trade	26.1	24.1
Transportation & warehousing	25.8	20.1
Real estate & rental & leasing	42.4	39.3
Professional, scientific, & technical services	54.8	45.8
Adm., support, waste management, remediation services	29.3	34.3
Educational services	20.1	50.2
Health care & social assistance	36.3	36.8
Arts, entertainment, & recreation	43.6	35.5
Accommodation & food services	27.0	28.3
Other services (except public administration)	23.0	13.6

The share of the nominal value of shipments/receipts of each of the three biopharmaceutical-related industries as a percent of total biopharmaceutical industry sales varied widely in both Massachusetts and the U.S. in 2002 (Chart 6). Research and development in the physical, engineering and life sciences services industry in Massachusetts accounted for the highest share (42%) of shipments/receipts of such industries followed by pharmaceutical and medicine manufacturing (34%) and medical instrument and supplies manufacturing (24%). The share of biopharmaceutical-related industries' value of shipments/receipts generated by firms in research and development in the physical, engineering and life sciences services industries of Massachusetts was nearly 14 percentage points higher than the U.S. average (43% versus 29%).

Chart 6:
Value of Shipments/Receipts of Three Biopharmaceutical-Related Industries as a Percent of Total Value of Shipments/Receipts of All Biopharmaceutical-Related Industries in Massachusetts and the U.S., 2002



The Financial and R&D Expenditures Performance of Biopharmaceutical Member Companies Operating in Massachusetts in Recent Years

PhRMA member companies are continuously generating breakthroughs in medical drugs through a comprehensive array of research and development activities in the medical field. These companies innovate rapidly, creating larger economic and shareholder values when their R&D strategies are successful. The products developed by these companies have directly improved both life expectancy and the quality of life by increasing longevity¹⁴ and by reducing death rates from various diseases and illnesses. The availability of new drugs often reduces other medical costs, and the gains to society from these drug improvements have been estimated to far exceed the value of the drugs themselves.¹⁵ In addition, PhRMA-member companies plow back a large share of their

¹⁴ See: Frank R. Lichtenberg, The Impact of New Drugs Launches on Longevity: Evidence from Longitudinal, Disease-Level Data from 52 Countries, 1982-2001, National Bureau of Economic Research (NBER), Working Paper 9754, June 2003.

¹⁵ See: (i) David M. Cutler, Your Money or Your Life: Strong Medicine for America's Health Care System, Oxford University Press, Inc., New York, 2004; (ii) Frank R. Lichtenberg, The Benefits and Costs of

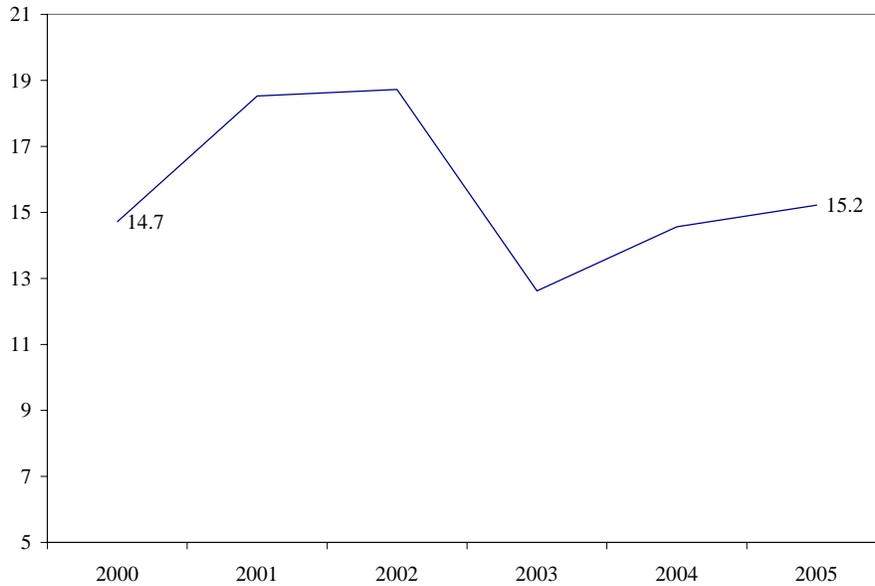
profits in R&D activities.¹⁶ The overall direct economic contributions of the PhRMA member companies operating in Massachusetts are quite substantial, with worldwide annual net sales exceeding \$277 billion, more than \$95 billion in gross operating profit, \$37.1 billion in expenditures on R&D activities, and employment of nearly 757,000 workers worldwide. In addition to the direct economic effects of these companies, their outputs also generate large income and employment multipliers on the rest of the state economy.

One of the key measures used in appraising the financial performance of companies is their profit margin during a fiscal year. Profit margins measure the ratio of profits generated for each dollar of sales in a company. Chart 7 displays 5-year trends in profit margins of 15 PhRMA member companies operating in Massachusetts. In the pharmaceutical industry, there often is a lengthy lag in realizing profits from R&D activities since a successful drug takes many years of development, and the drug is thoroughly tested and scrutinized by the FDA for its safety and efficacy before the drug is put on the market. For this reason, profits in PhRMA member companies are at times characterized by highly volatile trends. In 2000, PhRMA member companies' gross profit margin was nearly 15%, and it remained at the same level in 2005, but it ranged from 13 to 18 percent over this five year period.

Newer Drugs: Evidence from the 1996 Medical Expenditure Panel, NBER Working Paper 8147, Cambridge, Massachusetts, 2001.

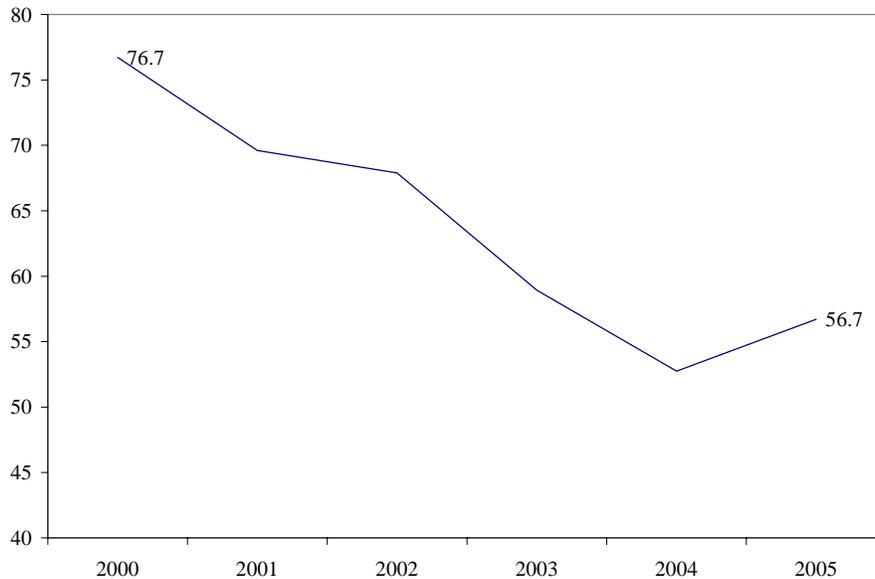
¹⁶ See: (i) CBO Study, Research and Development in the Pharmaceutical Industry, The Congress of the United States, Congressional Budget Office, Washington, D.C., October 2006; (ii) Scherer, F.M., "The Link Between Gross Profitability and Pharmaceutical R&D Spending", Health Affairs, (Millwood) 2001; 20 (5): 216-20.

Chart 7:
Trends in the Aggregate Profit Margins of 15 PhRMA Member
Companies Operating in Massachusetts, 2000-2005 (in %)



Another important measure of the financial performance of companies is their asset turnover rate. The value of this measure represents the ratio of sales generated to a company's assets. A higher asset turnover rate means that a company can generate higher sales from its existing stock of capital. Capital-intensive companies often have low asset turnover rates. For the 15 PhRMA member companies combined, the asset turnover rate has been characterized by a declining trend over the 2000-2005 period (Chart 8). These companies made 77 cents in sales for every \$1 in assets in 2000, but made only 57 cents in 2005. Nine of the 12 PhRMA member companies were characterized by a declining asset turnover ratio over the 2000-2005 period. To place these findings in comparative perspective, the recent asset turnover ratio for the major drugs industry was 64.0 while for firms in the S&P 500 the asset turnover ratio was 96.0.

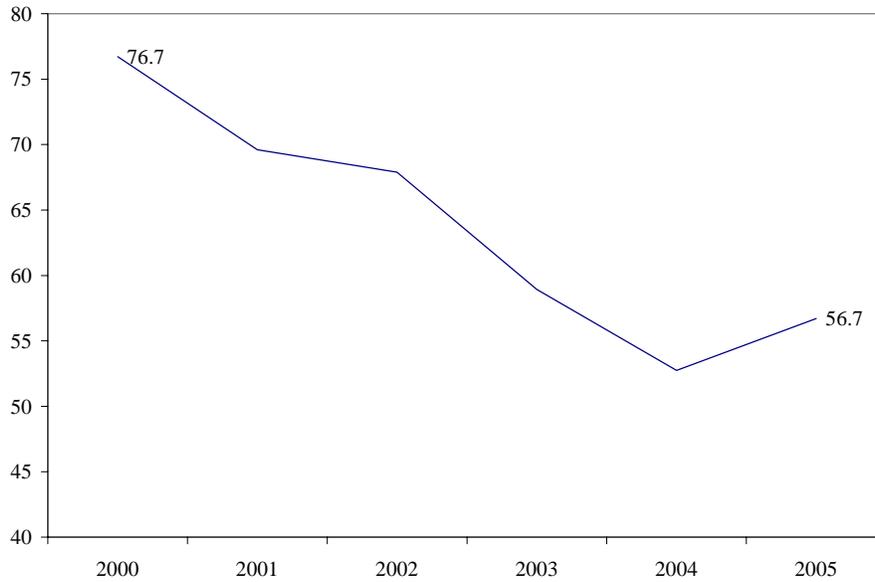
Chart 8:
Trends in the Asset Turnover Rates of 15 PhRMA Member Companies Operating in
Massachusetts, 2000-2005 (in %)



The most widely used measure of a company's financial performance is return on equity (ROE). This ROE measure represents the flow of income that a company returns to shareholders for their investments in the firm. In other words, return on equity is the percent returned on a dollar invested by shareholders. Return to equity measures for the 15 PhRMA member companies operating in Massachusetts were characterized by declines over the past six years. The ROE was 27.6% in 2000, peaked at 30.7% in 2001, and declined to 17.7% in 2005. This finding means that in 2005 shareholders obtained a 17.7% return for each dollar invested in PhRMA member companies (Chart 9). The return on equity for PhRMA firms closely matched the 5-year average ROE for companies in the S&P 500, which was around 18%.¹⁷

¹⁷ The source of the 5-year average ROE data for firms in the S&P 500 is Reuters Group LLC, web site www.reuters.com

Chart 9:
Trends in Return on Equity (ROE) of PhRMA Member Companies Operating in
Massachusetts, 2000-2005



PhRMA member companies have been characterized by relatively high Price/Earnings (P/E) ratios (Table 14). At the height of the stock market boom in 2000, the average P/E ratio of PhRMA member companies operating in Massachusetts was 27.0. Investors apparently were very bullish about the economic outlook for PhRMA member companies and were ready to pay \$27 for every \$1 in annual earnings of PhRMA member companies. However, in 2005, the P/E ratio of these companies was only 19.

Table 14:
Trends in Price/Earnings Ratios of PhRMA Member Companies Operating in
Massachusetts, 2000-2005

Company	2000	2005	Absolute Change in Ratio
Abbott	19.2	19.6	0.5
Alkermes ⁽¹⁾	--	--	NA
AstraZeneca	29.0	13.9	-15.1
Bayer	14.2	15.7	1.5
Bristol-Myers-Squib	21.6	14.6	-6.9
Genzyme ⁽¹⁾	--	38.5	NA
Idenix ⁽¹⁾	--	--	NA
Johnson & Johnson	24.3	17.7	-6.6
Merck	19.6	13.3	-6.3
Millennium ⁽¹⁾	--	--	NA
Pfizer	61.6	21.6	-40.0
Sanofi-Aventis ⁽²⁾	NA	24.2	NA
Schering-Plough	24.7	107.6	82.9
Sepracor ⁽¹⁾	--	NA	NA
Wyeth	NA	15.5	NA
Total of Above⁽³⁾	27.0	18.9	-8.1

Note: ⁽¹⁾ Alkermes, Idenix, and Millennium did not have positive incomes in either year, 2000 and 2005. Sepracor incurred a loss in 2005. Genzyme and Wyeth had losses in 2000.

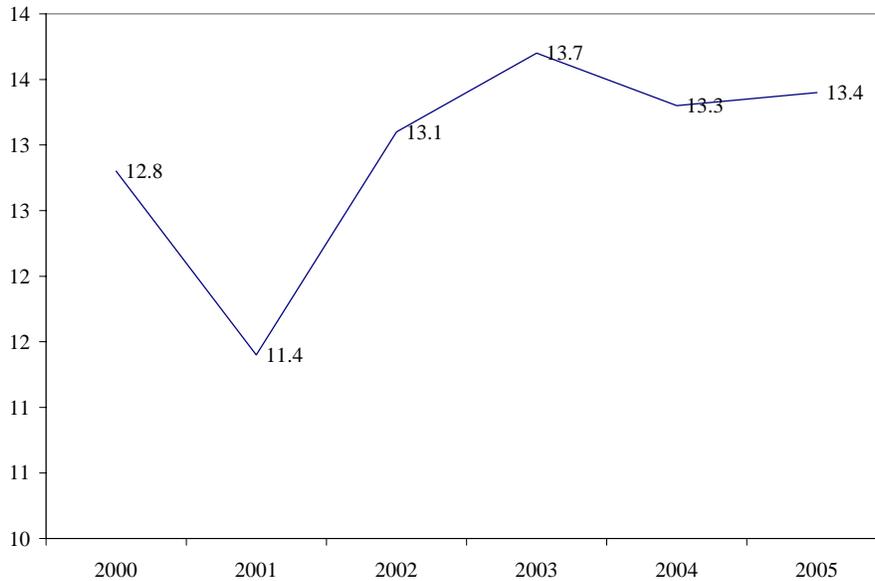
⁽²⁾ Data for Sanofi-Aventis were not available prior to 2002.

⁽³⁾ The total excludes companies with no positive earnings. PhRMA companies with negative earnings in 2000 also were excluded in 2005.

Intensive research and development activities are considered to be a hallmark characteristic of biopharmaceutical-related industries. How intensely do PhRMA member companies operating in Massachusetts invest in R&D? To answer this question, we compared R&D expenditures relative to sales for the 2000-2005 period. Over this five-year period, the 14 PhRMA member companies in Massachusetts spent 13% to 14% of their sales revenue on R&D activities (Chart 10).¹⁸

¹⁸ These R&D ratios are based on national expenditures/sales relationships for these PhRMA members not their behaviors in the state as a whole.

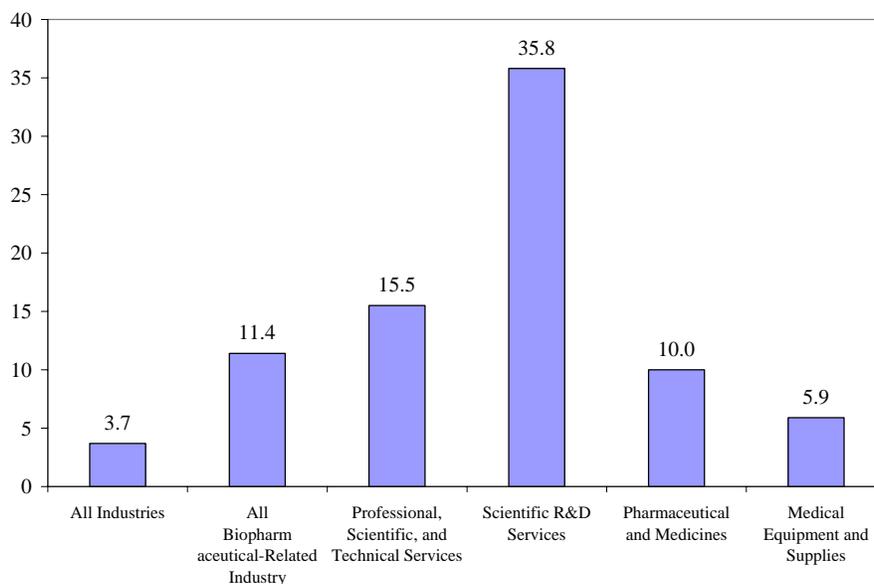
Chart 10:
R&D Intensity⁽¹⁾ of PhRMA Member Companies Operating in Massachusetts, 2000-2005
(in %)



R&D intensity in biopharmaceutical-related industries tends to be among the highest of all industries in the state and the country. In 2004, for all private sector industries in the U.S., R&D intensity was only 3.7% versus 11.4% for biopharmaceutical-related industries. The only industrial sector that had a higher R&D intensity ratio than these biopharmaceutical-related industries in the U.S. was the professional, scientific, and the technical services industry, which includes the scientific R&D industries comprising a key part of the biopharmaceutical sector¹⁹ (Chart 11).

¹⁹ Scientific R&D services is a subset of the professional, scientific, and technical services industries.

Chart 11:
R&D Intensity of Biopharmaceutical-Related Industries
Compared to All Industries, U.S., 2004

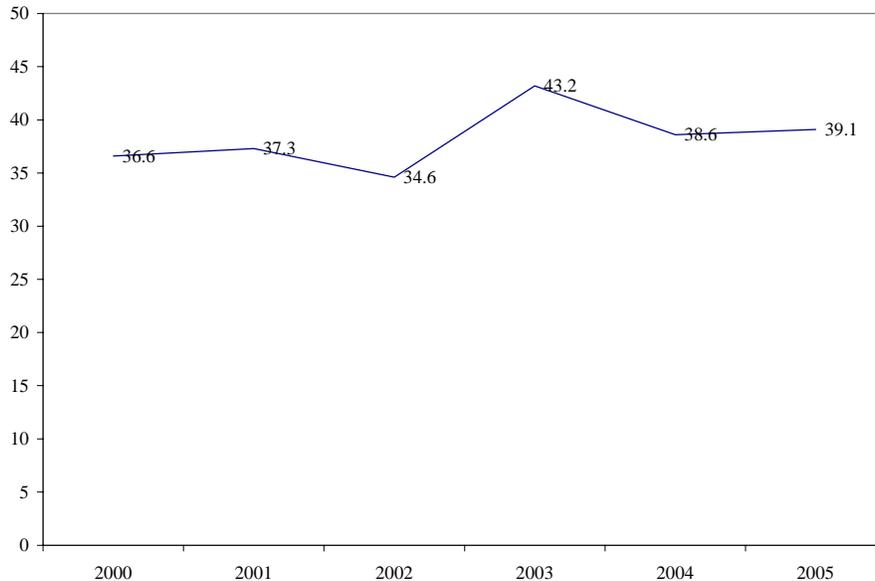


Source: National Science Foundation/Division of Science Resource Statistics, Survey of Industrial Research and Development: 2004 tabulations by authors.

PhRMA member companies tend to plow back a large share of their operating profits into R&D expenditures. Over the 2000-2005 period, R&D expenditures' share of operating profits in PhRMA member companies ranged from 37% to 39% (Chart 12). There is a strong link between the profitability of PhRMA companies and their investments in R&D and other capital expenditures. The Congressional Budget Office has argued that the future flow of R&D expenditures will be dependent on the future flow of profits in the industry.²⁰

²⁰ See: Congressional Budget Office Study, Research and Development in the Pharmaceutical Industry, The Congress of the United States, Washington, D.C., October 2006.

Chart 12:
R&D Expenditures as a Percent of Operating Profits in the 15 PhRMA Member
Companies Operating in Massachusetts, 2000-2005 (in %)



A Profile of the Demographic, Socioeconomic, and Job Characteristics of the Employed in Biopharmaceutical-Related and All Industries of Massachusetts and the U.S.

Knowledge of the demographic (age, gender, race-ethnic) and socioeconomic (educational attainment) characteristics of workers in a given industry and the occupational characteristics, skill backgrounds, and annual earnings of those workers is essential for career counseling and guidance and for workforce development policymaking and program planning. CLMS research staff have analyzed the findings of the American Community Surveys for calendar years 2003 to 2005 to identify the background characteristics of biopharmaceutical industry workers.²¹

One of the formal research papers was designed to provide a fairly detailed demographic and socioeconomic profile of resident workers employed by biopharmaceutical-related industries in Massachusetts and to compare the characteristics of these workers with those of their counterparts across all industries of the state and their

²¹The American Community Survey is a national household survey conducted annually by the U.S. Census Bureau since the late 1990s using a questionnaire similar to the long-form questionnaire in conducting the 2000 Census. In 2005, nearly 37,000 Massachusetts households completed ACS questionnaires.

peers in similar industries across the nation.²² Among the demographic and socioeconomic characteristics examined were the gender, age, race-ethnic status, nativity status, and educational attainment of the employed, including the types of college degrees held by these workers in recent years (2003-2005).

The American Community Surveys (ACS) of 2003-2005 for Massachusetts were analyzed to identify key demographic characteristics of the employed resident workforce in bio-pharmaceutical-related industries. The gender composition of the biopharmaceutical industry workforce in Massachusetts and the entire employed population of the state are displayed in Table 15. Women comprised nearly 45 percent of all workers in biopharmaceutical-related industries of the state in 2003-2005, with their share of the employed ranging from slightly under 41 percent in scientific research and development industries to a high of 49 percent in pharmaceutical and medicine manufacturing (Table 15)²³. The female share of the biopharmaceutical industry workforce in Massachusetts was statistically identical to that for the entire nation (45%), but it was slightly below that of all industries in Massachusetts. Women accounted for nearly 48% of all workers in the state in 2003-2005.

A substantial majority (82%) of all workers in biopharmaceutical-related industries of the state in 2003-2005 were in the prime-aged work group (25-54 years old). This age group accounted for a very high share of the workforce in each of the three biopharmaceutical-related industries in the state, with the size of these shares ranging from 79 to 89 percent. Statewide, only 71 percent of all of the employed in 2003-2005 were in the prime-aged work group. Teens, young adults (20-24), and the elderly (65+) were under-represented in these industries. For example, only 5 percent of biopharmaceutical-related workers were in the 16-24 age group versus nearly 12 percent of all workers in the state, and the elderly accounted for only 2 percent of workers in this

²² The bulk of the analyses are focused on Massachusetts residents who were employed in biopharmaceutical-related industries regardless of the locations of their jobs. One section of the research paper identified the numbers and characteristics of workers who commute into Massachusetts for their jobs in such industries. The state attracts more workers from other states in New England to work in biopharmaceutical-related industries here in Massachusetts than the number of residents who commute outside the state to work in such firms in the rest of the region.

²³ The scientific R&D industries contain a relatively high share of Ph.D. degree holders in the physical and life sciences, a high fraction of whom are foreign immigrants. Males are disproportionately represented among these groups.

sector versus nearly 4 percent of all of the employed across the state. A relatively high share of biopharmaceutical industry workers possess college degrees, including a substantial number with advanced degrees (Master's or higher). One would, thus, anticipate that teens and young adults (20-22) still in college would be under-represented in these industries.²⁴ Nevertheless, firms in these industries could play a greater role in expanding both teen and young adult employment through paid internships, cooperative education program hires, and summer employment opportunities. Exposing more teens and college students to jobs in these industries could help expand the future supply of labor in the state. Since 2000, job opportunities for teens in Massachusetts have declined considerably, and the resident labor force has shown practically no growth.²⁵

²⁴ Due to the exclusion of young adults in-group quarters (college dormitories, fraternities, sororities) from the 2004-2005 ACS universe, the survey may slightly underestimate the number of young adults who are employed in biopharmaceutical-related industries.

²⁵ See: Andrew Sum, Joseph McLaughlin, Ishwar Khatiwada, Tracking and Assessing the Steep Declines in the Massachusetts Teen Labor Force and the Employed Teen Population, Report Prepared for the Commonwealth Corporation, Boston, 2007.

Table 15:
The Gender, Age and Race-Ethnic Characteristics of
Employed Resident Workers in Biopharmaceutical-Related Industries and
All Industries of Massachusetts, 2003-2005 Averages
(in Percent)

Characteristic	(A) All Industries	(B) Biopharmaceutical- Related	(C) Pharmaceutical and Medicine Mfg.	(D) Medical Instruments and Supplies Mfg.	(E) Scientific Research and Development
<i>Gender</i>					
• Men	52.3	55.2	50.9	52.8	59.2
• Women	47.7	44.8	49.1	47.2	40.8
<i>Age</i>					
• 16-19	3.5	.8	.5	1.4	.6
• 20-24	8.0	4.6	5.3	2.7	5.6
• 25-34	21.8	27.6	32.5	22.4	28.5
• 35-44	25.8	30.1	34.1	27.3	29.8
• 45-54	23.7	24.0	22.1	30.0	20.9
• 55-64	13.3	11.1	5.4	14.3	12.0
• 65+	3.8	1.9	.2	2.0	2.7
<i>Race-Ethnic Group</i>					
• Asian	4.6	11.3	13.2	11.5	10.1
• Black	5.0	4.9	7.5	6.3	2.5
• Hispanic	6.1	3.6	1.2	7.5	2.2
• Other	1.5	1.8	3.2	2.7	.5
• White	82.6	78.5	74.9	72.1	84.6

Source: 2003, 2004, and 2005 American Community Surveys, public use files, tabulations by authors.

In 2003-2005, nearly 79 percent of the employed in biopharmaceutical-related industries of Massachusetts were White, non-Hispanic versus nearly 85 percent in all industries of the state. Members of each race-ethnic minority group, except Hispanics, are either as well represented in biopharmaceutical industries as they are in all industries of the state or they are somewhat over-represented. For example, Black workers accounted for 5% of all workers in biopharmaceutical-related industries combined and

for 5% of all workers in the state in 2003-2005.²⁶ Asian workers were represented in these industries at a rate nearly two and a half times as high as that of their share of all of the employed in the state (11.3% vs. 4.6%). The much higher degree of representation of Asian workers in biopharmaceutical industries is primarily attributable to their high rates of college completion and their over-representation in science and engineering fields which are important sources of labor in these industries. The below average share of Hispanics in these industries is a consequence of two sets of forces: the sharply below average share of Hispanic workers with college degrees and the high share of immigrants among the Hispanic employed. A disproportionate share of Hispanic immigrants have very limited formal schooling with many lacking a high school education from their countries of origin.²⁷

During the past few decades, Massachusetts has become overwhelmingly dependent on new foreign immigrants for its population and labor force growth.²⁸ All of the state's labor force growth in the 1990's was attributable to new foreign immigrants, and the resident labor force of the state would have declined considerably over the 2000-2006 time period in the absence of new immigrant inflows. Foreign-born workers also play a key role in staffing positions in the state's biopharmaceutical-related industries. Over the 2003-2005 time period, nearly one-fourth of the resident employed in these industries of Massachusetts were foreign born (Table 16). The foreign born share of the employed ranged from slightly over 20 percent in scientific research and development industries to nearly 30 percent in medical equipment and supplies manufacturing industries. The foreign-born share of the work force in bio-pharmaceutical-related industries exceeded that for all industries of the state (24.5% vs. 18%).

²⁶ Black workers are more heavily represented in the manufacturing industries of the biopharmaceutical sector than in scientific research and development.

²⁷ For a recent analysis of the educational backgrounds and English-speaking proficiencies of adult immigrants in Massachusetts,

See: Andrew Sum, Johan Uvin, Ishwar Khatiwada, et al., The Changing Face of Massachusetts, Massachusetts Institute for A New Commonwealth, Boston, 2005.

²⁸ For a comprehensive review of the changing size, demographic characteristics, and labor market behaviors of the state's immigrant population,

See: Andrew Sum, Johan Uvin, Ishwar Khatiwada, et al., The Changing Face of Massachusetts, Massachusetts Institute for A New Commonwealth, Boston, 2005.

Table 16:
The Distribution of the Employed in Biopharmaceutical-Related and
All Industries of Massachusetts by Nativity Status, 2003-2005
(in Percent)

Industry	(A)	(B)
	Native Born	Foreign Born
All Biopharmaceutical-Related Industries	75.5	24.5
• Pharmaceutical and medicine mfg.	74.6	25.4
• Medical equipment and supplies mfg.	70.4	29.6
• Scientific research and development industries	79.5	20.5
All Industries	81.9	18.1

Firms in most of the biopharmaceutical-related industries employ a large number of professional, management, high level sales, and technical workers for whom post-secondary schooling is typically required for entry into the occupation. The ACS questionnaires collected information from each household member on the amount of schooling that they had completed including the highest degree attained by the time of the survey. In Table 17, we present the percentage distribution of the employed in biopharmaceutical-related industries and all industries of the state over the 2003-2005 time period in the following five educational subgroups:

- Less than 12 or 12 years, no high school diploma or GED certificate
- High School diploma or GED, no completed years of college
- 13-15 years, including Associate degree holders
- Bachelor's degree
- Master's or higher degree

Findings in Table 17 reveal that very few workers (2.8%) in biopharmaceutical-related industries of the state in 2003-2005 lacked a high school diploma or a GED certificate while nearly 9% of the employed across the entire state did so. Approximately 82% of all of the employed in biopharmaceutical-related industries had completed some post-secondary schooling versus only 66% of all state workers in 2005. Biopharmaceutical industry workers also were considerably more likely than all workers

in the state to have obtained a Bachelor’s or higher degree (64% versus 40%), and they were twice as likely to have received a Master’s or higher degree (34% versus 17%).

Table 17:
Percentage Distribution of the Employed (16+) in All Industries and Biopharmaceutical-Related Industries in Massachusetts by Educational Attainment, 2003-2005

	(A)	(B)	(C)
Educational Attainment	All Industries	Biopharmaceutical-Related Industries	Biopharmaceutical/All
Less than 12 or 12, no diploma/GED	8.5	2.8	.33
H.S. diploma/GED	25.3	15.0	.60
13-15 years	25.9	17.8	.67
Bachelor’s degree	23.5	30.3	1.29
Master’s or higher degree	16.8	34.0	2.03

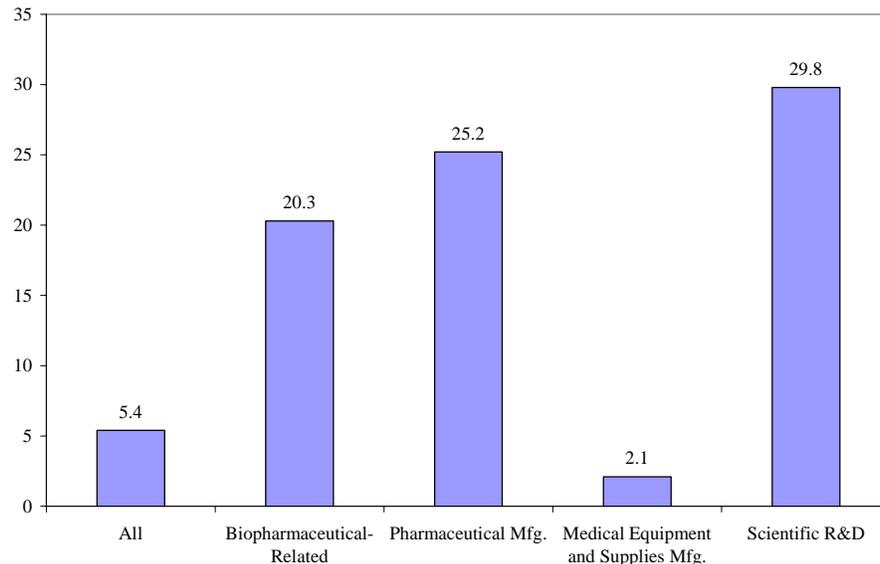
Source: 2003-2005, American Community Surveys, public use files, tabulations by authors.

The share of biopharmaceutical industry workers with a Bachelor’s or higher degree varied fairly widely across the three industrial sub-sectors, ranging from a low of 41% in medical instruments and supplies manufacturing to a high of 78% in pharmaceutical manufacturing. In all three sub-sectors, the share of workers with at least a four year college degree either matched or substantially exceeded the average for all industries. Thus, biopharmaceutical industries are a key source of jobs for college graduates in Massachusetts. Their continued growth could play a key role in keeping newer college graduates in the state and help reduce the high levels of domestic out-migration of relatively young well educated workers that have plagued the state over the past six years.

The ACS surveys also collected information on the types of college degrees held by workers. We have identified all workers in Massachusetts with a Ph.D. or professional degree (medicine, law) at the time of the 2005 ACS surveys and the industries of their employers. In 2005, slightly more than one of five workers in the state’s biopharmaceutical-related industries held a Ph.D. or a professional degree (Chart 13). The share of workers with a Ph.D. or professional degree in biopharmaceutical-related industries exceeded the statewide average by a multiple of four. The share of workers with such an advanced degree varied widely across the three biopharmaceutical sub-

sectors, ranging from a low of 2 percent in medical equipment and supplies manufacturing to a high of nearly 30 percent in scientific R&D industries.

Chart 13:
Percent of the Employed (16+) in All Industries of Massachusetts and Biopharmaceutical-Related Industries with a Professional or Ph.D. Degree, 2005



The Occupational Structure of Employment in Biopharmaceutical-Related Industries of Massachusetts: Comparisons with the Occupational Structure of Employment in All Industries of the State

The direct labor market impacts of a given industry are influenced by a variety of factors, including the volume of real output, the productivity of its workers, the occupational characteristics of the jobs in the industry, the annual weeks and hours of employment offered by these jobs, their wage/salary levels, and the hiring/training policies of the firms comprising the industry.²⁹ In turn, the occupational structure of employment in an industry has a major influence on the educational and skill requirements for entry into those jobs. Firms that generate a high share of jobs in professional, managerial, technical, and high level sales occupations will tend to hire an above average share of college graduates and workers with stronger literacy and

²⁹The indirect impacts and induced employment impacts of the industry are dependent upon inter-industry links between the industry and other industries across the state as well as the spending behavior of workers, managers, and owners in the industry. Important segments of the biopharmaceutical industries in Massachusetts have very high employment multipliers.

numeracy proficiencies.³⁰ Given the favorable economic returns to post-secondary schooling and literacy/numeracy skills, these jobs also typically pay annual wages well above the annual average for all workers and raise the purchasing power of these workers. Skilled, blue-collar production jobs also tend to pay above average wages for workers with only a high school education.

CLMS research staff have analyzed the occupational staffing patterns of biopharmaceutical-related industries based in our state and compared them with those of other industries across Massachusetts. These occupational staffing patterns are based on a tabulation of the employment distribution by occupation within a given industry located in the state of Massachusetts. Some of the workers in these industries may commute to their job from outside Massachusetts. The source of the data underlying the analyses of occupational employment in biopharmaceutical-related industries and all other industries in the state is the Massachusetts occupational staffing patterns data provided by the Massachusetts Department of Workforce Development.³¹ The occupational staffing pattern data for industries are based on the Occupational Employment Statistics (OES) survey, which is conducted semiannually by the Massachusetts Department of Workforce Development. The findings on occupational staffing patterns correspond to the year 2003 and are based on responses to the OES surveys by more than 28,000 private and public employers in the state. The North American Industry Classification System (NAICS) and the Standard Occupational Classification System (SOC) are the coding systems used to identify and classify the industries and occupations included in the Massachusetts industry staffing patterns matrix.

The occupational staffing patterns of all biopharmaceutical-related industries combined and individual biopharmaceutical-related industries in Massachusetts during 2003 are displayed in Table 18. A review of the findings on the occupational distribution of employment in these three biopharmaceutical-related industries combined indicates a high level of skill for a majority of the workers employed by them. Overall employment

³⁰High-level sales positions include buyers, sales representatives, sales managers, commodity and stockbrokers, and real estate agents. They are distinguished from lower level sales occupations, such as cashiers and retail sales clerks.

³¹Massachusetts Department of Workforce Development, Massachusetts Industry Staffing Patterns, Boston, September 2005.

in the state's biopharmaceutical industries was highly concentrated in the management, professional and technical occupations. Of the 55,700 jobs in these three industries in 2003, nearly 57 percent were categorized under the management, professional and technical occupations, followed by service, sales and office occupations (22.9%), and construction, maintenance and repair, and production occupations (18.2%). A very similar occupational pattern is observed within two of the three individual biopharmaceutical-related industries. In the Medical Equipment and Supplies manufacturing industry (NAICS 3391), however, the majority of the jobs were in blue-collar construction, maintenance, and production occupations, with such positions accounting for just under 53 percent of all jobs in the industry. Among the high level professional and management occupations, the individual occupations accounting for a relatively high share of total employment in the biopharmaceutical-related industries of the state were computer and mathematical science occupations (10%), architecture and engineering occupations (10%), management occupations (13%), and life and physical scientists (7%). Within the pharmaceutical manufacturing industries, high level sales positions represented 13% of employment in the industry.

Table 18:
The Occupational Distribution of Employment in All Biopharmaceutical-Related Industries and Individual Biopharmaceutical-Related Industries of Massachusetts, 2003
(in %)

Occupational Group	(A) Biopharmaceutical- Related Industries	(B) NAICS 3254	(C) NAICS 3391	(D) NAICS 5417
All Workers (in 1000s)	55.7	8.8	13.1	33.8
Management, Professional and Technical Occupations	56.7	48.1	29.7	69.4
Management	13.0	19.0	12.1	11.8
Business and Financial Operations	7.7	3.9	4.2	10.1
Computer and Mathematical Science Occupations	10.5	3.1	1.9	15.7
Architecture and Engineering	10.4	5.1	10.4	11.9
Life, Physical, and Social Science	7.1	17.0	1.1	6.9
Legal	5.0	0.0	0.0	8.3
Education, Training, and Library	0.2	0.0	0.0	0.4
Arts, Design, Entertainment, Sports, and Media	2.2	0.0	0.0	3.7
Healthcare Practitioner and Technical	0.4	0.0	0.0	0.7
Service, Sales and Office Occupations	22.9	28.2	15.5	24.4
Healthcare Support	0.6	0.0	0.0	0.9
Building and Grounds Cleaning and Maintenance	0.2	0.0	0.0	0.4
Sales and Related	5.2	13.4	3.1	3.8
Office and Administrative Support	17.0	14.9	12.4	19.3
Construction, Maintenance, Repair, and Production Occupations	18.2	19.7	52.8	4.5
Construction and Extraction	0.4	0.0	0.0	0.7
Installation, Maintenance, and Repair	1.4	2.4	1.8	1.0
Production	14.9	15.2	48.9	1.7
Transportation and Material Moving	1.5	2.2	2.1	1.1
All Other Occupations*	2.2	4.0	2.0	1.7

Source: Massachusetts Department of Workforce Development, "Industry Staffing Patterns"

*Note: Occupational employment shares for Massachusetts do not always add to 100% because some individual occupations were not identified. Some of these occupations could have been in the professional, managerial and technical occupations; therefore the share of employment in these occupations could be higher than showed.

The occupational staffing patterns of biopharmaceutical-related industries in Massachusetts also can be compared to those of all industries in the Commonwealth. Findings of a comparison of the occupational staffing patterns of all industries of Massachusetts and biopharmaceutical-related industries in 2003 are presented in Table 19. The findings presented in this table corroborate what we had noted earlier about the substantial concentration of employment in biopharmaceutical-related industries in occupations that demand a relatively high level of formal educational attainment and skill from the workforce. In all Massachusetts industries, the occupations accounting for the largest share of total employment in 2003 were the sales, service, and office occupations representing 47% of total employment. The second highest share of jobs were in the management, professional and technical occupations (34%) followed by construction, maintenance, repair and production occupations, accounting for approximately 19% of total employment across the state.

Table 19:
A Comparison of the Occupational Distribution of Employment in
All Industries of Massachusetts and Biopharmaceutical-Related Industries, 2003
(in %)

Occupational Group	(A) All Industries	(B) Biopharmaceutical- Related Industries
All Workers (in 1000s)	3,187	55.7
Management, Professional and Technical Occupations	34.3	56.7
Management	7.5	13.0
Computer and Mathematical Science	3.6	10.5
Architecture and Engineering	1.9	10.4
Business and Financial Operations	4.2	7.7
Life, Physical, and Social Science	1.2	7.1
Legal	1.1	5.0
Arts, Design, Entertainment, Sports, and Media	1.3	2.2
Healthcare Practitioner and Technical	5.7	0.4
Education, Training, and Library	6.2	0.2
Community and Social Services	1.6	0.0
Service, Sales and Office Occupations	47.1	22.9
Office and Administrative Support	18.1	17.0
Sales and Related	9.9	5.2
Healthcare Support	2.7	0.6
Building and Grounds Cleaning and Maintenance	4.0	0.2
Protective Service	2.0	0.0
Food Preparation and Serving Related	8.1	0.0
Personal Care and Service	2.3	0.0
Construction, Maintenance, Repair, Production Occupations	18.6	18.2
Production	6.3	14.9
Transportation and Material Moving	5.4	1.5
Installation, Maintenance, and Repair	3.2	1.4
Construction and Extraction	3.6	0.4
Farming, Fishing, and Forestry	0.1	0.0

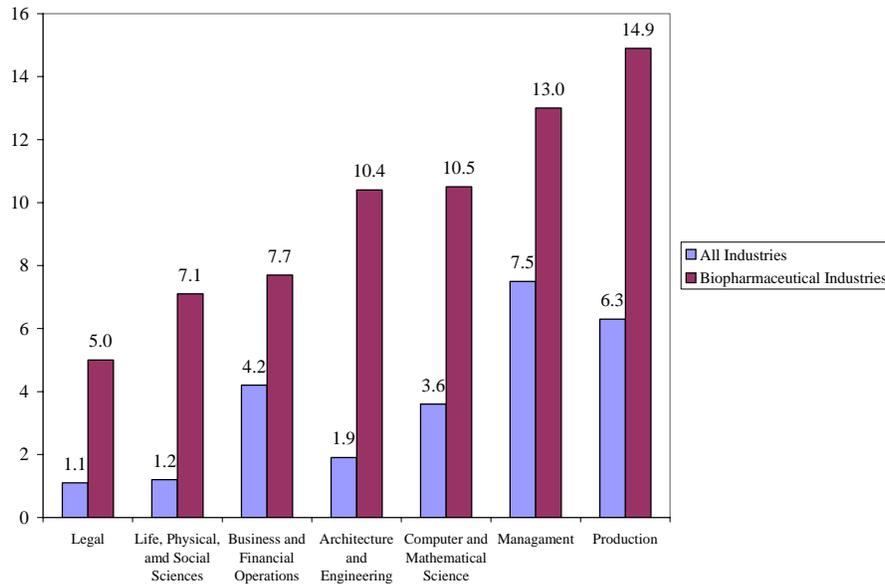
Massachusetts' biopharmaceutical-related industries were characterized by a quite different occupational distribution of employment than all industries in Massachusetts combined. Within the state's biopharmaceutical-related industries, the occupational group that accounted for the highest share of employment was the management, professional and technical occupations, which employed just under 57% of all workers in these industries. This employment share was 22 percentage points higher than that for all

industries in Massachusetts. The much higher share of professional, technical and management jobs in the biopharmaceutical-related industries indicates a high level of concentration of jobs that typically require four or more years of college. The above average share of employment in college labor market jobs is particularly valuable in creating a demand for graduates from the state's higher education system, providing economic incentives for them to remain in the state. Since 2001, Massachusetts has been characterized by high levels of out-migration of relatively young well-educated adults (24-39 years old).

The biopharmaceutical-related industries also employed an above share of production workers (15% vs. 6% statewide), an occupational group that has been characterized by steep job declines in our state over the past two decades. The sharp decline in good paying, blue collar jobs has contributed in an important way to the deterioration in the real annual earnings of males with 12 or fewer years of schooling with its adverse social and economic consequences, including a steep decline in married couple families among such persons.

In Chart 14, we identify the seven individual occupational clusters that accounted for the highest share of employment in Massachusetts biopharmaceutical-related industries and compare their shares of employment in these industries with those for all industries combined in the state. Six of these seven occupations required a high level of educational attainment, and each of them accounted for a larger share of employment in biopharmaceutical-related industries than they did in all industries combined across the state. They included life and physical scientists, engineers, managers, and computer/mathematical scientists. The one major exception to this pattern was production occupations. Workers in this set of occupations were 2.4 times more concentrated in biopharmaceutical-related industries, primarily the manufacturing segments, than in the Massachusetts economy as a whole.

Chart 14:
Comparison of the Occupational Distributions of Employment in All Industries of Massachusetts and Biopharmaceutical-Related Industries: Occupations with the Highest Share of Total Employment in the Biopharmaceutical-Related Industries, 2003
 (in %)



The Annual Earnings of Workers in Biopharmaceutical-Related Industries of Massachusetts and the U.S.

Among the most important economic characteristics of jobs in a given industry is the average level of annual earnings of its workers. Both the median and mean annual earnings of workers can be used to represent their average earnings. The median annual earnings is that earnings level which divides the distribution into two equal parts. The mean annual earnings is a measure of the simple arithmetic average of the earnings of workers. Unlike the median, the mean is influenced by the values of observations all along the distribution. Since the right-hand tail of the earnings distribution typically contains a relatively small number of very high earners, the value of the mean annual earnings exceeds the median earnings level.³²

For the vast majority of non-elderly families, the annual earnings of workers are the key determinant of their family's income and living standards. Higher earnings allow

³² If the distribution of earnings was characterized by a normal distribution (the bell shaped curve in statistics that is symmetrical around the mean), then the median and mean earnings level would be identical. In real life, the earnings distribution is skewed to the right, yielding a mean in excess of the median.

for greater consumption of goods and services and the ability to own homes and finance other investments, including the education of one’s children. The mean annual earnings of workers in biopharmaceutical-related industries is also important for another economic reason. The economic multiplier effects of a given industry on the rest of the economy are heavily dependent on the induced, local spending of the workers, managers and owners in the industry. The consumption spending of workers is substantially influenced by their after-tax, real incomes. The above average employment multipliers that typically prevail in biopharmaceutical-related industries are largely attributable to the high mean annual earnings of workers in these industries.

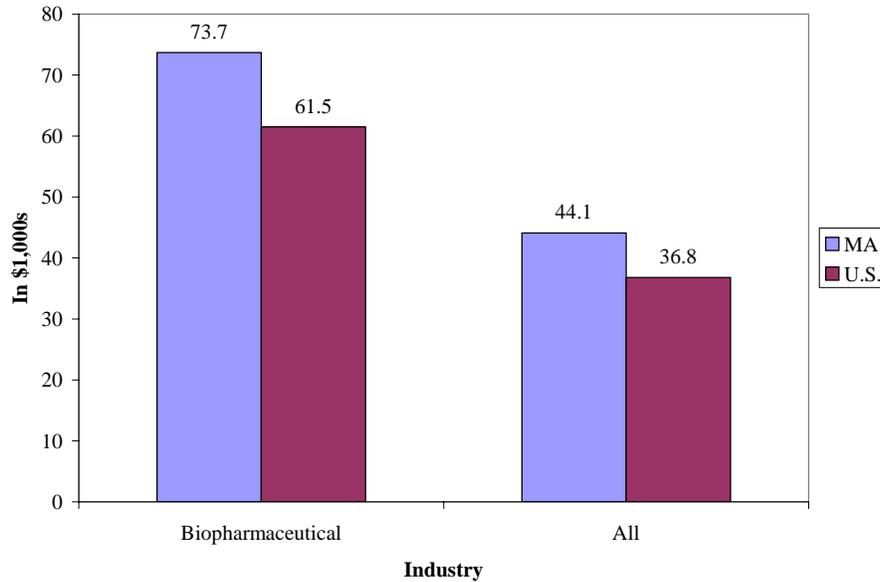
Both the median and mean annual earnings of biopharmaceutical industry workers in Massachusetts in 2005 were well above those of their peers in other industries of the state. Median annual earnings of all persons (16+) who were employed in biopharmaceutical-related industries of Massachusetts in 2005 were equal to \$56,000 (Table 20). The median annual earnings of workers in these industries were \$24,000 or 75 percent higher than those of all workers in the state during that year. Mean annual earnings of all biopharmaceutical industry workers were estimated to be approximately \$73,760, an earnings level that was 67 percent above the mean for all of the employed in the state (\$44,100) (See Chart 15).

Table 20:
Median Annual Earnings of Employed Persons (16+) in Biopharmaceutical-Related Industries and All Industries of Massachusetts and the U.S.; 2004-2005

Industry	(A)	(B)
	Massachusetts	U.S.
Biopharmaceutical-Related Industries	\$56,000	\$46,000
Pharmaceutical and medicine manufacturing	60,000	55,000
Medical equipment and supplies manufacturing	40,000	36,000
Scientific research and development	66,000	50,000
All Industries	32,000	26,000
Biopharmaceutical-Related/All Industries	1.75*	1.77*

Source: 2005 American Community Surveys, public use files, tabulations by authors.

Chart 15:
Comparisons of the Mean Annual Earnings of the Employed in Biopharmaceutical-
Related Industries and All Industries of Massachusetts and the U.S., 2004-2005
(in \$1000)



The median and mean annual earnings of workers in the state’s biopharmaceutical-related industries also were above those of their employed peers in the same industries across the nation. The median annual earnings of the employed in these industries of Massachusetts were about 22% higher than the median for their counterparts nationwide (Table 20). The annual earnings advantages of biopharmaceutical-industry workers in Massachusetts in recent years were attributable to a variety of forces, including more full-time, year-round jobs, a more highly educated labor force, a higher proportion of jobs in professional, managerial, and technical occupations, and above average earnings in comparison to their counterparts with similar levels of education and experience in other industries.

Ninety percent of the employed in biopharmaceutical-related industries of Massachusetts worked full-time for 40 or more weeks in 2005 versus only 75 percent of the employed in all industries of the state.³³ Biopharmaceutical-industry workers in each of the five educational attainment subgroups were more likely to work full-time, year-round in 2005 than their employed peers in all industries of the state. Even when they

³³ Full-time is defined as working on average for 35 or more hours per week during the year.

worked full-time, year-round, workers in the state’s biopharmaceutical-related industries obtained higher median and mean annual earnings than their counterparts in all industries of the state. The relative size of the advantage in median annual earnings for all full-time, year-round workers was 33%. Biopharmaceutical-industry workers in all educational subgroups, except for high school graduates, obtained higher median annual earnings than each of their respective counterparts in all other industries across the state.

Table 21:
Comparisons of the Median Annual Earnings of Year-Round,
Full-Time Workers in Biopharmaceutical Industries and
All Industries of Massachusetts by Educational Attainment, 2005
(in Current Dollars)

Educational Attainment	Biopharmaceutical- Industries	All Industries	Biopharmaceutical Minus All	Biopharmaceutical as a % of All
Less than 12 years	\$31,798	\$28,537	\$3,261	111
H.S. diploma / GED	\$35,671	\$35,671	-0	100
13-15 years	\$49,940	\$40,767	\$9,173	122
Bachelor’s degree	\$66,247	\$56,055	\$10,192	118
Master’s or higher degree	\$91,727	\$71,343	\$20,394	129
All educational groups	\$61,1651	\$45,863	\$15,288	133

Source: 2005 American Community Surveys, public use files, tabulations by authors.

Findings of our multivariate statistical analysis of the annual earnings of full-time, year-round workers in Massachusetts in 2004-2005 revealed that being employed in a biopharmaceutical-related industry would, *ceteris paribus*, raise the expected annual earnings of Massachusetts workers by approximately 23 percent. Similar-sized annual earnings premiums were found for men and women, for workers without Bachelor degrees, and for those with a Bachelor’s or higher degree.

Table 22:
Estimated Independent Impacts of Being Employed in a Biopharmaceutical-Related
Industry in Massachusetts on the Expected Annual Earnings of Selected Groups of
Full-Time, Year-Round Workers in 2005

Group of Workers	Percentage Point Effect
All	23%
• Medical equipment mfg.	16%
• Pharmaceutical mfg.	35%
• Scientific R&D	22%
Men	21%
Women	26%
Workers with 1-15 years of schooling	18%
Workers with Bachelor's or higher degree	22%

The biopharmaceutical-related industries of Massachusetts were found to be very intensive employers of college graduates, especially those with advanced degrees, and they provided relatively high-paying, full-time, year-round positions for college educated adults. Growth of employment in such industries will be indispensable to the future retention of young, well-educated adults in our state and to a reduction in the high levels of domestic out-migration that have prevailed since early 2001.

Given the critical export orientation of a large volume of employment and output in the state's biopharmaceutical-related industries and the high median and mean annual earnings of its workers, these industries should be characterized by relatively high output and employment multipliers. The higher locally induced spending of workers and owners in these industries brought about by their higher earnings will create larger multiplier effects, generating additional jobs for state residents in other industries. As revealed below, the multiplier effects from growth in biopharmaceutical industries are quite substantial.

Output and Employment Multipliers of Biopharmaceutical-Related Industries in Massachusetts and the U.S.

The economic impacts of an industry often go well beyond their direct effects on output, earnings, and employment in the state or local economy in which they are located.

Industries that export their goods or services outside of the state in which they are located can generate multiplier effects on the rest of the state economy.³⁴ These multiplier effects include both indirect effects on other state industries through the purchases of inputs by an exporting firm from other state firms and the induced effects on other industries from the local consumption spending of workers and owners in the exporting industries.³⁵

A major share of the output of biopharmaceutical-related industries in Massachusetts is exported outside of the state, including sales to other countries.³⁶ These industries, thus, constitute part of the export base of Massachusetts and can generate multiplier effects on output and employment in the rest of the economy. Due to their high purchases from other industries in the state and the high levels of induced local spending by workers and managers in these industries, biopharmaceutical-related industries in Massachusetts and the U.S. tend to generate relatively high output, earnings, and especially employment multipliers. In a separate research paper, CLMS research staff analyzed output, earnings, and employment multipliers for four biopharmaceutical-related industries in the state. The values of these multipliers were provided to the Center for Labor Market Studies by the U.S. Department of Commerce's Bureau of Economic Analysis under its Regional Input-Output Modeling System known by its acronym (RIMSII).³⁷

There are a variety of economic multipliers that can be used in conducting impact analyses of changes in final demands, earnings, or employment of a given industrial sector. We have relied upon three different multipliers for industries generated by the U.S. Bureau of Economic Analysis. They are the following:

³⁴ In some cases, the exports of services and goods involve customers coming into the state from other states or countries to make these purchases, such as tourists or college students enrolling in Massachusetts universities from other states.

³⁵ Industries that produce goods and services for local sale that can substitute for imports from other states and countries also can generate multiplier effects on the state economy.

³⁶ Research and development activities financed by public and private monies from outside the state also can be treated as export-oriented activities.

³⁷ See: U.S. Department of Commerce, Bureau of Economic Analysis, Regional Multipliers: A User Handbook for the Regional Input-Output Modeling Systems (RIMSII), (Third Edition, 1997), U.S. Government Printing Office, Washington, D.C., 1997.

- The final demand output multiplier. This multiplier represents the change in gross output of all industries in the state that will be generated by a change in one dollar of final demand sales from the industry being examined.³⁸

- The direct earnings multiplier. This multiplier represents the change in the earnings of all households in the state from a one-dollar change in the earnings of workers in the state industry.

- The employment multiplier. This multiplier represents the change in total employment in the state from an increase of one job in the specific state industry being examined. An employment multiplier of 3.0 for a given industry would imply that an increase of one job in the industry under analysis (i.e., pharmaceutical manufacturing) would directly and indirectly create three jobs in the state economy.³⁹

The U.S. Bureau of Economic Analysis provides multiplier estimates for specific NAICS industries at the national, regional, and state level. The national multipliers for a given industry will always be greater than the value of the state multipliers for the same industry for several reasons. First, the indirect effects of an industry's expansion will be greater at the national level than at the state level since some of the purchases of goods and services by the industry will take place outside of the state. Interindustry purchases outside of the state but inside the U.S. will add to the national multiplier but not the state multiplier for that industry. Second, the induced effects of an industry's expansion will be greater at the national level than at the state level since some of the purchases of the industry's workers and owners will take place outside of the state rather than inside the state. This will be especially true when the workers and owners of the industry do not live in the same state in which the industry is located. Their induced spending will create incomes and jobs in surrounding states or states in other parts of the country.

³⁸ Final demands represent sales to final users including households, firms (in the form of new capital expenditures), local/state/federal government, or exports to other states and countries.

³⁹ The BEA multipliers are Type II multipliers that capture direct, indirect, and induced effects. Multipliers in macroeconomic analysis are generally based on marginal relationships; i.e., how a change in one variable will generate a change in another variable, *ceteris paribus*. The BEA multipliers are based on average rather than marginal relationships between variables. If the average and marginal relationships are of equal magnitude, then the BEA multipliers will accurately measure the change in outputs and employment at the margin.

The U.S. Bureau of Economic Analysis provided us with values of national and state multipliers for five bio-pharmaceutical-related industries. We selected four of these industries for our multiplier analysis. The NAICS industry codes and titles of these four industries are presented below:

- NAICS 3254000, Pharmaceutical and Medicine Manufacturing
- NAICS 339112, Surgical and Medical Instrument Manufacturing
- NAICS 339113, Surgical Appliance and Supplies Manufacturing
- NAICS 571700, Scientific Research and Development Services

For each of these four industries, we obtained estimates of three multipliers: final demand output multipliers, direct effect earnings multipliers, and direct-effect employment multipliers for the U.S., Massachusetts, and each of the other 49 states and the District of Columbia. We calculated Massachusetts' ranking among the 50 states and DC for each of these three multipliers for each of the four industries. Findings are displayed in Tables 23 to 25.

The final demand – output multipliers represent the change in the value of the gross outputs of all state industries that will occur both directly and indirectly as a consequence of a \$1 million change in final demand from the particular industry in question. For example, an output multiplier of 2.77 for the national pharmaceutical manufacturing industry would imply that a one million dollar increase in final sales of the pharmaceutical manufacturing industry would generate \$2.77 million in output in all industries across the U.S. The final demand output multipliers for the four biopharmaceutical-related industries at the national level range in value from 2.77 (pharmaceutical and medicine manufacturing) to 3.10 for scientific research and development services. Within Massachusetts, the final demand output multipliers for these same four industries varied over a fairly narrow range from 2.01 to 2.14. Massachusetts ranked well above average on three of these four multipliers, ranking 8th highest for the output multiplier for pharmaceutical and medicine manufacturing and 11th to 12th highest for the output multipliers for surgical and medical instruments and supplies.

Table 23:
Final Demand Output Multipliers in Biopharmaceutical-Related Industries of
Massachusetts and the U.S., 1997/2004

Area	Pharmaceutical and Medicine Manufacturing	Surgical and Medical Instrument Manufacturing	Surgical Appliances and Supplies Manufacturing	Scientific Research and Development Services,
U.S.	2.769	2.861	2.862	3.101
Massachusetts	2.066	2.051	2.014	2.14
Mass. Ranking Among 50 states and D.C.	8 th Highest	12 th Highest	11 th Highest	17 th Highest

Source: Regional Input-Output Modeling System (RIMS), Regional Economic Analysis Division, U.S. Bureau of Economic, tabulations by authors.

The direct-effect earnings multipliers for the four biopharmaceutical-related industries typically are higher than the output multipliers at both the national and state level, with the exception of the scientific research and development services industry.⁴⁰ The national direct-effect earnings multiplier measures the number of dollars in earnings that will accrue to all households across the country from a one-dollar increase in the earnings of workers in the industry being examined. A direct-effect earnings multiplier of 4.50 for the national pharmaceutical and medicine manufacturing industry implies that a one dollar increase in earnings of workers in this sector would generate \$4.50 in earnings for all households across the country. The national direct-effect earnings multipliers for the four biopharmaceutical industries ranged in value from a low of 2.23 for scientific R & D services to a high of 4.51 for pharmaceutical manufacturing (See Table 24). In Massachusetts, these direct earnings multipliers ranged in value from 1.71 in R & D services industries to a high of 3.28 for pharmaceutical manufacturing. Massachusetts ranked in the top ten states for three of the four bio-pharmaceutical industries, achieving the 6th and 7th highest earnings multipliers across all 50 states.

⁴⁰ The lower value of the direct earnings multiplier for R & D services is primarily attributable to the higher labor intensity of production in these industries. Labor costs are a much higher share of gross output in these industries; thus, a dollar of earnings in R & D service industries will constitute a much higher share of gross output than it will in the other biopharmaceutical industries.

Table 24:
Direct Effect Earnings Multipliers in Biopharmaceutical-Related Industries of
Massachusetts and the U.S., 1997/2004

Area	Pharmaceutical and Medicine Manufacturing	Surgical and Medical Instrument Manufacturing	Surgical Appliances and Supplies Manufacturing	Scientific Research and Development Services,
U.S.	4.507	3.070	3.291	2.226
Massachusetts	3.281	2.299	2.386	1.715
Mass. Ranking Among 50 states and D.C.	7 th Highest	6 th Highest	7 th Highest	16 th Highest

Source: Regional Input-Output Modeling System (RIMS), Regional Economic Analysis Division, U.S. Bureau of Economic, tabulations by authors.

Our third set of multipliers are direct effect employment multipliers. The value of this multiplier represents the number of jobs that will be created across all industries of the nation (state) from an increase of 1 job in a given industry at the national (state) level. Most biopharmaceutical industries in both the nation and the state have very high direct effect employment multipliers. At the national level, the pharmaceutical and medicine manufacturing industry has one of the highest direct employment multipliers (9.36). For each job created in this bio-pharmaceutical industry, more than 9 jobs will be created across the country, reflecting a combination of very large indirect and induced job creation effects. Pharmaceutical firms tend to purchase a high volume of their inputs from other industries, thereby creating high indirect effects, and workers in the industry earn high annual salaries that generate large induced effects via their purchases of consumer goods and services and new homes.

Table 25:
Direct Effect Employment Multipliers in Biopharmaceutical-Related Industries of Massachusetts and the U.S., 1997/2004

Area	Pharmaceutical and Medicine Manufacturing	Surgical and Medical Instrument Manufacturing	Surgical Appliances and Supplies Manufacturing	Scientific Research and Development Services
U.S.	9.359	5.198	5.211	3.458
Massachusetts	6.033	3.500	2.979	2.414
Mass. Ranking Among 50 states and D.C.	8 th Highest	9 th Highest	18 th Highest	19 th Highest

Source: Regional Input-Output Modeling System (RIMS), Regional Economic Analysis Division, U.S. Bureau of Economic, tabulations by authors.

The direct effect employment multipliers for the four biopharmaceutical-related industries in Massachusetts ranged in value from 2.41 for scientific research and development services to a high of 6.03 for pharmaceutical and medicine manufacturing. Massachusetts ranked 8th and 9th highest among the 50 states on its direct effect multipliers for pharmaceutical manufacturing and surgical and medical instrument manufacturing, respectively. The state ranked above average (18th and 19th) on its two other biopharmaceutical industry direct employment multipliers.

Future growth in employment in the state's biopharmaceutical-related industries would have very strong positive impacts on employment in other industries of the state, especially for pharmaceutical and medicine manufacturing and surgical and medical instrument manufacturing. Among the major beneficiaries of an expansion in pharmaceutical manufacturing are other manufacturing industries, professional and technical service industries, health care, leisure and hospitality, and retail trade.

The Net Fiscal Impacts of Workers Employed in Biopharmaceutical-Related Industries of Massachusetts

Among the economic impacts of industries are their fiscal impacts on federal, state, and local government budgets. One methodology developed by the authors for estimating the fiscal impacts of an industry's workers is to estimate the differences between the annual value of their federal and state income taxes and Social Security

payroll taxes and the value of the cash and in-kind transfers that they received from federal, state, and local governments (See Table 26).

Table 26:
A Listing of the Cash Transfer, Non-Cash Transfer, and Personal Tax Items Used in Conducting the Fiscal Impact Analysis

Total Costs to Government		Total Benefits to Government
Cash Transfers	Non-Cash Transfers	Tax Receipts
Unemployment benefits	Market value of food stamps	Federal income tax payment ⁽¹⁾
Worker's compensation	Market value of Medicare insurance	State income tax payment ⁽¹⁾
Social Security retirement benefits	Market value of Medicaid benefits	Federal retirement payroll deductions
Supplemental Social Income for the disabled and aged	Family market value of housing subsidies	Social Security retirement payroll taxes
Public assistance income	Energy assistance payments	
Veteran's payments		
Survivor's income benefits		
Earned Income Tax Credits		
Other disability incomes		

Note ⁽¹⁾ The U.S. Census Bureau assigns federal and state income tax payments of both husbands and wives in married couple families to the family householder.

Findings of our comprehensive fiscal analyses revealed that workers in biopharmaceutical-related industries of Massachusetts and the U.S. make large, net positive fiscal contributions by paying high, mean annual amounts of taxes to state and federal governments through their combined Social Security payroll, federal income tax, and state income taxes. As a consequence of their higher mean annual earnings and the high elasticity of the federal and state income tax systems, biopharmaceutical industry workers can be expected to pay considerable more on average annually in payroll and state/federal income taxes than their employed counterparts in all other industries of the state combined (Table 27). Due to their higher annual earnings from employment, less frequent unemployment, and relatively high family incomes, biopharmaceutical industry workers are less dependent than other workers on both cash (TANF, unemployment insurance, general relief) and in-kind transfers (food stamps, rental subsidies, energy

assistance, Medicaid) from state and federal governments. Biopharmaceutical industry workers and their families also are more likely to own their home, own higher valued homes, and pay more in annual property taxes to local governments. Finally, due to higher rates of health insurance coverage from their employers, workers in these industries are less likely to depend on the Medicaid or Medicare systems for their health care coverage and, thus, impose fewer health care costs on the rest of society. On average, biopharmaceutical industry workers are also healthier than other workers and less likely to be in need of comprehensive health care treatment at least in the near future.

Table 27 displays estimates of the net annual fiscal contributions of workers in biopharmaceutical-related and all other industries in Massachusetts in calendar years 2004 and 2005. The mean, net annual fiscal contribution (annual taxes paid-transfers received) of workers in biopharmaceutical-related industries of Massachusetts was \$20,157 compared to only \$9,336 for workers in all industries. Thus, the absolute size of the net, annual fiscal contribution of workers in biopharmaceutical-related industries was more than twice as high as that of workers in all industries of the Commonwealth in 2004-2005.⁴¹

Table 27:
Net Annual Fiscal Contributions of Workers (16+) in Biopharmaceutical-Related and All Industries of Massachusetts, 2004 and 2005 Averages

Fiscal Measure	(A) Biopharmaceutical- Related	(B) All Industries	(C) Biopharmaceutical Minus All Industries
(a) Taxes Paid	\$21,019	\$11,340	\$9,679
(b) Transfers Received	\$862	\$1,404	-\$542
(c) Net fiscal contribution (a – b)	+\$20,157	+\$9,936	+\$10,221

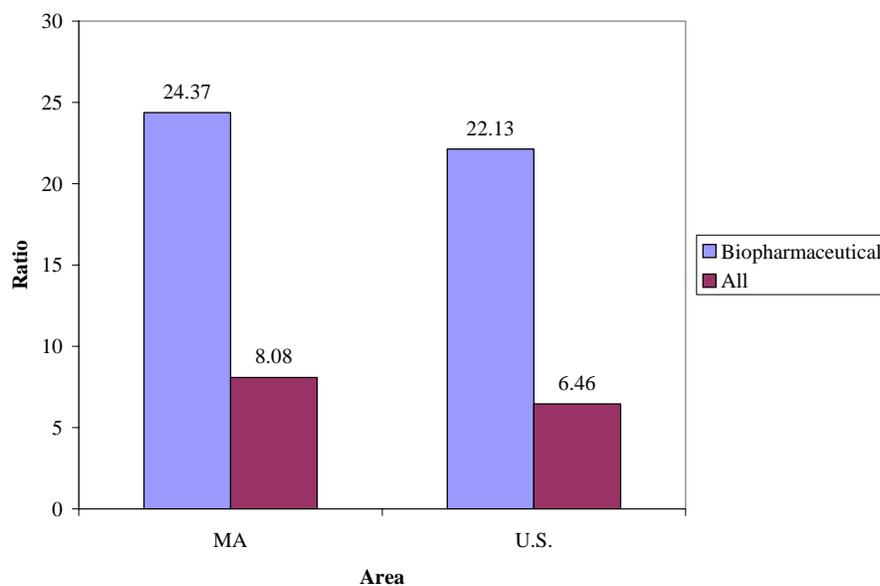
Source: March 2005 and March 2006 CPS Surveys, work experience and income supplements, public use files, tabulations by authors.

Another method for measuring the fiscal impacts of workers in biopharmaceutical-related and other industries involves calculating the ratio of mean annual taxes paid to the mean value of cash and in-kind transfers received. Chart 16

⁴¹ These estimates are quite conservative since they exclude the payroll taxes paid by the employers of these workers, the higher state sales taxes paid by biopharmaceutical workers, and their higher local property taxes.

displays the ratio of annual average tax payments to cash and in-kind benefits received by workers in biopharmaceutical-related industries and all industries within both Massachusetts and the U.S. Those workers employed in biopharmaceutical-related industries of Massachusetts paid \$24.37 in payroll and state/federal income taxes for every dollar they received in cash and in-kind transfers. The comparable ratio for workers in all industries of the state was 8.08, i.e. workers in all industries paid on average \$8.08 in income and payroll taxes for every dollar of transfers that they received. Clearly, workers in biopharmaceutical-related industries of Massachusetts were substantial net contributors to the fiscal position of both state and national governments in recent years.

Chart 16:
Ratios of Mean Annual Taxes Paid to Mean Transfers Received by
Employed Workers (16-64) in Biopharmaceutical-Related and All Industries of
Massachusetts and the U.S., 2004-2005 Averages



Local governments of Massachusetts are heavily dependent on property taxes to finance their activities. Workers in biopharmaceutical-related industries are more likely than their peers in other industries of the state to own the homes in which they live. The higher home ownership rates of workers in biopharmaceutical-related industries also were accompanied by higher property values; thus, they paid more in property taxes for their homes. The estimated median value of property taxes paid by biopharmaceutical-related workers in Massachusetts in 2005 was \$3,565, which was \$547 or 15% higher

than the median value of the property taxes paid by workers in all industries of the state who owned their homes (Table 28). This pattern of higher median property taxes for workers in biopharmaceutical-related industries held true for the entire nation. Table 29 displays the expected annual value of property taxes of workers in biopharmaceutical-related industries and all industries of Massachusetts in 2005. The expected value of annual property taxes of workers who were householders in biopharmaceutical-related industries was \$2,622 in Massachusetts. This expected annual value of property taxes paid by workers in these related industries was \$607 higher than the expected annual property tax payments of workers employed in all industries of Massachusetts. Workers in biopharmaceutical industries, thus, contribute in an important way to the fiscal position of the local governments in the communities in which they reside.

Table 28:
Median Value of Annual Property Taxes Paid by Employed Homeowners in
Massachusetts and the U.S. by Major Industry of Employer, 2005

	(A)	(B)	(C)
Geographic Area	Biopharmaceutical Industry	All Industries	Biopharmaceutical Minus All Industries
Massachusetts	\$3,563	\$3,026	\$547
U.S.	\$2,500	\$1,847	\$653

Source: 2005 American Community Surveys, public use files, tabulations by authors.

Table 29:
Estimated Expected Annual Values of Property Tax Payments by Employed
Homeowners in Massachusetts by Major Industry of Employers, 2005

	(A)	(B)	(C)
Variable	Biopharmaceutical- Related	All Industries	Biopharmaceutical Minus All Industries
Homeownership Rate	73.6%	66.6%	+7 percentage points
Median Value of Property Tax of Home Owners	\$3,563	\$3,026	\$547
Expected Value of Annual Property Tax Payments	\$2,622	\$2,015	\$607

Source: 2005 American Community Surveys, public use files, tabulations by authors.

Appendix A: A Listing of Center for Labor Market Studies Research Papers for the Pharmaceutical Research and Manufacturers of America (PhRMA)

Research Paper # 1

Ishwar Khatiwada and Andrew Sum, Data Sources and Methodologies Used in Conducting the Economic and Labor Market Analyses of Biopharmaceutical Related Industries in Massachusetts, December 2006.

Research Paper # 2

Joseph McLaughlin, Ishwar Khatiwada and Andrew Sum, Recent Trends in Payroll Employment in Massachusetts in the Pharmaceutical and Medicine Manufacturing, Surgical and Medical Instrument Manufacturing Industries, and Physical, Engineering, and Biological Research Service Industries of Massachusetts: A Comparative Perspective, December 2006.

Research Paper # 3

Ishwar Khatiwada and Andrew Sum, The Geographic Concentration and Export Orientation of Biopharmaceutical Related Industries in Massachusetts, December 2006.

Research Paper # 4

Ishwar Khatiwada and Andrew Sum, Massachusetts' Competitive Ranking Among the 50 States with Respect to Employment, Payrolls, and Revenues for Biopharmaceutical Related Industries and Overall Competitiveness Factors, January 2007.

Research Paper # 5

Ishwar Khatiwada and Andrew Sum, Trends in the Values of Shipments/Receipts of Bio-Pharmaceutical Related Industries in Massachusetts and the U.S. Over the 1997-2002 Time Period, January 2007.

Research Paper # 6

Andrew Sum, Ishwar Khatiwada and Paulo Tobar, The Occupational Structure of Employment in the State's Bio-Pharmaceutical Related Industries in 2003: Comparisons with The Occupational Employment Structure in All Industries and Selected Industrial Sectors of the State, January 2007.

Research Paper # 7

Ishwar Khatiwada and Andrew Sum, Annual Earnings Levels and Trends in the Real Annual Earnings of Workers in Biopharmaceutical Related Industries in Massachusetts and the U.S., February 2007.

Research Paper # 8

Ishwar Khatiwada and Andrew Sum, Trends in Employment, the Number of Establishments, and Workers Per Establishment in Biopharmaceutical Related Industries in Massachusetts and the U.S., March 2007.

Research Paper # 9

Ishwar Khatiwada and Andrew Sum, The Financial, Stock Market, and R&D Expenditures Performance of PhRMA Member Companies Operating in Massachusetts in Recent Years, April 2007.

Research Paper # 10

Ishwar Khatiwada and Andrew Sum with Sheila Palma, The Annual Earnings of Workers in Biopharmaceutical-Related Industries of Massachusetts And the U.S.: A Comparative Assessment, April 2007.

Research Paper # 11

Ishwar Khatiwada and Andrew Sum, Sheila Palma, and Joseph McLaughlin, A Profile of the Demographic, Socioeconomic, and Job Characteristics of the Employed in Biopharmaceutical-Related and All Industries of Massachusetts and the U.S., May 2007.

Research Paper # 12

Ishwar Khatiwada, Joseph McLaughlin and Andrew Sum, The Net Fiscal Impacts of Workers Employed in Biopharmaceutical-Related Industries of Massachusetts, June 2007.

Research Paper # 13

Paulo Tobar, Andrew Sum and Sheila Palma, Recent Employment Developments and Projected Employment Trends in Biopharmaceutical-Related Industries and Occupations in Massachusetts and the U.S., July 2007.

Research Paper # 14

Andrew Sum, Ishwar Khatiwada, Joseph McLaughlin with Sheila Palma, Economic Impacts of Biopharmaceutical-Related Industries in Massachusetts and the U.S.: Estimates of Output, Earnings, and Employment Multipliers, August 2007.

Research Paper # 15: Summary of the 14 Research Reports

Andrew Sum, Ishwar Khatiwada, Joseph McLaughlin and Sheila Palma, The Economic, Labor Market, and Fiscal Performance and Impacts of the Biopharmaceutical Industries of Massachusetts, August 2007.