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Introduction

The direct effects of biopharmaceutical-related industries in Massachusetts on a variety of economic and labor market outcomes were examined in a number of previous research papers in this series.[1] These research papers described and assessed the outputs, research and development expenditures, financial performance, and employment levels of these industries both at various points in time and over time. The demographic and socioeconomic traits of workers in these industries, the occupational characteristics of their jobs, and their annual earnings also were analyzed.

The economic and labor market impacts of an industry often go well beyond their direct effects on output, earnings, and employment in the regional, state or local economy in which they are located. Industries, especially those that export their goods or services outside of the state in which they are located, can generate important multiplier effects on the rest of the state economy.[2] These multiplier effects can 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.[3] Knowledge of the magnitude of these multiplier effects of individual industries is indispensable for evaluating their overall contributions to the state economy.

As we have shown in an earlier research paper, a major share of the output of biopharmaceutical related industries in Massachusetts is exported outside of the state, including sales to other countries.[4] Biopharmaceutical industries, thus, constitute part of the export base of Massachusetts and can generate multiplier effects on the output and employment of industries in

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[1] <u>See:</u> (i) Joseph McLaughlin, Ishwar Khatiwada, and Andrew Sum, <u>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 Industries of Massachusetts: A Comparative Perspective</u>, PhRMA Research Paper #2, December 2006; (ii) Ishwar Khatiwada and Andrew Sum, <u>Annual Earnings Levels and Trends in the Real Annual Earnings of Workers in Biopharmaceutical-Related Industries in Massachusetts and the U.S.</u> PhRMA Research Paper #7, January 2007; and (iii) Ishwar Khatiwada and Andrew Sum, <u>The Financial Stock Market, and R&D Expenditures Performance of PhRMA Member Companies Operating in Massachusetts in Recent Years</u>, PhRMA Research Paper #9, April 2007.

[2] 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 coming into Massachusetts colleges and universities from other states.

[3] 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.

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

the rest of the economy. Due to their high levels of 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 this research paper, we will define, describe, and analyze a variety of output, earnings, and employment multipliers for four biopharmaceutical-related industries in the state and compare findings for Massachusetts with those for the nation and all other states. 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 more widely known by its acronym (RIMSII).[5]

Input-Output Models and the RIMS Models of the U.S. Bureau of Economic Analysis

The economic multipliers for state biopharmaceutical-related industries that will be presented in this paper are based on a comprehensive set of national/state input-output models developed by the U.S. Department of Commerce. An input-output model provides a statistical depiction of the inter-industry linkages within a national or state economy.[6] The national or state economy is divided into a set of industries. For each industry, its gross output is allocated to either final sales (households, capital goods sales to industries, government, exports to other states/nations).[7] These linkages in terms of sales to other industries are referred to as forward linkages. The input-output models also trace purchases of each state industry from other industries in the state. These linkages are referred to as backward linkages.

The data on the gross outputs of industries and these inter-industry linkages are used to calculate a matrix of input-output coefficients (or technical coefficients). This set of data on

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

[6] For an introduction to input-output analysis and its applications to state and regional economies, See: (i) H.B. Chenery and P.J. Clark, Interindustry Economics, John Wiley, New York, 1962; (ii) M. Javin Emerson and F. Charles Lamphere, Urban and Regional Economics: Structure and Change, Allyn and Bacon, Inc., Boston, 1975; (iii) William H. Miernyk, The Elements of Input-Output Analysis, New York, Random House, 1965; (iv) William H. Miernyk, et al., Impact of the Space Program on a Local Economy: An Input-Output Analysis, West Virginia University, Morgantown, 1967.

[7] Annual gross output is the value of all revenues received from sales of the product or services plus the change in inventories. Output produced but not sold is part of the gross output of the industry.

gross outputs, final demand sales, and technical coefficients is used with a set of matrix algebra calculations to calculate the direct and indirect output requirements from each industry of the state to produce a dollar of final sales from each industry. By incorporating the economic links between households and each industry into the input-output model, we can also calculate the induced effects of an expansion of final sales from each industry. [8] As will be described more fully below, these induced effects are brought about by the spending of workers, managers, and owners of the industry on the goods and services produced by other industries across the state.

During the 1970s, the U.S. Department of Commerce's Bureau of Economic Analysis (BEA) developed a statistical methodology to estimate regional Input-Output (I-O) multipliers known as the Regional Industrial Multiplier System (RIMS). In the 1980s, the BEA enhanced this methodology, and it was called the Regional Input-Output Modeling System II (RIMS II). The multipliers for industries are based on complex set of Input-Output (I-O) tables originally developed by Wassily Leontief for which he was awarded the Nobel Prize In Economics in 1973. The I-O table shows for each industry the value of the inputs it purchased from other industries and outputs sold to other industries. RIMS II multipliers are available for 473 industries or 60 industry aggregates in the I-O table.[9] The Bureau of Economic Analysis produces these multipliers for the nation, geographic regions (New England, Mid-Atlantic), individual states, and major metropolitan areas. In this paper, we primarily rely on BEA multipliers at the state level for four major biopharmaceutical related industries.

There have been numerous input-output studies conducted in the U.S. on various industries to assess their economic impacts on regions, states, or the nation as a whole. For example, a recent study on the contribution of the biofuels industry to the Iowa economy used a variety of multipliers generated by BEA.[10] There also are studies on the economic impacts of hospitals, colleges, drug industries, the aviation industry, tourism, transportation, healthcare, biotechnology, and venture capital, at the local, state, and national level.[11] These studies use

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[8] Households both provide labor and capital services (bonds, stocks, land) to an industry for which they receive a stream of income and they purchase goods and services from industries.

[9] See: U.S. Department of Commerce, Bureau of Economic Analysis, Regional Multipliers: A User Handbook for the Regional Input-Output Modeling System, (RIMS II), U.S. Government Printing Office, Washington, D.C., 1997.

[10] See: John M. Ubarchuk, "Contribution of the Biofuels Industry to the Economy of Iowa," Prepared by LEGC LLC, Prepared for the Iowa Renewable Fuels Association, February 2007.

[11] See: (i) "The Economic Impact of the Biotechnology and Pharmaceutical Industries in New York," Published by Office of the State Comptroller, New York, February 2005; (ii) Ernst and Young, "The Economic Contribution of the Biotechnology Industry to the U.S. Economy," Prepared for the Biotechnology Organization, February 2006;

multipliers from the BEA as well as those based on their own simulations that rely on sophisticated computer modeling.

Alternative Types of Economic Multipliers in Input-Output Analysis

There are a number of different types of multipliers that can be generated by input-output models. The first general category of multipliers consists of Type I and Type II multipliers. The Type I multiplier captures only the direct and indirect effects of a change in final demand sales, earnings, or employment in a given industry. For example, a Type I final demand output multiplier would capture the direct effect of an expansion in final demand sales of industry i plus all the indirect effects via the changes in the outputs of all other industries in the state brought about by industry i's purchases from other industries. As a pharmaceutical manufacturing industry increases its sales to consumers in the state or to consumers in other states and countries,[12] the industry will directly purchase inputs of goods and services from other state industries, including itself. These industries in turn will buy goods and services from other state industries to produce additional inputs, which will then initiate another cycle of inter-industry spending of increasingly smaller sizes.[13] The combined effects of these second and third round and additional rounds of spending are the indirect effects of the increase in final demand sales of industry i. The higher the purchases by industry i from other state industries (i.e., these inter-industry linkages), the higher will be the size of these indirect effects. The value of the Type I

(iii) The Campbell-Hill Aviation Group, Inc., "Commercial Aviation and The American Economy", Prepared for the Air Transport Association of America, March 2006; (iv) Global Insight Inc., "The Economic Importance of Venture Capital Backed Companies to the U.S. Economy", Prepared for National Venture Capital Association, 2007; (v) Eastern Research Group Inc., "Economic Analysis for Final Effluent Limitations Guidelines and Standards for the Pharmaceutical Industry", Report Prepared for U.S. Environmental Protection Agency (EPA), July 1998; (vi) American Hospitals Associations, "Beyond Healthcare: The Economic Contributions of Hospitals", 2006; (vii) "Economic Impact of Skidmore College on Saratoga County", Prepared by Capital District Regional Planning Commission, Albany, New York, April 2007; (viii). Ross DeVol, Rob Koepp with Perry Wong and Armen Bedroussian, "The Economic Contributions of Health care to New England", A Report Prepared by Milken Institute for New England Healthcare Institute, February 3003; (ix) The Boston Consulting Group, "MassBiotech 2010: Achieving Global Leadership in The Life-Sciences Economy", Prepared for Massachusetts Biotechnology Council, 2002; (x) Tim Lynch, "Florida High Speed Ground Transportation Economic Benefit and Cost Impact Restudy and Public Transportation Financing and Subsidies by Mode in the United States", Econometrics Consultant Inc., August 2002.

[12] In a state input-output model, sales to consumers within the state are treated as consumption expenditures under the final demand matrix while sales to consumers in other states and countries would be classified as export sales under the final demand matrix.

[13] In input-output models, the size of the direct and indirect requirements from each industry to produce a dollar of gross output from industry i are estimated by inverting the [I – A] matrix of coefficients where A is the technical coefficients matrix and I is the identify matrix.

multiplier for a given industry is calculated by dividing the sum of the direct and indirect effects by the direct effects (Table 1).

<div align="center">
Table 1:
The Formulas for the Two Types of Multipliers in Input-Output Analysis
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Type I Multiplier	=	$\dfrac{\text{Direct} + \text{Indirect Effects}}{\text{Direct Effects}}$
Type II Multiplier	=	$\dfrac{\text{Direct} + \text{Indirect} + \text{Induced Effects}}{\text{Direct Effects}}$

The Type II multiplier captures the direct, indirect, and induced effects of an expansion in final sales, earnings, or employment in a given industry. The induced effects capture the impacts of the spending of workers, managers, and owners in the affected industry. When an industry expands its output level, it will create a stream of wages and salaries for its workforce and a stream of profits/interest/rents for its owners. These workers and owners will spend a portion of their incomes on goods and services and new housing produced by other state industries, thereby expanding output, earnings, and employment in these other state industries. The higher the wages and salaries of workers in the industry, the higher their degree of residency in the state, the higher their propensity to consume locally produced goods and services, and the higher the geographic concentration of owners in the state, the higher will be the size of these induced effects. As revealed in several of our earlier research papers, mean annual wages and salaries of biopharmaceutical industry workers in Massachusetts are considerably above the statewide average, and the vast majority of workers in these industries reside in the state.[14] Both of these developments will raise the induced effects from an expansion of final demand sales and employment in biopharmaceutical industries, thereby increasing the value of Type II multipliers. The value of the Type II multiplier for a given industry is calculated by dividing the sum of the direct, indirect, and induced effects by the direct effect (Table 1). The higher the indirect and induced effects, the higher will be the value of the Type II multiplier.

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[14] See: 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. PhRMA Research Paper #7, January 2007; and Andrew Sum, Ishwar Khatiwada with Meredith Franks and Sheila Palma, The Annual Earnings of Workers in Biopharmaceutical-Related Industries of Massachusetts and the U.S.: A Comparative Assessment, Research Paper #10, April 2007.

A variety of economic multipliers can be produced through the application of input output analysis particularly when the I/O analysis is supplemented by earnings and employment data by industry. Among the types of multipliers used in economic impact studies at the national, state, and local level are output, earnings, income, and employment multipliers. In its RIMS modeling, the U.S. Bureau of Economic Analysis produces values for the following five types of multipliers (See Table 2 for a description of the formula for each type of multiplier).

- Final demand output multipliers

- Final demand earnings multipliers

- Final demand employment multipliers

- Direct-effect earnings multipliers

- Direct-effect employment multipliers

Table 2:
Algebraic Formulas for the Five Types of Industry Multipliers
Available from the BEA RIMS Modeling at the State Level

(1)	Final demand output multiplier of industry i	=	$\dfrac{\Delta \text{ in Gross Output of All State Industries}}{\Delta \text{ in Final Demand of Industry } i}$
(2)	Final demand earnings multiplier of industry i	=	$\dfrac{\Delta \text{ in Earnings of All Workers in State}}{\Delta \text{ in Final Demand of Industry } i}$
(3)	Final demand employment multiplier of industry i	=	$\dfrac{\Delta \text{ Total Employment in State}}{\Delta \text{ in \$1 million dollars in final demand sales of industry } i}$
(4)	Direct earnings multiplier of industry i	=	$\dfrac{\Delta \text{ in Earnings of All Workers in State}}{\Delta \text{ in Earnings of Industry } i}$
(5)	Direct employment multiplier of industry i	=	$\dfrac{\Delta \text{ in Total Employment in State}}{\Delta \text{ in Employment in Industry } i}$

Each of the final demand multipliers is designed to measure the change in the outcome being analyzed (output, earnings) from a given level of change in final demand delivered by the industry being analyzed. For example, the final demand output multiplier represents the change in the gross output of all industries in a state from a change in one-dollar of final demand sales from a given industry (e.g., pharmaceutical manufacturing). The output multiplier captures direct, indirect, and induced output effects of the increase in final demand.

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The final demand earnings multiplier captures the increase in the total earnings from employment of all household members in the state from a change in final demand sales from industry i. The value of this multiplier will be influenced by the size of the direct, indirect, and induced earnings effects from an expansion in final demand sales of the industry. The size of the direct earnings effects of biopharmaceutical industries vary across industry subgroup. They are smaller in more capital intensive and R&D intensive industries such as pharmaceutical and medicine manufacturing where the earnings of workers are a smaller share of gross output. The direct earnings effects are large in more human capital intensive industries such as scientific research and development industries where the earnings of workers employed by the industry account for a higher share of the gross output of the industry.

The third multiplier is the final demand employment multiplier of industry i. This multiplier measures the number of additional jobs that will be created across all industries of the state from a $1 million increase in final sales of industry i. A final demand employment multiplier for an industry equal to 8.2 implies that an additional million dollars in final demand sales will create 8.2 jobs in the state's economy. These job creation effects capture the direct, indirect, and induced employment effects of this additional billion dollars in final sales.[15] For this employment multiplier, the BEA also identifies the major industrial sectors in which these additional jobs will be created by an expansion of final sales in industry i.

There are two other types of multipliers produced by the U.S. Bureau of Economic Analysis for industries in each state. They are the <u>direct earnings multiplier</u> and <u>the direct employment multiplier</u>. The definitions of these two alternative multipliers are displayed below.

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

- The direct 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 5.0 for a given industry would imply that an increase of

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[15] The key assumption underlying these calculations is that the marginal change in employment per dollar of output in each industry is equal to the average ratio of employment per dollar of gross output in each industry. For this relationship to hold true, there should be no significant degree of underemployment of workers in these industries at the time of the expansion in sales.

one job in the industry under analysis (i.e., pharmaceutical manufacturing) would directly and indirectly create five jobs in the state economy.

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 a given 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.

The U.S. Bureau of Economic Analysis provided us with values of national and state multipliers for five biopharmaceutical-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 four multipliers: final demand output multipliers, final demand employment 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 3 to 6.

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 (including induced effects) as a consequence of a $1 million change in final demand from the particular industry in question. For example, an output multiplier for 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 3:
Final Demand Output Multipliers in Biopharmaceutical -Related Industries of
Massachusetts and the U.S.

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.	8th Highest	12th Highest	11th Highest	17th Highest

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

Our second multiplier is the final demand employment multiplier. As described earlier, it measures the number of jobs that will be created across the entire nation or state from a $1 million increase in final demand sales by the industry. For both the nation and the state, these final demand employment multipliers varied quite widely across the four biopharmaceutical related industries. For the U.S., the size of these multipliers ranged from a low of approximately 12.6 for pharmaceutical and medicine manufacturing industries to a high of 24.2 for scientific research and development services. In Massachusetts, these final demand employment

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multipliers ranged from a low of 7.4 jobs per $1 million in pharmaceutical and medicine manufacturing to a high of nearly 23 jobs per $1 million in sales of scientific research and development services. The manufacturing segments of biopharmaceutical do not create as many jobs per $1 million of sales as research and development services for several different reasons. Annual wages and salaries including bonuses and stock options per worker tend to be higher in the biopharmaceutical manufacturing sector, specifically pharmaceutical manufacturing. The manufacturing industries are more capital intensive; thus, they generate directly fewer jobs per million dollars of sales than research and development services. Also, some of the key industrial suppliers of R&D services appear to be more labor intensive in their operations.

Table 4:
Final Demand Employment Multipliers in Biopharmaceutical-Related
Industries of Massachusetts and the U.S.

Geographic Area	(A) Pharmaceutical and Medicine Mfg.	(B) Surgical and Medical Instrument Mfg.	(C) Surgical Appliances and Supplies Mfg.	(D) Scientific Research and Development Services
U.S.	12.58	16.11	15.72	24.19
Massachusetts	7.39	9.76	9.84	14.97
Massachusetts Ranking Among 50 States and DC	29th	39th	40th	43rd

For this final demand employment multiplier, Massachusetts biopharmaceutical industries tend to rank below average in comparison to those for all other states. The highest rank achieved was 29th and the lowest was 40th. Massachusetts biopharmaceutical industries pay high annual wages and salaries for their workers than most of their national counterparts, and their suppliers also pay above average wages. As a consequence fewer jobs will be created for a given dollar amount of final sales in Massachusetts.

In addition to estimating the total number of jobs that will be created across all sectors of the state from an increase of $1 million in final sales by a given industry, the U.S. Bureau of Economic Analysis also generates estimates of the distribution of those jobs across 20 different major industrial sectors of the state. In Table 5, we display the findings on the industrial

distribution of the jobs in Massachusetts that would be created by a $1 million increase in final sales by the pharmaceutical and medicine manufacturing industry and the scientific research and development industries of the state. Findings for all four biopharmaceutical-related industries are displayed in Appendix B.

Table 5:
The Number of Jobs That Will Be Created in Each Major Industrial Sector of Massachusetts from a $1 Million Increase in Final Sales by the Pharmaceutical and Medicine Manufacturing Industry and the Scientific Research and Development Industry

Pharmaceutical Manufacturing (NAICS 3254)		Scientific Research and Development Services (NAICS 5417)	
Sector	Jobs	Sector	Jobs
1. Manufacturing	1.90	1. Prof./Scientific/Tech.	6.97
2. Management of Companies	.64	2. Health Care/Social Assistance	1.20
3. Prof./Tech./Scientific Services	.63	3. Accommodate/Food Services	1.04
4. Health Care/Social Assistance	.63	4. Administrative/Waste Mgt.	1.03
5. Accommodation/Food Services	.59	5. Retail Trade	1.01
6. Retail Trade	.54	6. Manufacturing	.61
7. Wholesale Trade	.41	7. Other Services	.50
8. Administrative/Waste Mgt.	.32	8. Finance/Insurance	.48
9. Finance/Insurance	.29	9. Real Estate and Rental	.35
10. Other Services	.28	10. Transportation/Wholesaling	.30
11. Information	.24	11. Wholesale Trade	.29
12. Transportation/Warehousing	.23	12. Information Services	.27
13. Educational Services	.19	13. Educational Services	.25
14. Real Estate and Rental	.18	14. Arts/Entertainment	.18
15. Arts, Entertainment	.11	15. Management of Companies	.15
16. Household Services	.06	16. Household Services	.12
17. Agriculture/Forestry/Fishing	.06	17. Construction	.09
18. Construction	.04	18. Agriculture/Forestry/Fishing	.06
19. Utilities	.03	19. Utilities	.04
20. Mining	.01	20. Mining	.01
Total, All Sectors	7.39	Total, All Sectors	14.97

Overall, $1 million in final sales by the pharmaceutical and medicine manufacturing industries would be expected to create approximately 7.4 jobs across the state. The highest number of such jobs would be created in manufacturing industries of the state (1.9 jobs); however, nearly 3 of every 4 new jobs created would be outside of the manufacturing sector. Another 1.9 jobs would be created in the health care and professional/scientific/technical

services industries of the state through strong backward linkages between pharmaceutical and medicine manufacturing industries and these industries, including the provision of research and development services. The induced spending of workers and managers of pharmaceutical manufacturing firms would create another 1.13 jobs in retail trade, food services, and accommodations industries. Another .7 jobs would be created in finance/insurance, information services, and educational services industries (See Table 5).

A $1 million increase in final sales by the state's scientific research and development services industries would be expected to create nearly 15 jobs across the state, with approximately half of these jobs being created in the professional, scientific, and technical services sector. Slightly over half of these 15 jobs would be created in other industrial sectors of the state, with health care/social assistance, administrative/waste management, and manufacturing sectors accounting for about one-half of the jobs in the other 19 sectors of the state economy. The state's retail trade and food services/accommodation industries also are important beneficiaries of an expansion in final sales by biopharmaceutical-related scientific research and development services industries in the state.

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.[16] The 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 6). 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

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[16] 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.

ranked in the top ten states for three of the four biopharmaceutical industries, achieving the 6th and 7th highest earnings multipliers across all 50 states.

Table 6:
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.	7th Highest	6th Highest	7th Highest	16th Highest

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

Our fourth 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 multiplier (9.36). For each job created in this biopharmaceutical 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, 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 7:
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.	8th Highest	9th Highest	18th Highest	19th 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.

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.