

**Economic Impact on Delaware's Economy:
The Biopharmaceutical & Related Sectors**

By

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Executive Summary

The Center for Applied Demography & Survey Research at the University of Delaware conducted this study to measure the economic impact of the biopharmaceutical and related sectors in Delaware during 2008. The study was made possible by a grant from the Pharmaceutical Research and Manufacturers of America (PhRMA). The Center conducted the study independently and the authors are solely responsible for the design and execution of the study.

The Center employed the REMI Policy Insight model which is a dynamic economic simulation model. Since it is a structural model, it is capable of estimating causal relationships. It is a general equilibrium model with feedback. The REMI model is tailored to Delaware using data from the Bureau of Census, the Bureau of Economic Analysis, the Bureau of Labor Statistics and the Energy Information Administration among others.

Biopharmaceutical companies are a relatively diverse group. Consequently no single sector fully captures all companies engaged in biopharmaceutical-related activities. Therefore, biopharmaceutical companies must be identified by looking at multiple sectors. Two tiers of activities were defined to allow for a narrow definition and a broader definition of the sector. The general findings of the impact study are outlined below.

- In 2008 nearly 11,500 people were employed in the sector.
- While employment in the sector has declined slightly due to mergers and acquisitions, both nominal sector wages and the number of establishments are rising. Trends in general have been positive in both the United States and Delaware.
- Aggregate sector wages approach \$1.25bn and an estimated \$59.7m in state personal income taxes were paid.
- Annual wages in this sector (\$110,000) are significantly higher than in all other sectors in Delaware. Those wages have been rising more rapidly as well.

- The biopharmaceutical sector is clearly export-based and thus has a significant positive impact on the entire economy.
- While Delaware is small, the biopharmaceutical sector's share of Delaware's jobs and wages is 6th largest in the US.
- In spite of its small size, Delaware ranks 20th over the past five years in the number of biopharmaceutical patents. However, if this is adjusted for the size of the state, Delaware ranks 3rd behind Connecticut and Massachusetts.
- Collectively, Delaware's biopharmaceutical sector generates \$4.5bn in sales annually and that is growing.
- Activities of the sector generate an additional 15,500 jobs annually over and above the 11,500 employed directly by the sector.
- The direct and indirect impact of the sector generates \$3.1bn in gross state product (5.1% of total GSP) and \$1.7bn in personal income (4.8% of total PI).
- The sector pays an estimated \$9.5m in corporate income taxes, \$7.5m in property taxes, \$435m in employee benefits, \$66m in corporate charitable contributions, and their employees contribute another \$47m annually.
- The overall outlook for this sector both locally and nationally is positive, and employment is expected to grow steadily over the next twenty years.

Introduction

The Center for Applied Demography & Survey Research at the University of Delaware conducted this study to measure the economic impact of the biopharmaceutical and related sectors in Delaware during 2008. The study was made possible by a grant from the Pharmaceutical Research and Manufacturers of America (PhRMA). The Center conducted the study independently and the authors are solely responsible for the design and execution of the study.

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Biopharmaceutical companies are a relatively diverse group. Consequently no single sector fully captures all companies engaged in Biopharmaceutical-related activities. Therefore, Biopharmaceutical companies must be identified by looking at multiple sectors. While there is no formal definition of what sectors comprise Biopharmaceutical, some consensus has emerged through various published reports. Commonly cited Biopharmaceutical sectors are:

325412	Pharmaceutical Preparation Manufacturing
541711	Research and Development in Biotechnology
541712	R&D in the Physical, Engineering, and Life Sciences

These sectors serve as a starting point to measuring the impact of Biopharmaceuticals in Delaware.

Firms are classified into sectors based upon their primary function. This can lead to certain firms who are engaged in Biopharmaceutical activities to fall outside of the above mentioned sectors. A noteworthy example is a Delaware Biopharmaceutical company whose local operation is also a regional managing office. Under the North America Industry Classification system, this company will fall in a different industry code than those above.

With this caveat in mind, the research began by first identifying the Delaware companies that fall in the three sectors above. Added to these companies were known Delaware Biopharmaceutical establishments that fall into NACIS 551114: Corporate, Subsidiary, and Regional Managing Offices of Biopharmaceutical Companies. This collection defines the base of Delaware’s Biopharmaceutical industry.

Delaware’s Biopharmaceutical activities extend beyond these afore-mentioned sectors, however. An extended definition of the Biopharmaceutical industry is created by adding NAICS 3391 (Medical Equipment and Supplies Manufacturing) and NAICS 3345 (Navigational, Measuring, Electro medical, and Control Instruments Manufacturing) to the base group. The terms “base industry” and “extended industry” are summarized in Table 1 and will be used throughout the report.

Table 1
Classification of Biopharmaceutical Firms

NAICS Code	Class	Description
325412	Base & Extended	Pharmaceutical Preparation Manufacturing
541711	Base & Extended	Research and Development in Biotechnology
541712	Base & Extended	R&D in the Physical, Engineering, and Life Sciences
551114	Base & Extended	Corporate, Subsidiary, and Regional Managing Offices of Biopharmaceutical Companies
3391	Extended only	Medical Equipment and Supplies Manufacturing
3345	Extended only	Navigational, Measuring, Electro Medical, and Control Instruments Manufacturing

The data are drawn from a number of sources. Department of Labor data are a principle source. These quarterly data contain sector detail, monthly employment, and quarterly wages for Delaware's approximately 30,000 businesses that are subject to the Unemployment Insurance program (UI). Using the aforementioned NAICS codes, it is possible to identify the individual companies that comprise Delaware's Biopharmaceutical sector. The list of these candidate companies are then verified with the Delaware Economic Development Office and PhRMA to check for errors and omissions. Once identified, it is possible to construct establishment counts, employment, and wage data for the industry.

The Department of Labor data provide very detailed NAICS data. Other data sources, such as the Bureau of Labor Statistics (BLS), Bureau of Economic Analysis (BEA), and the Economic Census do not offer data as detailed. The reason is that these agencies typically suppress the most detailed sector data to protect the confidentiality of firms. This necessitates using data that are slightly aggregated from the six-digit NAICS listed above. These data still provide great insight into the state's Biopharmaceutical sector even at this level of detail. Moreover, these sources provide data for inter-industry and interstate comparisons. The research reported here uses the most detailed available data.

The employment and wage data gleaned from Department of Labor and other sources form the inputs to the economic impact modeling process. The REMI model is a computable general equilibrium model of the state economy. The employment and wage measures calculated from the various data sets are then used to trace the total impact of Biopharmaceutical activities in the state. Further description about the modeling process is contained in the section "Impact on the People of Delaware."

Trends in the Sector

Delaware's biopharmaceutical companies are significant employers in the state. Nearly 11,500 positions were held within the extended industry in 2008. While sector employment is slightly lower than it was in 2003, both sector wages and establishment numbers are rising (which is in line with the national trend).

Companies are classified by their primary function. Therefore a biopharmaceutical company's headquarters may find its employment being reported under the "management of companies" category, even though its line of business is Biopharmaceuticals. In 2008, employment in the Biopharmaceutical sector was mainly concentrated in scientific research activity. The sector with the second highest employment was the management of companies, followed by navigational, measuring, electro medical, and control instruments manufacturing. The fourth largest sector for employment includes those medical equipment and supplies manufacturing companies. The chemical manufacturing sector employs the fewest individuals in Delaware's Biopharmaceutical industry. Confidentiality stipulations prevent these magnitudes from being reported.

The table below compares the trends in Biopharmaceutical average annual employment for Delaware versus the U.S. Delaware's Biopharmaceutical sector has shed between 962 and 1,282 jobs (depending on which definition is being considered) over the period 2003-2008.

Table 2
Biopharmaceutical Employment Trends 2008

Industry	Employment	Change 2003-2008	DE TREND	U.S. TREND
Base	7,773	(1,193)	DOWN	UP
Extended	11,482	(962)	DOWN	UP

Source: Bureau of Labor Statistics, Covered Employment and Wages Program.
Delaware Department of Labor

While the aggregate number of employees has trended downwards since 2003, the number of Biopharmaceutical companies is rising in Delaware—in line with the national trend. Delaware has added an average of 13 Biopharmaceutical operations between 2003 and 2008. The information in Tables 2 and 3 implies that the average employment per establishment has fallen.

Table 3
Biopharmaceutical Establishment Trends 2008

Industry	Establishments	Change 2003-2008	DE TREND	U.S. TREND
Base	80	15	UP	UP
Extended	122	13	UP	UP

Source: Bureau of Labor Statistics, Covered Employment and Wages Program.
Delaware Department of Labor

Total wages paid by Delaware Biopharmaceutical companies have been posting solid growth over the past five years. Both base and extended industry definitions experienced over 19% growth in total wages paid between 2003 and 2008.

Table 4
Biopharmaceutical Wages 2008

Industry	Delaware	Change 2003-2008 (\$)	DE TREND	U.S. TREND
Base	\$979,745,502	\$157,666,629	UP	UP
Extended	\$1,261,709,067	\$223,033,824	UP	UP

Source: Bureau of Labor Statistics, Covered Employment and Wages Program.
Delaware Department of Labor

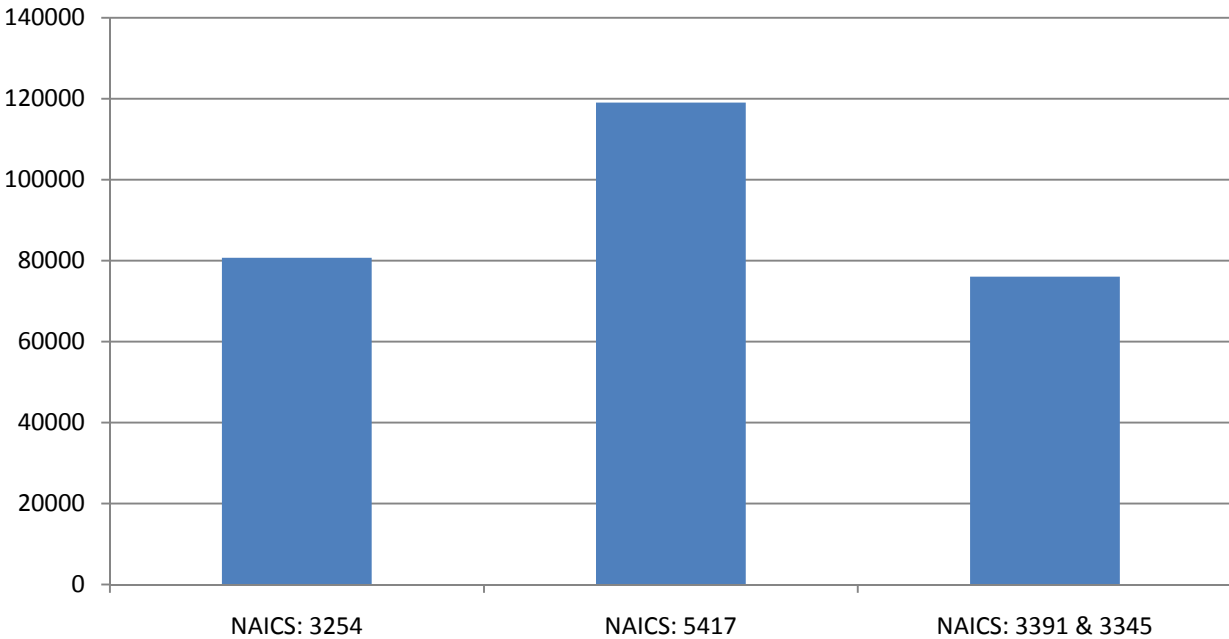
Table 5
Estimated Personal Income Taxes Paid in Delaware 2008

Industry	State Taxes	Effective Tax Rate
Base	\$47,798,218	4.88%
Extended	\$59,686,550	4.73%

Source: Delaware Department of Finance and Delaware Department of Labor

Personal income tax revenues to the State of Delaware are presented in the table above. Delaware personal tax revenue may be derived using the total wages by sector, and applying the effective personal income tax rate per the Delaware Department of Finance. Assuming all Biopharmaceutical employees reside in Delaware, the estimated tax revenues is approximately \$47.8 million for the base industry and \$59.7 million for the extended industry.

Figure 1
Average Annual Salaries of Delaware Biopharmaceutical Employees in 2008



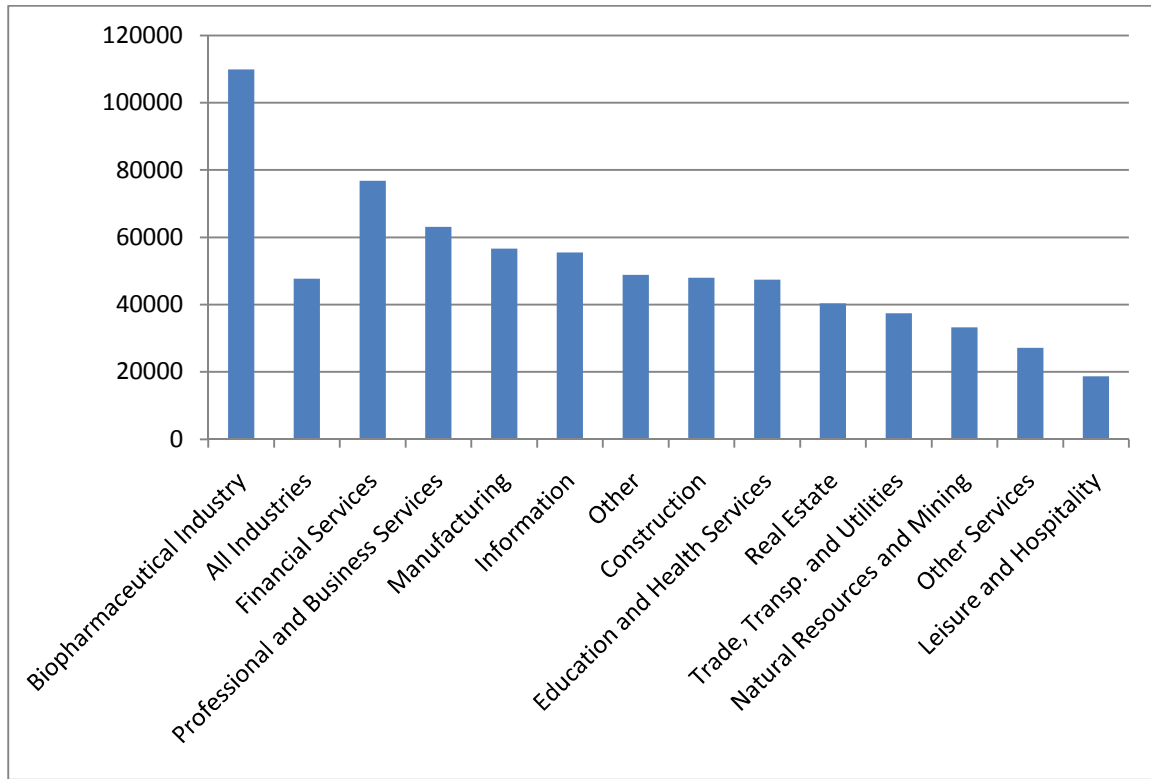
Source: Delaware Department of Labor

The average annual wage within the Delaware Biopharmaceutical sector is substantial. The average wage varies considerably between the different types of firms found in the sector. Employees of those companies devoted to research and development (NAICS 5417) receive nearly 50% higher salaries on average than employees in two of the other biopharmaceutical sectors.¹

Overall, Delaware Biopharmaceutical companies pay significantly higher wages than other industries in the state. The average Biopharmaceutical wage is slightly below \$110,000, which is more than double the average wage for Delaware (see chart below).

¹ Data from the Corporate, Subsidiary, and Regional Managing Offices sector of the biopharmaceutical industry is confidential.

Figure 2
Delaware Average Annual Salaries: Biopharmaceutical and Other Industries



Source: Delaware Department of Labor

This chart in particular illustrates the importance of the sector to Delaware. Clearly the biopharmaceutical sector attracts well educated and thus highly compensated individuals to the state, especially in comparison to other sectors. Fortunately, this is only one of several positive characteristics of the sector.

Delaware's biopharmaceutical wages are rising which further bolsters the impact of the sector. Since 2003, average biopharmaceutical salaries increased 22.8%, while average annual pay across all Delaware industries grew by only 15.5% in the same period (source: BLS Covered Employment and Wages Program, Total Covered Annual Wages 2002-2007).

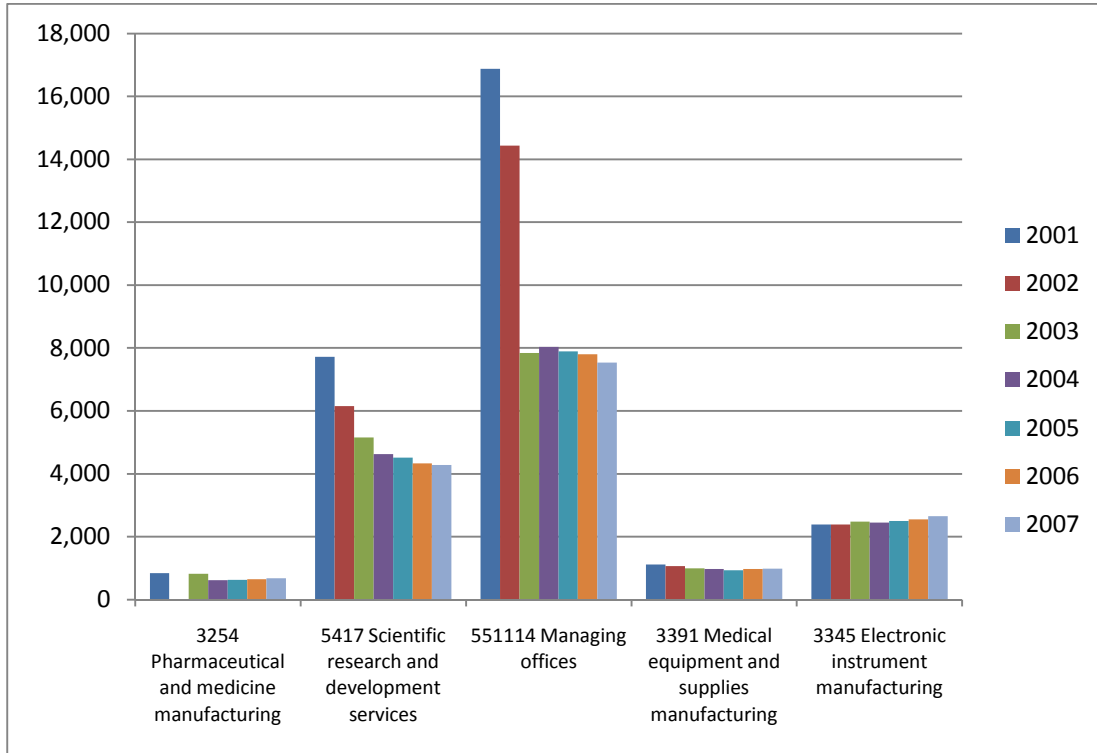
Table 6
Delaware Biopharmaceutical Employment and Establishments

Sector	Employees	Total Establishments
32541 Pharmaceutical and Medicine Manufacturing	1,000-2,499 New Castle 250-499 Sussex	4 New Castle 2 Sussex
3345 Navigational Electro Medical and Control Instruments Manufacturing	1,000-2,499 New Castle 0-19 Sussex	17 New Castle 1 Sussex
3391 Medical Equipment and Supplies Manufacturing	250-499 Kent 100-249 New Castle 250-499 Sussex	5 Kent 15 New Castle 2 Sussex
54171 Research and Development in the Physical, Engineering and Life Sciences	0-19 Kent 5,000-9,999 New Castle 0-19 Sussex	2 Kent 48 New Castle 1 Sussex
551114 Corporate, Subsidiary and Regional Managing Offices	308 Kent 10,787 New Castle 100-249 Sussex	13 Kent 124 New Castle 13 Sussex

Source: County Business Patterns. Employees are the number of employees for the week including March 12th, 2006. Not all establishments may be reported, resulting in some variation compared to other sources.

County Business Patterns (Census) data confirm the biopharmaceutical employment and establishment data from other sources. Biopharmaceutical-related firms and employees are concentrated in New Castle County. Across the five sectors listed above, New Castle bests Kent and Sussex in each for employment and establishments.

Figure 3
Trends in Biopharmaceutical-Related Employment



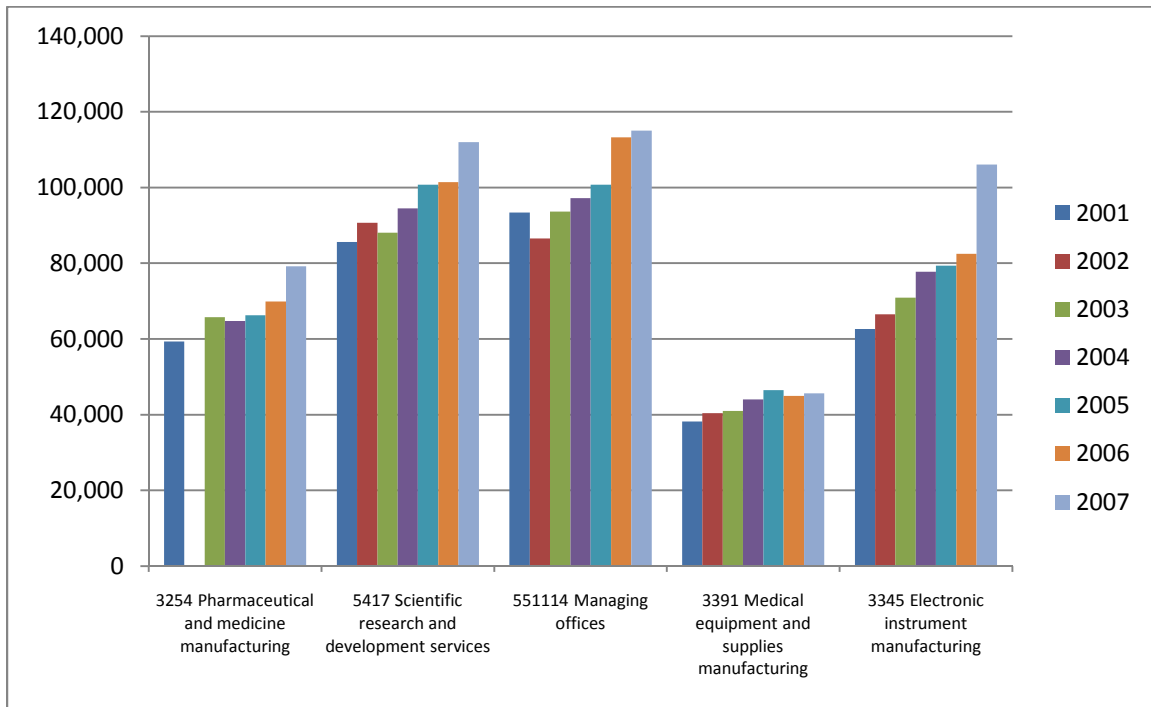
Source: Bureau of Labor Statistics, Covered Employment and Wages. 2002 Pharmaceutical and medicine manufacturing is not available due to a reporting error. 551114, Managing offices, includes all establishments, not just biopharmaceutical enterprises.

Per Bureau of Labor Statistics Covered Employment and Wages (BLS CEW) data, the fall in Biopharmaceutical employment began in 2003. Pharmaceutical and medicine manufacturing employment fell from 823 in 2003 to 620 in 2004. Scientific research and development services (5,417) also shed jobs in 2003, although this downturn began earlier. Managing offices also

pared payroll in 2002. While this trend began earlier, the cull in 2002 was significantly greater than in prior years.

The chart above shows Delaware biopharmaceutical-related employment by sector 2001-2007. Managing offices is the single largest sector and has seen a sharp decline in employment from 2001 to 2003, after which employment stabilized. It should be noted that these data reflect *all* managing offices in Delaware, and not simply the few that are managing offices of biopharmaceutical companies. Of the sectors shown above, managing offices is the least pure measure of the Biopharmaceutical sector.

Figure 4
Delaware Biopharmaceutical-related Sectors Average Annual Wages



Source: Bureau of Labor Statistics, average annual pay, unadjusted dollars. 2002 is omitted for 3254 Pharmaceutical and medicine manufacturing due to a reporting error.

BLS data indicate that scientific research and development services are experiencing a downward trend in employment. However, the rate of decline is dissipating. Research employment is approximately 4,000 in 2007.

Medical equipment and supplies manufacturing employment has been relatively stable since 2002. Electronic instrument manufacturing is bucking the trend by adding jobs over the period 2001-2007.

Pharmaceutical and medicine manufacturing employment has fallen from its peak in 2002. Currently, employment is hovering just below 1,000. It is noteworthy that although pharmaceutical and medicine manufacturing employment is small relative to other Biopharmaceutical-related sectors, its impact on the economy is large.

Average annual pay among biopharmaceutical-related sectors is growing strongly. Universally, annual pay is higher in 2007 than 2001. In 2007, workers in scientific research and development services, managing offices, and electronic instrument manufacturing boasted six-figure annual pay.

Location quotients identify clusters and export industries. A location quotient compares the local concentration of employment in a particular sector against some benchmark employment concentration, usually the national average. Location quotients greater than one indicate that local employment is more concentrated in a sector than the national average. See below.

Table 7
Interpreting Location Quotients

Location Quotient	Interpretation
Greater than one	Local employment is more concentrated in an industry than the national average.
Equal to one	Local employment is as concentrated in an industry as the national average.
Less than one	Local employment is less concentrated in an industry as the national average.

Many Biopharmaceutical-related sectors in Delaware have location quotients in excess of one, which indicates an export based industry or economic cluster. Electronic instrument manufacturing, which includes electro medical devices, has almost double the share of state employment than the national average. Physical engineering and biological research employment's share of total employment is two and a half times greater than the national average. Medical equipment and supplies manufacturing employment as a share of total employment, is fractionally higher than the national average.

Only pharmaceutical and medicine manufacturing has a location quotient of less than one, suggesting a low concentration of employment in this industry relative to the nation. However, this statistic may be biased by a number of pharmaceutical and medicines manufacturers in the state which also serve as regional managing offices. In such a case as this, their employment will fall in the managing offices category. Overall, Delaware's Biopharmaceutical sector represents an export-based orientation, which bolsters its contribution to the economy. Export-based sectors grow beyond the local market. By tapping larger markets, the export-based sectors bring direct revenue into the state. This, in turn, generates indirect effects on other state sectors

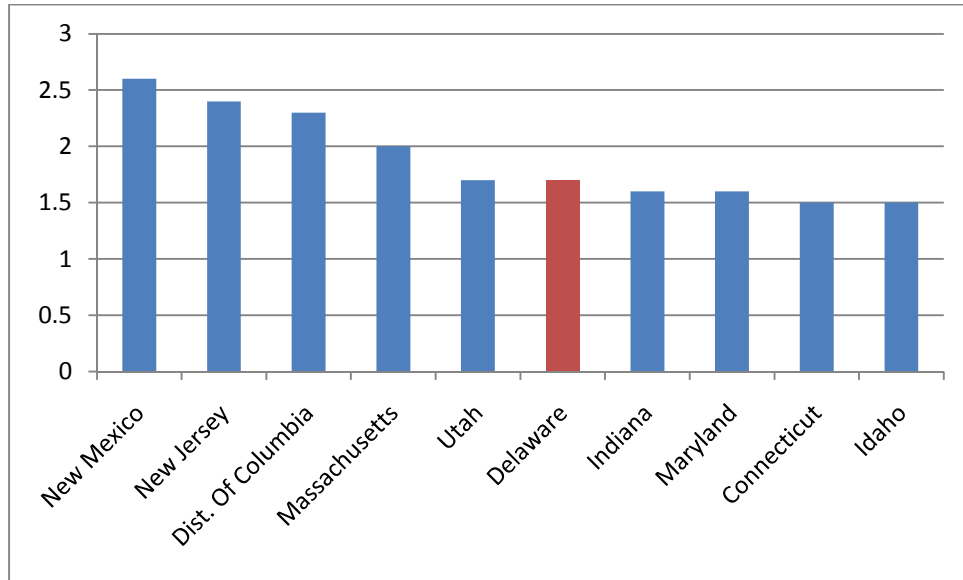
through the purchases of inputs from other local firms. Finally, local purchases made by workers within these sectors positively impact the local firms.

Table 8
Location Quotients

Sector	Location Quotient	Percent of Delaware Private Employment (%)	Percent of U.S. Private Employment (%)
Pharmaceutical and medicine manufacturing (3254)	0.72	0.19	0.26
Electronic instrument manufacturing (3345)	1.87	0.73	0.39
Medical equipment and supplies manufacturing (33911)	1.02	0.27	0.27
Physical engineering and biological research (54171)	2.50	1.17	0.47
Managing offices (551114)	1.35	2.07	1.53

Source: Bureau of Labor Statistics, Covered Employment and Wages Program. 2007 annual figures.

Figure 5
Top 10 Ranked States by Share of Biopharmaceutical-Related Wages/Jobs in 2005



Source: Biopharmaceutical Industries of Massachusetts: Economic, Labor Market, and Fiscal Performance Impacts, Northeastern University, November 2007.

A further gauge of a sector's importance to an economy is the size of its employment relative to the total state employment. While Delaware's Biopharmaceutical-related employment is relatively small next to other larger states, as a percentage of the total employment the state ranks in the top ten.

The figure above shows the top ten states ranked by Biopharmaceutical-related sectors' share to total private sector jobs. Almost two percent of Delaware's private sector wage and salary jobs are in Biopharmaceutical sectors. This is the sixth highest in the nation.

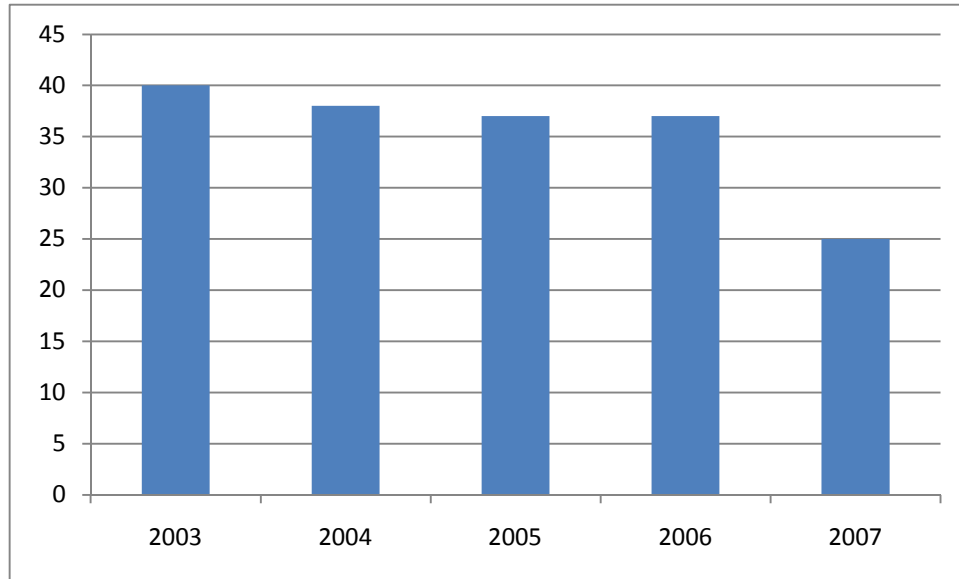
Outputs of the Sector

Biopharmaceutical operations in Delaware produce a diverse range of products and services. These include pharmaceutical products, research and development, clinical diagnostic products and services, and molecular biotechnology research, to name but a few.

The value of goods and services produced by this Delaware sector has grown steadily over the past five years. Chemical manufacturing, which includes pharmaceutical manufacturing, grew from \$863m in 2003 to \$1.7bn in 2006 (the latest year of data available, source BEA). Other professional, scientific and technical services, which encompass the largest share of Biopharmaceutical employment in the state, saw the value of goods and services grow from \$2.0bn in 2003 to \$2.2bn in 2006.

Biopharmaceutical patenting has been brisk among Delaware companies. A total of 177 patents have been granted since 2003 in the area of drug, bio-affecting and body treating compositions. See below.

Figure 6
Delaware Biopharmaceutical Patents



Source: U.S. Patent and Trade Mark Office: <http://www.uspto.gov/go/taf/reports.htm>

Table 9
Delaware Patents by First-Named Assignee

First-Named Assignee	2003	2004	2005	2006	2007	Total
AGILENT TECHNOLOGIES, INC.	3	3	3	4	4	17
E. I. DU PONT DE NEMOURS AND COMPANY	136	148	122	162	172	740
BRISTOL-MYERS SQUIBB PHARMA COMPANY	23	18	20	9	7	77
BRISTOL-MYERS SQUIBB COMPANY	11	5	9	15	5	45
ASTRAZENECA AB	6	9	6	8	6	35
DADE BEHRING INC.	1	3	1	7	12	24
HERCULES INCORPORATED	8	4	3	4	5	24
ILC DOVER, INC.	4	2	3	1	0	10
DENTSPLY RESEARCH + DEVELOPMENT CORP.	4	1	0	0	0	5

Source: U.S. Patent and Trade Mark Office: <http://www.uspto.gov/go/taf/reports.htm>

The table above breaks out the patent activities of Delaware biopharmaceutical-related businesses for the period 2003-2007. DuPont is irrefutably the leader in patenting activity in the state. However, not all DuPont's patents are necessarily biopharmaceutical related. Bristol-Myers is the second most active company for patents, followed by AstraZeneca, Dade Behring, and Hercules.

Delaware ranks twentieth nationally for patents of drug, bio-affecting and body treating compositions. California is ranked first. Several of Delaware's nearby states rank in the top ten—a testament to the Biopharmaceutical cluster in the mid-Atlantic area. These fellow Mid-Atlantic States with high Biopharmaceutical patent activity are New Jersey, Pennsylvania, Maryland, and New York.

Table 10
State Ranking by Patents for Drug, Bio-Affecting and Body Treating Compositions

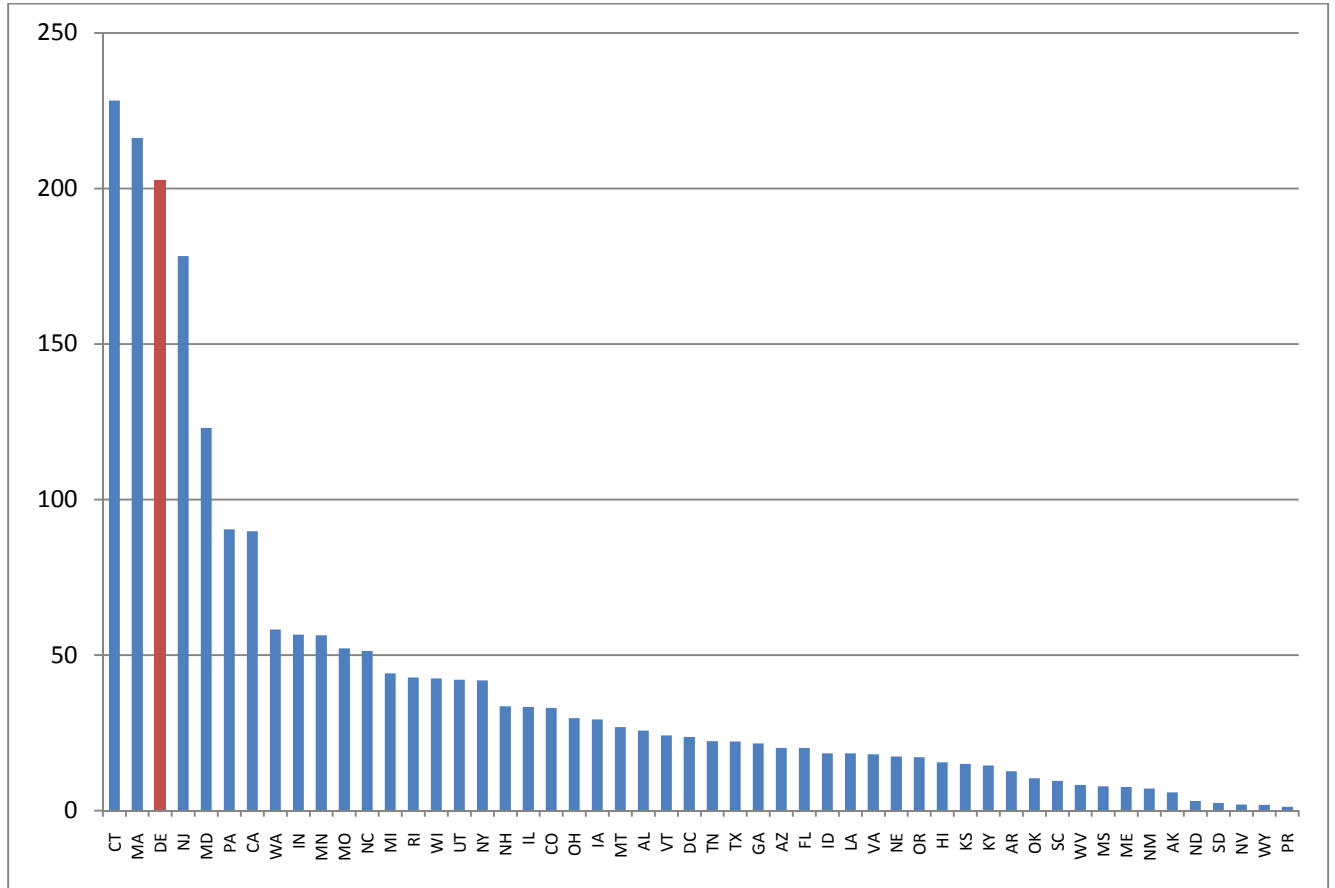
Code	State-Territory or Country	2003	2004	2005	2006	2007	Total	Rank
CA	CALIFORNIA	772	612	538	722	655	3299	1
NJ	NEW JERSEY	418	264	230	356	280	1548	2
MA	MASSACHUSETTS	343	280	250	270	262	1405	3
PA	PENNSYLVANIA	320	191	165	216	234	1126	4
NY	NEW YORK	197	169	128	167	154	815	5
CT	CONNECTICUT	180	144	171	165	139	799	6
MD	MARYLAND	176	134	108	143	132	693	7
TX	TEXAS	139	108	85	103	105	540	8
NC	NORTH CAROLINA	120	73	76	107	97	473	9
MI	MICHIGAN	112	92	105	79	53	441	10
IL	ILLINOIS	130	73	65	87	75	430	11
WA	WASHINGTON	90	55	66	86	84	381	12
FL	FLORIDA	113	68	55	68	65	369	13
IN	INDIANA	99	70	60	64	68	361	14
OH	OHIO	104	75	57	61	44	341	15
MO	MISSOURI	77	88	53	60	30	308	16
MN	MINNESOTA	84	71	38	61	40	294	17
WI	WISCONSIN	70	32	43	51	43	239	18
GA	GEORGIA	47	31	36	50	45	209	19
DE	DELAWARE	40	38	37	37	25	177	20
CO	COLORADO	47	38	24	28	26	163	21
VA	VIRGINIA	53	18	20	22	28	141	22
TN	TENNESSEE	35	32	25	25	22	139	23
AZ	ARIZONA	29	31	19	30	22	131	24
AL	ALABAMA	35	23	22	20	20	120	25
UT	UTAH	27	34	10	25	19	115	26
IA	IOWA	19	16	12	16	25	88	27
LA	LOUISIANA	24	16	14	16	11	81	28
OR	OREGON	17	15	8	14	11	65	29
KY	KENTUCKY	18	11	11	11	11	62	30
RI	RHODE ISLAND	10	6	13	12	4	45	31
NH	NEW HAMPSHIRE	12	8	7	9	8	44	32
SC	SOUTH CAROLINA	11	9	6	13	4	43	33
KS	KANSAS	12	12	5	7	6	42	34
OK	OKLAHOMA	11	5	6	7	9	38	35

AR	ARKANSAS	13	5	8	7	3	36	36
NE	NEBRASKA	7	8	4	6	6	31	37
ID	IDAHO	8	3	3	8	6	28	38
MT	MONTANA	8	3	5	6	4	26	39
MS	MISSISSIPPI	5	5	6	4	3	23	40
HI	HAWAII	4	3	4	5	4	20	41
VT	VERMONT	2	2	3	5	3	15	42
WV	WEST VIRGINIA	6	1	5	3	0	15	43
DC	DISTRICT OF COLUMBIA	4	1	3	4	2	14	44
NM	NEW MEXICO	5	5	2	0	2	14	45
ME	MAINE	1	2	0	2	5	10	46
NV	NEVADA	0	2	0	1	2	5	47
PR	PUERTO RICO	3	0	0	1	1	5	48
AK	ALASKA	2	1	0	1	0	4	49
ND	NORTH DAKOTA	2	0	0	0	0	2	50
SD	SOUTH DAKOTA	0	0	0	1	1	2	51
GU	GUAM	0	0	0	0	1	1	52
WY	WYOMING	0	0	0	1	0	1	52
	-- Subtotal --	4061	2983	2611	3263	2899	15817	

Source: U.S. Patent and Trade Mark Office: <http://www.uspto.gov/go/taf/reports.htm> The table above ranks states by patents of Class 424: Drug, Bio-Affecting and Body Treating Compositions (includes Class 514). Delaware ranks twentieth by total patents 2003-2007.

The above ranking favors the largest states. One way to adjust for this bias is to express patenting per million of population. This yields the rankings below. Delaware ranks third in the nation with just over 200 patents per million of population.

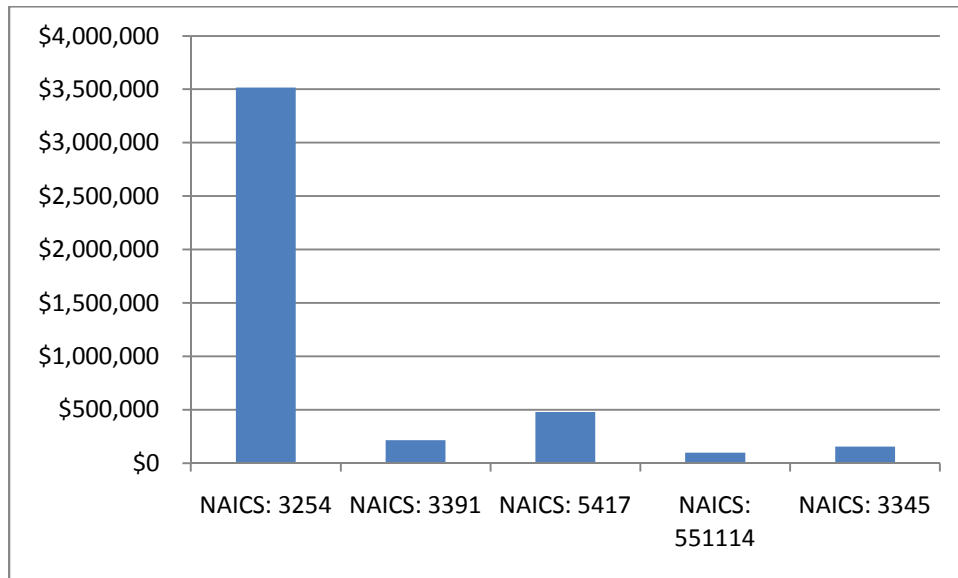
Figure 7
Drug, Bio-Affecting and Body Treating Compositions Patents
by State Population



Source: U.S. Patent and Trade Mark Office: <http://www.uspto.gov/go/taf/reports.htm>, Census Bureau July 1st, 2008 population by state.

Delaware’s Biopharmaceutical sector output is significant. Sales by pharmaceutical and medicine manufacturers alone exceed \$3.5bn (Economic Census 2002). This equates to more than one-fifth of total manufacturing sales.

Figure 8
Delaware Biopharmaceutical Sales (thousands \$)



Source: 2002 Economic Census. Thousands of 2002 dollars. The 2007 Economic Census data will not be released until the end of 2009.

Delaware's scientific research and development services (5417) are second largest in terms of sales among the state's Biopharmaceutical-related sectors. This sector has annual sales just short of one-half billion dollars. Medical equipment and supplies manufacturing (3391), medical and control instruments manufacturing (3345), and regional managing offices (551114) round out the sales value.

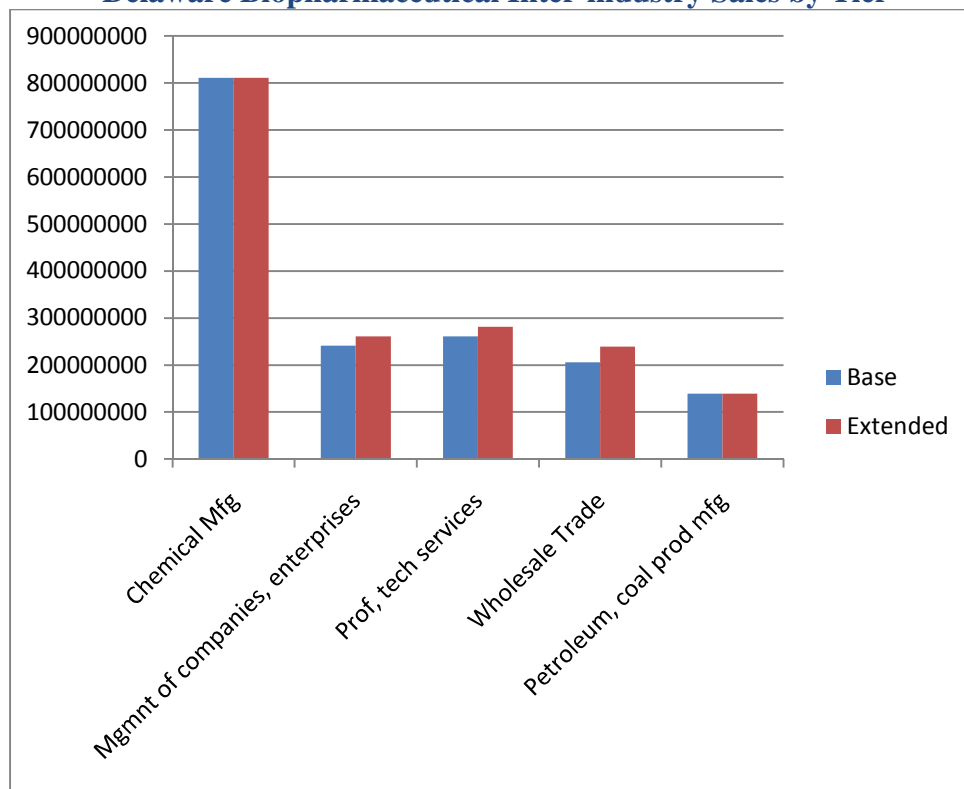
Collectively Delaware's Biopharmaceutical-related sectors generate sales of almost \$4.5bn.

Impact on Delaware and Regional Industry

Delaware's Biopharmaceutical firms can have linkages to firms that are local, regional, national and even international. Hence, the sector's operations generate demand for goods and services from numerous suppliers. By tracing these linkages from the Biopharmaceutical sector to other industries, it is possible to estimate the inter-industry sales and, furthermore, the broader impact that the Delaware Biopharmaceutical sector has on other industries.

Inter-industry linkages are available through an input-output matrix. This matrix identifies how an increase in sales in one industry in turn generates sales amongst its suppliers. Using the sales of Delaware Biopharmaceutical companies in conjunction with an input-output matrix, it is possible to estimate how much inter-industry demand is supported by the operations of Delaware's Biopharmaceutical companies.

Figure 9
Delaware Biopharmaceutical Inter-industry Sales by Tier



Source: US Economic Census 2002 and Regional Models, Inc.

The chart above details the top five industry sales (2008 \$) generated by activities of Delaware Biopharmaceutical companies. These inter-industry sales could be supplied by local, regional, or national companies. The Delaware Biopharmaceutical sector supports approximately \$811m in sales from local, regional, or national chemical manufacturing; \$281m in sales from professional, technical services industries; \$261m in sales from management of companies and enterprises; \$239m in sales from wholesale trade suppliers; and \$139m in sales from petroleum and coal product manufacturers.

The pharmaceutical preparation manufacturing sector's principal supplier is the local, regional or national chemical manufacturing industry, from which it purchases \$811m. Research and development in biotechnology and physical, engineering, and life sciences' principal supply is the professional and technical services industry, from which it purchases \$38m. Corporate, subsidiary, and regional managing offices of Biopharmaceutical companies principal supplier is professional and technical services, from which \$10m in sales is generated.

Medical equipment and supplies manufacturing's largest supplier is the computer and electronic product manufacturing industry, from which \$34m in products and services are purchased. Finally, navigational, measuring, electro medical and control instrument manufacturing generate \$17m in sales from the miscellaneous manufacturing industry.

Chemical manufacturing receives the most benefit from Delaware's Biopharmaceutical sector. However, the impact of Biopharmaceutical firm operations extends across a relatively diverse group of industries. Professional, technical services, management of companies and enterprises, wholesale trade, and petroleum and coal product manufacturing each have sizeable ties to the sector.

Impact on the People of Delaware

The economic impact of the Delaware Biopharmaceutical sector is presented below. Each Biopharmaceutical job in Delaware supports an additional 1.1 to 1.4 other jobs in the state (depending on the industry definition, respectively). For the base industry's employment, the 7,773 direct Biopharmaceutical jobs yield a total employment impact of 17,400. This equates to 3.2% of the state's total jobs (BEA). The total impact is \$2.0bn in gross state product and \$1.2bn in personal income. These figures capture 3.2% and 3.4% of their respective state total.

Table 11
Economic Impact of the Biopharmaceutical Sector in Delaware 2008

	Direct	Total Impact	Pct of State	Implied Multiplier
Base				
Employment (# of jobs)	7,773	17,986	3.28%	2.31
Gross Product (Current Dollars)		\$1,979,951,760	3.22%	
Personal Income (Current Dollars)		\$1,173,000,000	3.39%	
Extended				
Employment (# of jobs)	11,482	27,042	4.93%	2.36
Gross Product (Current Dollars)		\$3,126,111,680	5.08%	
Personal Income (Current Dollars)		\$1,668,000,000	4.82%	

Source: Regional Models, Inc., BEA personal income 2008 Q1, gross state product 2007, total employment 2007.

The extended Biopharmaceutical operations have a total impact of 27,000 jobs in the state. The direct employment therefore has a multiplier effect of 2.36. Total employment generates a gross state product of \$3.1bn and personal income of \$1.7bn, which is large relative to other industries. Gross state product generated directly and indirectly by the extended Biopharmaceutical employment is approximately 5.1% of total state gross product.

One example of the indirect and induced impact on other industries is shown below. The table shows the full first year impact on the construction sector.

Table 12
Economic Impact of the Biopharmaceutical Sector on the Construction Industry in Delaware 2008

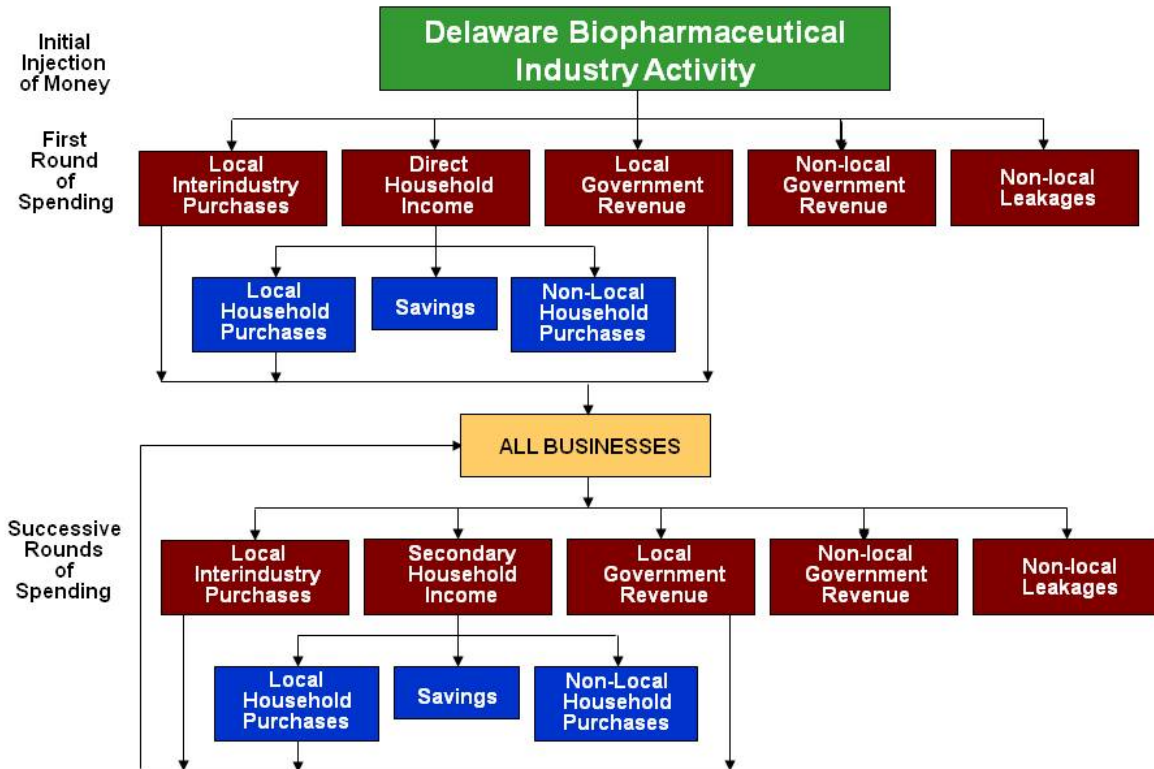
	Employment	Gross State Product	Personal Income
Base	822	\$58,894,388	\$40,531,300
Extended	1,220	\$68,772,078	\$57,823,300

Source: Regional Models, Inc.

In summary, the presence of the Biopharmaceutical sector is a boon to the Delaware economy. The sector directly employs between 7,773 (Base industry) and 11,482 (Extended industry) employees. However, the footprint of the sector extends beyond its employment. Its impact is multiplied by its high employee compensation coupled with its strong links to related industries.

A multiplier is the numerical relationship between an initial change in economic activity and the resultant change in total activity as money is spent and re-spent through various sectors of the economy. See chart below.

Figure 10
Illustration of the Multiplier Effect



Activity among Delaware’s Biopharmaceutical firms flows to five possible recipients in the first round of spending. Among these recipients are local inter-industry purchases, direct household income (wages paid to persons employed at the Biopharmaceutical companies), and local government revenue (taxes paid to the city, county and state). Some of direct household income will be spent on non-local household purchases or saved and is lost to the local economy. The

portion of direct household income that is re-spent locally, along with the local inter-industry purchases and local government revenue will then be recycled through successive rounds of spending. Thus the initial activity in the economy is *multiplied* over further rounds of spending. The relationship between the final effect and the initial activity is the multiplier effect.

The following section discusses the REMI modeling system used in the papers estimates.

REMI Policy Insight

REMI Policy Insight™ is the leading regional economic forecasting and policy analysis model. For this study, the REMI Policy Insight™ model for Delaware is employed. The model was built using the REMI model building system, which consists of hundreds of programs developed over the last two decades. The system assembled the Delaware model using data from the Bureau of Economic Analysis, the Bureau of Labor Statistics, the Department of Energy, the Bureau of Census, and other public sources.

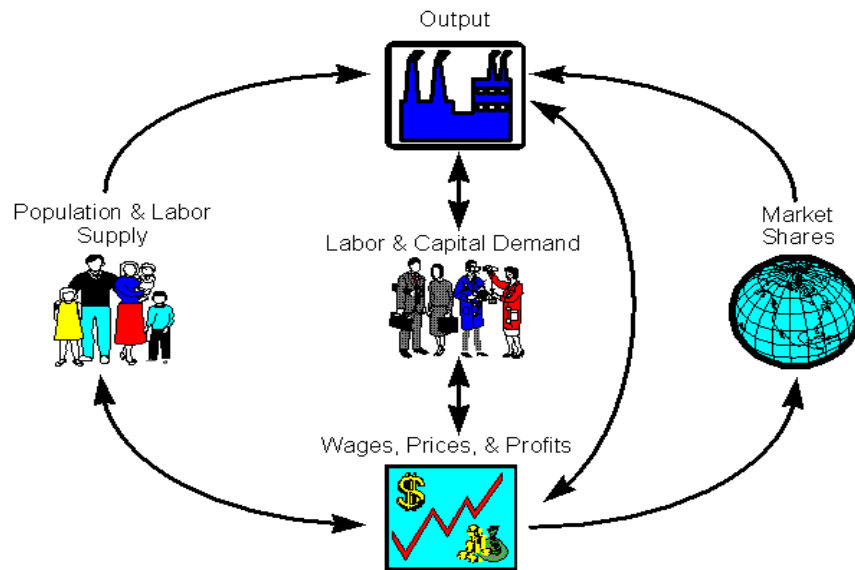
REMI Policy Insight™ is a structural model, meaning that it clearly includes cause-and-effect relationships. The model is based on two key underlying assumptions from mainstream economic theory: households maximize utility and producers maximize profits. Since these assumptions make sense to most people, lay people as well as trained economists can understand the model.

In the model, businesses produce goods to sell to other firms, consumers, investors, governments and purchasers outside the region. The output is produced using labor, capital, fuel, and intermediate inputs. The demand for labor, capital and fuel per unit of output depends on their relative costs, since an increase in the price of any one of these inputs leads to substitution away from that input to other inputs. The supply of labor in the model depends on the number of people in the population and the proportion of those people who participate in the labor force. Economic migration affects the population size. People will move into an area if the real after-tax wage rates or the likelihood of being employed increases in a region.

Supply and demand for labor in the model determine the wage rates. These wage rates, along with other prices and productivity, determine the cost of doing business for every industry in the model. An increase in the cost of doing business causes either an increase in prices or a cut in profits, depending on the market for the product. In either case, an increase in costs would decrease the share of the local and U.S. market supplied by local firms. This market share combined with the demand described above determines the amount of local output. Of course, the model has many other feedbacks. For example, changes in wages and employment impact income and consumption, while economic expansion changes investment, and population growth impacts government spending.

The figure below is a pictorial representation of REMI Policy Insight. The Output block shows a business that sells to all the sectors of final demand as well as to other industries. The Labor and Capital Demand block shows how labor and capital requirements depend both on output and their relative costs. Population and Labor Supply contribute to demand and to wage determination. Economic migrants in turn respond to wages and other labor market conditions. Supply and demand interact in the Wage, Price and Profit block. Prices and profits determine market shares. Output depends on market shares and the components of demand.

Figure 11
REMI Policy Insight™ Overview

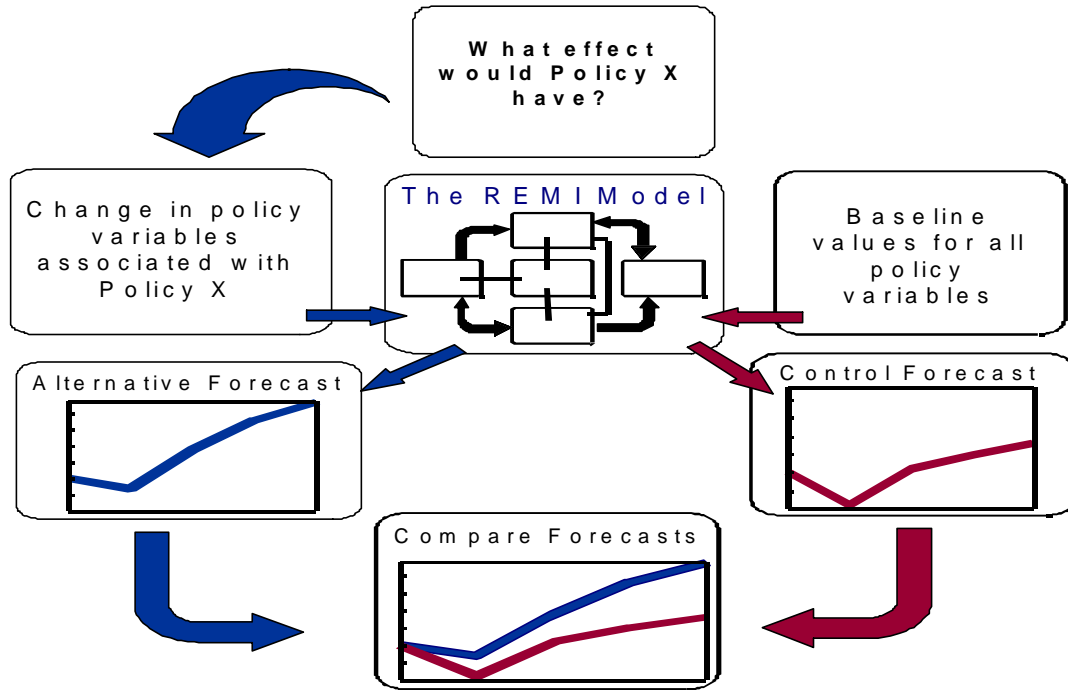


The REMI model brings together all of the above elements to determine the value of each of the variables in the model for each year in the baseline forecast. The model includes all the inter-industry interactions that are included in input-output models in the Output block, but goes well beyond an input-output model by including the linkages among all of the other blocks shown in the figure above.

In order to broaden the model in this way, it was necessary to estimate key relationships. This was accomplished by using extensive data sets covering all areas in the country. These large data sets and two decades of research effort have enabled REMI to simultaneously maintain a theoretically sound model structure and build a model based on all the relevant data available.

The figure below shows the policy simulation process for a scenario called Policy X. The effects of a scenario are determined by comparing the baseline REMI forecast with an alternative forecast that incorporates the assumptions for the scenario. The baseline REMI forecast uses recent data and thousands of equations to generate projected economic activity for a particular region. The policy variables in the model are set equal to their baseline value (typically zero for additive variables and one for multiplicative variables) when solving for the baseline forecast. To show the effects of a given scenario, these policy variables are given values that represent the direct effects of the scenario. The alternative forecast is generated using these policy variable inputs. The figure below shows how this process would work for a policy change called Policy X.

Figure 12
Policy X Scenario



Two published sources of economic multipliers are the Bureau of Economic Analysis' Regional Input-Output Modeling System II (RIMS II) and IMPLAN (Minnesota IMPLAN Group). These multipliers tend to differ from the REMI results listed above due to their differing modeling techniques. REMI is a general equilibrium model that permits feedback so that an economy can adjust fully to any changes. For example, adding a new manufacturing plant can increase the demand for labor, driving wages higher and impacting the competitiveness of the state, and also attracting workers to the state in search of higher wages. RIMS II and IMPLAN allow no such feedback adjustments.

With this caveat in mind, it is useful to consider how the Biopharmaceutical multipliers of RIMS II and IMPLAN compare to those of other industries. The table below lists the employment and earnings multipliers of RIMS II and IMPLAN by industry.

The earnings column represents the total dollar change in earnings of all households for each additional dollar earned by the corresponding industry. The employment column represents the total change in number of jobs of all industries for each additional job in the corresponding industry.

Table 13
Economic Multiplier: Bureau of Economic Analysis and IMPLAN

Code	Industry	BEA		IMPLAN	
		Earnings (\$)	Employment (# of jobs)	Earnings (\$)	Employment (# of jobs)
3254	Pharmaceutical and medicine manufacturing	2.68	4.35	2.87	4.72
522A00	Nondepository credit intermediation and related activities	1.90	3.03	1.42	2.26
3391114	Dental equipment and supplies manufacturing	1.88	2.51	2.07	2.59
334510	Electro medical apparatus manufacturing	1.95	3.23	1.79	2.34
541700	Scientific research and development services	1.55	2.29	1.41	2.09
550000	Management of companies and enterprises	1.49	1.89	1.43	1.94
7	Construction	1.67	1.81	1.67	1.81
15	Motor vehicle, body, trailer, parts manufacturing	2.39	4.18	1.70	2.01
27	Wholesale trade	1.61	2.04	1.45	1.95
28	Retail trade	1.63	1.41	1.42	1.21
52	Ambulatory health care services	1.48	1.78	1.66	1.67

Source: BEA tables Summary Table 15 BII and 25 B II. IMPLAN 2007 multipliers. Note: IMPLAN construction multipliers are for new residential 1 unit structures, motor vehicle, body, trailer, parts manufacturing multipliers are for motor vehicle parts manufacturing, retail trade multipliers are for miscellaneous store retailers.

Delaware's Biopharmaceutical-related sectors exhibit relatively high multiplier effects. Thus the impact of Delaware's Biopharmaceutical sectors is significant. According to the Bureau of Economic Analysis' Regional Impact Multiplier System (BEA RIMS II), every one job in pharmaceutical and medicine manufacturing supports a total of 4.35 jobs in the state. For each dollar of earnings in pharmaceutical and medicine manufacturing in the state, a total of \$2.68 in earnings is supported in the state. The IMPLAN multipliers for earnings and employment for pharmaceutical and medicine manufacturing are 2.87 and 4.72, respectively.

Dental equipment and supplies manufacturing employment supports an additional 1.59 (IMPLAN) and 1.51 (RIMS II) jobs for each position in the state. Manufacturing of electro-medical apparatus supports between 1.34 (IMPLAN) and 2.23 (RIMS II) additional jobs in the state. For a state of Delaware's size, these are quite high multipliers. Smaller states tend to rely greatly on interstate trade for inputs. Interstate trade-of-inputs are leakages from the state economy and therefore lower the multiplier and lessen an industry's economic impact. For Delaware's Biopharmaceutical sectors to have these high multipliers, their in-state supply of inputs is likely to be significant.

Further Impacts

The full impact of the Delaware Biopharmaceutical sector extends beyond what can be fully attributed by the impact modeling and are better estimated directly by examining data from secondary sources such as IRS statistics, Delaware Division of Revenue public information, publicly available property tax records, and studies prepared by the US Bureau of Labor Statistics. The estimates are provided in the table below.

Table 14
Other Impacts of the Biopharmaceutical Sector in Delaware 2008

Category	Estimate
State Corporate Taxes	\$9,482,357
Property Taxes	\$7,542,166
Employee Benefits	\$435,071,230
Corporate Contributions	\$66,447,242
Employee Contributions	\$47,462,316

Source: US Bureau of Labor Statistics, Statistics of Income: US Internal Revenue

Corporate taxes and the two estimates of contributions are affected by either multi-state tax laws or the fact that contributions can and do flow across state lines. In all cases, only the output and employment estimated for the state are used in the calculations.

State corporate income taxes were estimated from IRS data for 2006 after reviewing the same data for 2001-2005. The size of the biopharmaceutical firms in the state in terms of their wages paid and income earned played a role in the estimation.

Property taxes were estimated directly from the properties that were identified as belonging to members of the sector. Not all firms could be located, and in some cases the property may have been leased, in which case the property taxes were paid through the lease. In general, this

estimate is probably conservative. No information was available about special tax breaks given by the municipalities or the counties.

Employee benefits were estimated both by looking at deductions from the IRS corporate income tax statistics, total compensation studies provided by the Bureau of Labor Statistics and available industry studies. The base for the computation was 2008 wages in the sector.

Corporate contributions were estimated from the IRS 2006 corporate income tax information. A simple ratio between wages paid and contributions reported was developed and then applied to wages for the sector. The underlying assumption used was that contributions were likely to be proportional to the footprint in the state as measured by wages paid. This measure does not include any estimate on the value of contributed time or physical resources which are routinely observed in the state. Members of the sector are routinely part of health care related conferences, panels, and other public service commitments.

Employee contributions were estimated using average wages and contributions as reported on IRS statistics for 2006. No attempt was made to estimate volunteer time or to estimate the share of contributions that would be made to entities in Delaware as opposed to elsewhere. Obviously, there are people who live outside the state but regularly contribute to organizations inside the state. Implicitly, the assumption is that these effects cancel one another.

There are probably other indirect impacts that are not estimated here but are implicitly included in the REMI model.

Future of the Sector

The long-run outlook for Delaware's Biopharmaceutical sector is positive. The Bureau of Labor Statistics' national projections show strong growth in both pharmaceutical and medicine manufacturing, and research and development in the physical, engineering, and life sciences. See table below.

Table 15

National Occupation Forecasts 2006-2016

Occupation	2006 employment	Projected 2016 employment	Change, 2006-2016	
	Number	Number	Number	Percent
Pharmaceutical and Medicine Manufacturing	292,400	361,800	69,400	23.7
Research and Development in the physical, engineering, and life sciences	529,400	581,300	51,900	9.8

Source: Bureau of Labor Statistics.

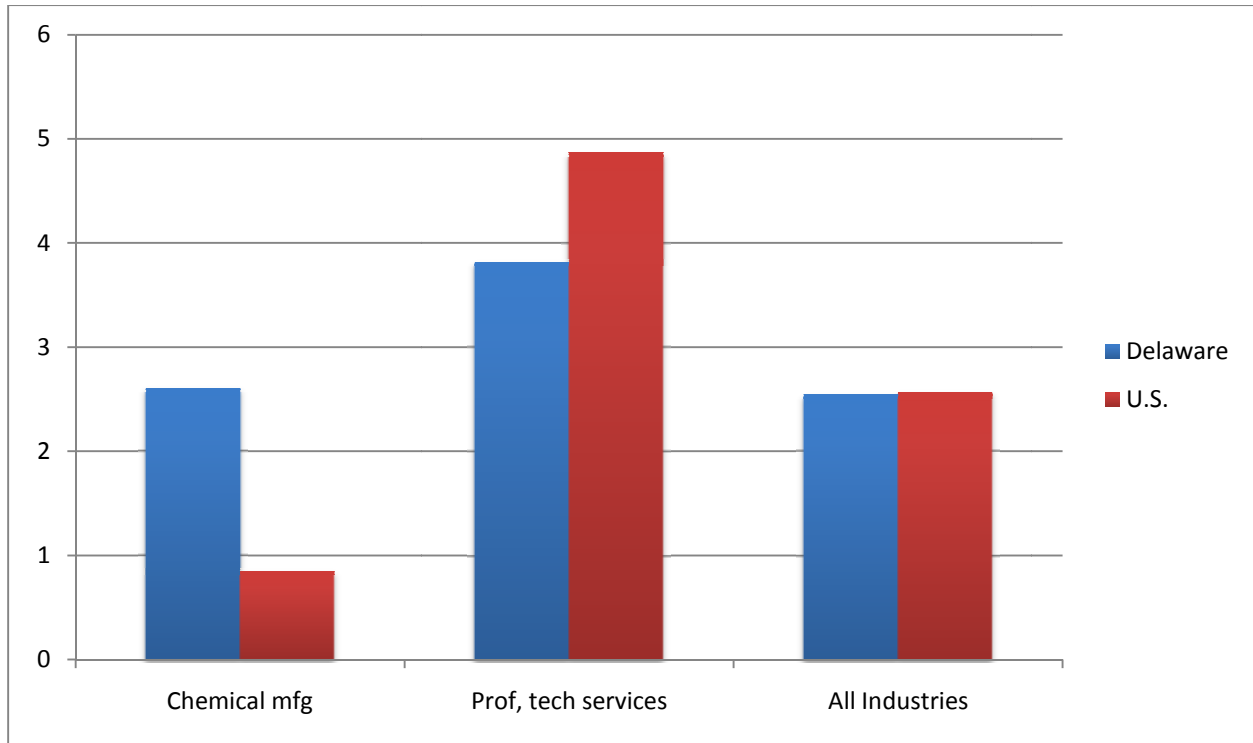
Biopharmaceutical employment is forecast to increase both locally and nationally between 2010 and 2030. Chemical manufacturing, which includes Biopharmaceutical preparations, is projected to increase 13% over the next twenty years (2.6% annually) in Delaware—with most of the growth occurring after 2015.

Scientific research employment, which falls under professional and technical services, is projected to experience brisk growth both locally and nationally. Average annual growth of this

employment is expected to be approximately 4% locally and 5% nationally between 2010 and 2030, see below.

Figure 13

Average Annual Percentage Growth in Biopharmaceutical Employment, 2010-2030



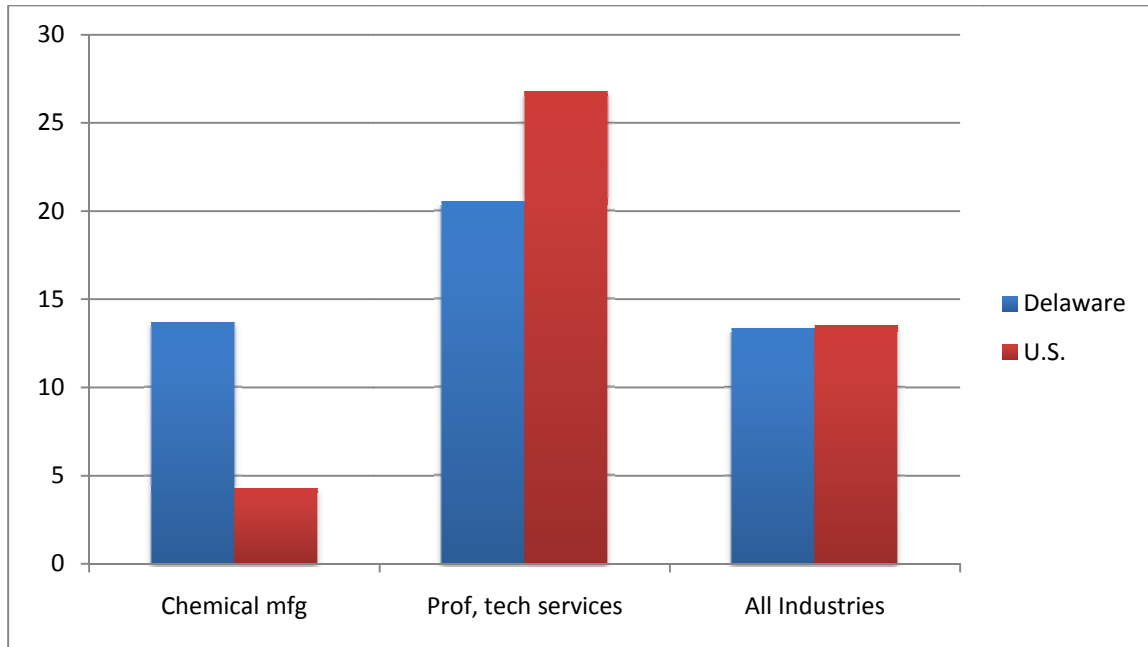
Source: REMI. Chemical manufacturing includes pharmaceutical and medicine manufacturing. Professional and technical services include research and development in biotechnology and research and development in the physical, engineering, and life sciences.

Professional and technical services employment is forecast to outstrip employment growth across all industries. This is expected for both Delaware and the nation. Chemical manufacturing employment is also expected to record positive growth, albeit slower than that of professional and technical and services. Nationally the growth of chemical manufacturing is forecast to be a

relatively anemic 1%; however, in Delaware the forecast is over 2%. Delaware's cluster of professional and scientific services means the state is well positioned to capitalize on the growth of this high-wage sector.

Figure 14

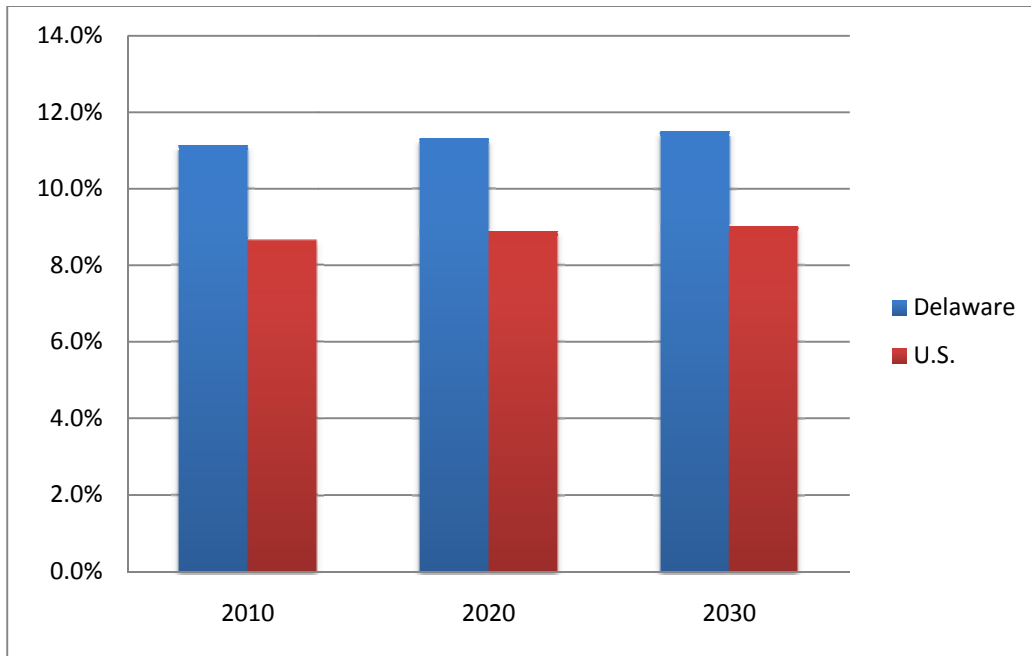
Percentage Growth in Biopharmaceutical Employment, 2010-2030



Source: REMI. Note: Chemical manufacturing includes pharmaceutical and medicine manufacturing. Professional and technical services include research and development in biotechnology as well as research and development in the physical, engineering, and life sciences.

Biopharmaceutical-related sectors are predicted to increase their role in the economy over the next twenty years. Chemical manufacturing and professional and technical services will account for approximately 8.7% of the national gross domestic product in 2010, and are expected to rise to 9% by 2030. These industries will account for a larger proportion of Delaware's state product: 11% in 2010. Delaware will mirror the nation's growth and, by 2030 these industries' share of the state's product will rise to 11.5%.

Figure 15

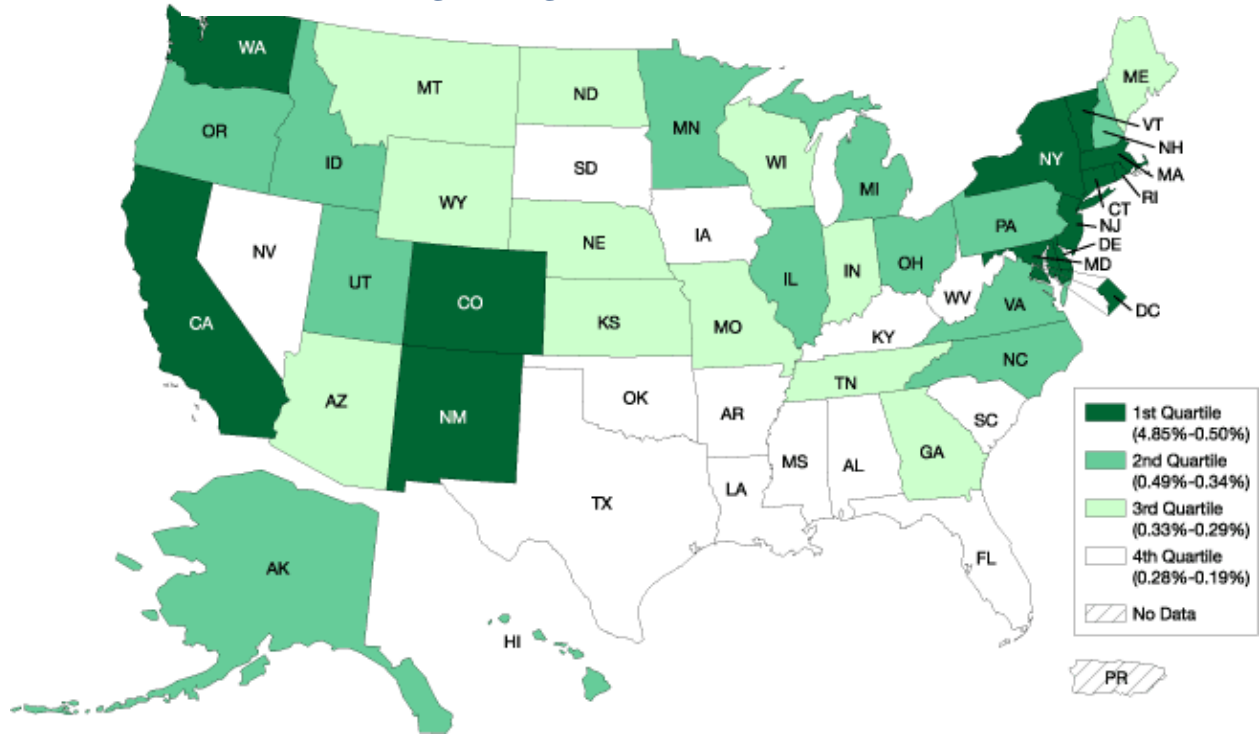
Biopharmaceutical Sector's Share of Gross State Product

Source: REMI. Note: Chemical manufacturing and professional and technical services' share of total gross domestic product and gross state product. Chemical manufacturing includes pharmaceutical and medicine manufacturing. Professional and technical services include research and development in biotechnology and research and development in the physical, engineering, and life sciences.

These positive prospects augur well for Delaware's Biopharmaceutical sector. Growth in the sector will act as a catalyst to attract scientists and engineers to the state. Delaware already ranks in the top quartile for science and engineering doctorate holders in the nation. This will likely continue while the Biopharmaceutical sector flourishes in Delaware.

Figure 16

Science and Engineering Doctorate Holders as a Share of Workforce



Source: National Science Board, 2004. Data pertain to 2001.

<http://www.nsf.gov/statistics/seind04/c8/c8.cfm?opt=3&selected=yes&action=map&colname=200411>