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Bio-Pharma's Impact
On California's State and Local Economy

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Abstract

In California, a leading state in biotech research & development, and bio-pharmaceutical manufacturing, more than 100 establishments in these two related industries employ about 65,000 workers whose average wage exceeds $100,000 per year. On average, about 2000 construction workers build and refurbish the infrastructure of this industry in California annually putting in place about $1 billion of new and renovated buildings. The economic impact of this construction activity adds a total of more than $2 billion annually to the California economy. The annual economic contribution of the bio-pharmaceutical manufacturing industry to the California economy exceeds $65 billion, creates almost 200,000 jobs directly and indirectly and generates more than $2.5 billion in state and local tax revenues. The annual economic contribution of the biotech R&D sector to the California economy exceeds $9 billion, creating more than 50,000 jobs and more than $450 million in state and local tax revenues. An analysis of a project labor agreement (PLA) in Solano County shows that the local hire provisions of this agreement generated more than 3 times as much local employment and local tax revenues compared to had the project not been done under a PLA. An analysis of a bio-pharmaceutical manufacturing plant belonging to a California biotech firm that was built in Ohio instead of California shows that not building this facility in California meant the state lost almost 4,000 construction and other jobs, lost more than $900 million in economic activity associated with the construction of this plant and lost more than $9 million in local and state tax revenues associated with the building of the plant. California further lost annually 2400 jobs that would have been created directly or indirectly through the operation of this plant, almost $850 million in statewide economic activity and $31 million in state and local taxes.

Keywords: biotechnology, project labor agreements, construction
JEL Classification: O - Economic Development, Technological Change, and Growth; O14 - Industrialization; Manufacturing and Service Industries; Choice of Technology; O33 - Technological Change: Choices and Consequences; Diffusion Processes

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An Economic Impact and Industry Cluster Study:

Bio-Pharma's Impact

On California's State and Local Economies

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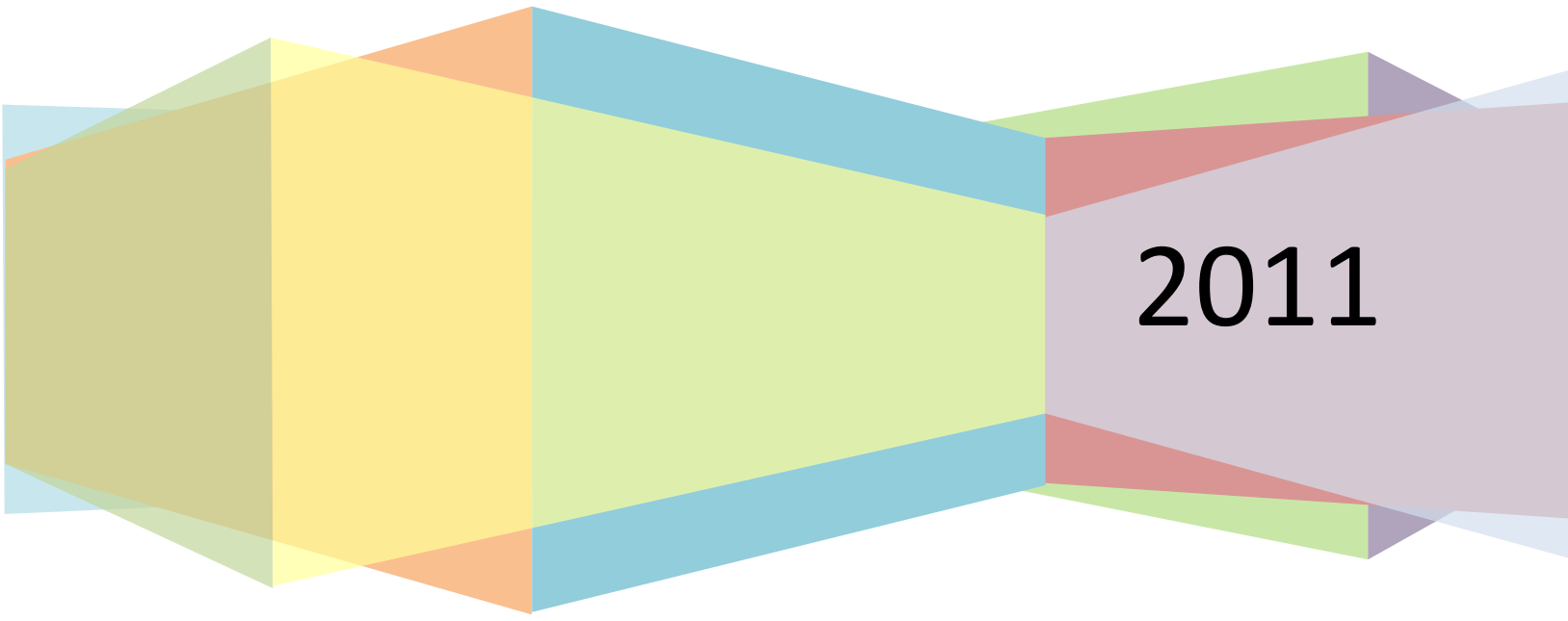


BIO-PHARMA'S ECONOMIC IMPACT

Overview

In California, a leading state in biotech research & development, and bio-pharmaceutical manufacturing, more than 100 establishments in these two related industries employ about 65,000 workers whose average wage exceeds $100,000 per year. The Bay Area, LA-Ventura and San Diego counties account for most of this employment.

On the manufacturing side, approximately 40% of the workers have more than a high school education while on the R&D side more than 80% have more than a high school degree.

On average, about 2000 construction workers build and refurbish the infrastructure of this industry in California annually putting in place about $1 billion of new and renovated buildings. The economic impact of this construction activity adds a total of more than $2 billion annually to the California economy. The top ten builders of this industry are all union contractors and account for more than 50% of all the construction in this industry.

The annual economic contribution of the bio-pharmaceutical manufacturing industry to the California economy exceeds $65 billion, creates almost 200,000 jobs directly and indirectly and generates more than $2.5 billion in state and local tax revenues.

The annual economic contribution of the biotech R&D sector to the California economy exceeds $9 billion, creating more than 50,000 jobs and more than $450 million in state and local tax revenues.

County Impacts

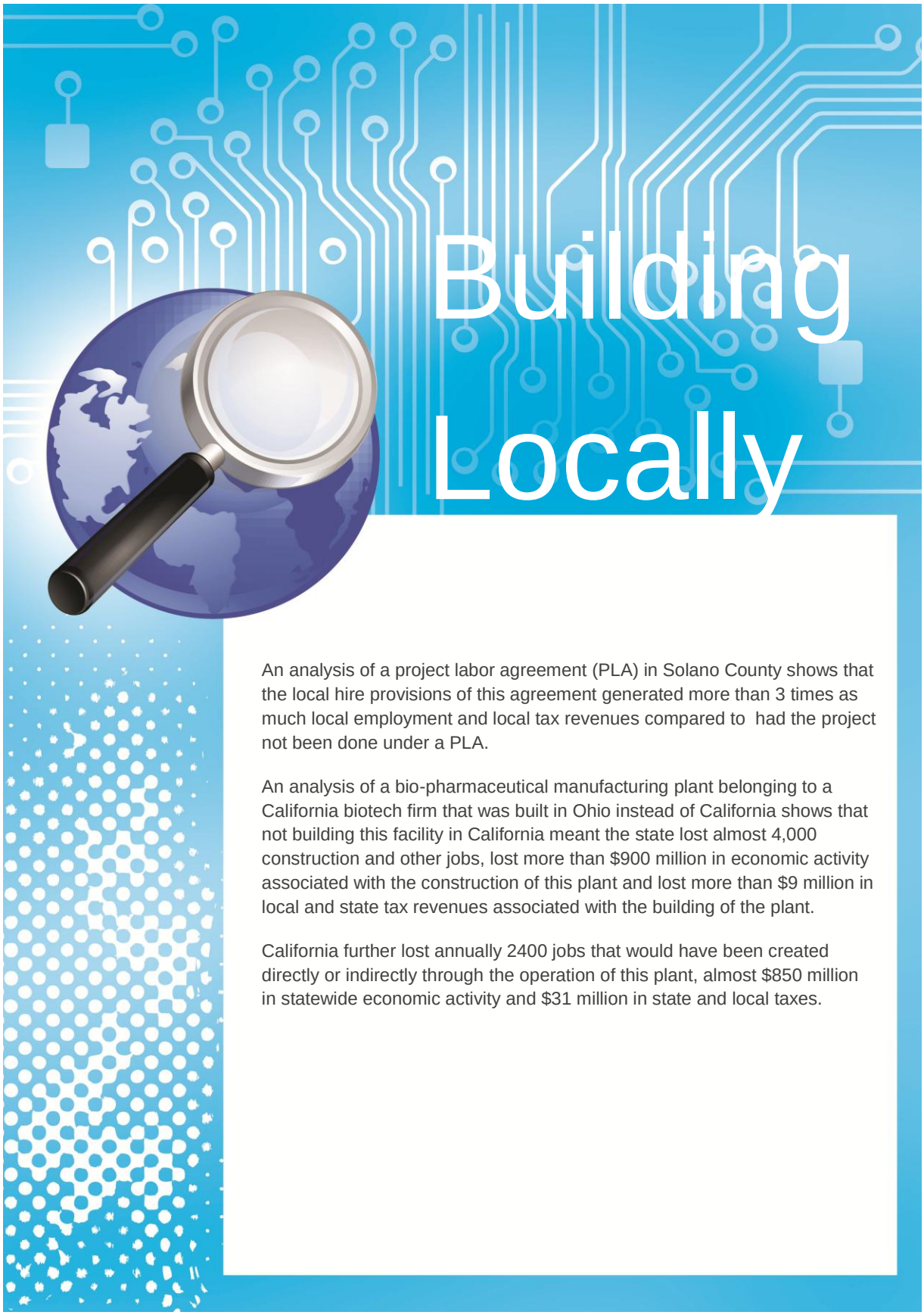
In Alameda County, the combined contribution of these two industries is $2.6 billion--approximately 3% of the county GDP, generating 7500 jobs and $20 million in local tax revenues.

In San Diego County, the combined contribution to the local county economy of the bio-pharmaceutical manufacturing and biotech R&D industries is almost $8 billion, about 4.6% of San Diego's GDP, generating 34,000 jobs and $66 million in local tax revenues.

In San Mateo County, the combined contribution of these industries amounts to $3.8 billion (6.3% of the county's GDP), 8600 jobs and $22 million in local taxes.

In Solano County, the bio-pharmaceutical manufacturing industry alone accounts for $1.5 billion in economic output (more than 10% of the local economy) generating 2900 jobs and about $6.6 million in local tax revenues.

The Ventura County impact is based on the manufacturing and R&D activity of a major bio-pharma company that is located in this county. The impact of this employer generates about $2.7 billion in county GDP, more than 12,500 jobs and almost $18 million in local tax revenues.



Building Locally

An analysis of a project labor agreement (PLA) in Solano County shows that the local hire provisions of this agreement generated more than 3 times as much local employment and local tax revenues compared to had the project not been done under a PLA.

An analysis of a bio-pharmaceutical manufacturing plant belonging to a California biotech firm that was built in Ohio instead of California shows that not building this facility in California meant the state lost almost 4,000 construction and other jobs, lost more than $900 million in economic activity associated with the construction of this plant and lost more than $9 million in local and state tax revenues associated with the building of the plant.

California further lost annually 2400 jobs that would have been created directly or indirectly through the operation of this plant, almost $850 million in statewide economic activity and $31 million in state and local taxes.

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Peter Philips is a labor economist and Professor and Chair of the Economics Department at the University of Utah. He received his Ph.D. from Stanford University in 1980 and his B.A. from Pomona College in 1970. Philips is the author of over 60 academic articles and books and the winner of the prestigious University Presidential Teaching Scholar award as well as the Graduate Mentor Award. Philips is the country's leading expert on the construction labor market and he has testified regarding construction labor market regulations numerous times before federal, state and local legislatures and policy-making bodies. Philips teaches labor economics and econometrics, the study of economic statistics. In the summers, Philips is a volunteer ranger in the Grand Tetons National Park.

Kevin Duncan is Professor and Senior Economist, Healy Center for Business and Economic Research, Hasan School of Business, Colorado State University, Pueblo. He specializes in labor and regional economics. He received his Ph.D. from the University of Utah in 1987 and his B.A. from the University of California, Riverside in 1981. Duncan is the author of 21 academic articles, 25 applied regional projects, and the winner of several honors and awards including the Provost's Award for Excellence in Teaching, the Provost's Award for Excellence in Research, the Outstanding Faculty Member Award for the Hasan School of Business, the Enterprise Rent-A-Car Student Choice Award for Excellence in Teaching, as well as the Dean's Advisory Council Award for Outstanding Faculty Member. He is the author of numerous economic impact studies that have examined the effect of the America's Cup Races, Colorado State Fair, CSU-Pueblo, project labor and local hire agreements, the installation and operation of wind energy towers, the nonprofit sector, as well as the impact of the proposed Colorado Amendment 61. He teaches regional economics where his students learn how to do economic impact studies.

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Executive Summary

- This study analyzes the economic impact of the biotechnology research and development and pharmaceutical manufacturing industries (hereinafter, bio-pharma industries) on five selected counties and the state of California. The study also includes a cluster analysis of these industries as well as an economic impact analysis of building bio-pharma infrastructure. All results are reported in 2010 dollars.

- We use data collected from the *Quarterly Census of Employment and Wages*, the *2007 Economic Census*, and information obtained from those involved in the bio-pharma industry. We use IMPLAN, an input-output model, to measure the effects of industry employment on state and county economic activity, total employment, and tax revenue. IMPLAN is also used in the cluster and construction impact studies.

- **Government statistics*:*** When a pharmaceutical manufacturing facility is researching, developing, and manufacturing a biologic product, the industry classification system used by the *Quarterly Census of Employment and Wages* will identify the "primary" activity as manufacturing even if many, or even most employees are engaged in research, or development, or company-wide management. This is because R&D and management are seen as preliminary or auxiliary steps in the manufacturing process of the establishment (i.e. the facility). Consequently, in government statistics, a lot of biotech R&D activity is subsumed within pharmaceutical manufacturing activity. Biotech R&D employment is only classified as a distinct category when these workers are employed in a facility with a primary R&D function. In addition, the government does not disclose data at the county level when it would reveal information about any one particular company. Consequently, employment data can be suppressed in small counties (like Solano County), or in larger counties with one very large company (like Ventura County).

- **County and state-level economic impacts of biotechnology R&D and pharmaceutical manufacturing employment.** Results for Alameda, San Diego, San Mateo, Solano, and Venture counties:

- ***Alameda County: Impact of Bio-Pharma Employment on the County and California Economies***: The economic impact analysis for this county is based on the average industry employment between 2002 and the second quarter of 2009 for pharmaceutical manufacturing workers and 2007 to QII, 2009 for biotech R&D employees. For the county-level impact study, the employment data are further adjusted to include those workers who reside within the county. This adjustment provides for a more accurate and conservative estimate of the impact of the bio-pharma industry on the county economy because this impact is based on the value of output produced by county-resident employees. This adjustment is not necessary for the state-level impact. Consequently, the state-level impact is based on unadjusted average employment. The average level of pharmaceutical manufacturing employment in this county is 2,627 of which approximately 1,734 are county residents. Average employment in the biotech R&D industry is 1,693 with 1,117 employees residing in the county. The economic impact results summarized below are annual impacts. Additional results, explanations of the methods used, and suggestions on how the results can be used to educate the public and elected officials can be found in the specific sections of the body of the report.

    - *Pharmaceutical Manufacturing*: The economic impact of the pharmaceutical manufacturing industry on the Alameda County economy is approximately $2.2 billion, 5,400 jobs, and about $15.6 million in local tax revenue. This economic impact represents 2.5 percent of Alameda County GDP and about 0.6 percent of total county employment. On a per-worker basis, the impact of each pharmaceutical manufacturing employee is approximately $1.3 million. The impact on local tax revenue per employee is about $9,000. The employment of one more pharmaceutical manufacturing worker in Alameda County creates a total of 3.1 more jobs in the county. Another dollar of manufacturing output that is produced in Alameda County results in a total of $1.47 in economic activity in the county. The impact of pharmaceutical manufacturing in Alameda County on the California economy is approximately $4.5 billion, 13,000 jobs, and about $168 million in state and local taxes. The state-level impact per pharmaceutical manufacturing employee is approximately $1.7 million. The impact per employee on state and local tax revenue is about $64,000. The employment of one more pharmaceutical manufacturing worker in Alameda County creates a total of 5 more jobs in California. One more dollar of manufacturing output produced in the county creates another $1.96 in economic activity in the state.

    - *Biotechnology Research and Development*: The economic impact of the biotechnology research and development industry on the county economy is approximately $411 million, 2,200 jobs, and about $4 million in local tax revenue. On a per-employee basis, each biotechnology research and development job contributes $368,000 to the county economy and about $3,500 to local tax revenues. An additional R&D job creates a total of 2 more jobs in the county. Another

dollar's worth of R&D activity is associated with an increase of about $1.75 in county GDP. The impact of biotechnology research and development in Alameda County on the California economy is approximately $850 million, 4,700 jobs, and about $41 million in state and local taxes. On a per-worker basis, the impact of each Alameda County R&D employee contributes approximately $500,000 to the California economy and about $25,000 to state and local tax revenues. The creation of another Alameda County R&D job creates a total of 2.8 jobs in California. One more dollar of R&D output in Alameda County creates about $2.40 of economic activity in the state.

- *Combined impact of pharmaceutical manufacturing and biotech R&D employment*: The combined impact of the two industries on the Alameda County economy is approximately $2.6 billion, 7,500 jobs, and $20 million in local tax revenue. This impact represents approximately 3 percent of county GDP and about 0.9 percent of county employment. The combined effect of these Alameda County industries on the California economy is approximately $5.3 billion, 17,700 jobs, and $210 million in state and local taxes. This impact represents about 0.3 percent of California GDP and about 0.1 percent of state employment.

- ***San Diego County: Impact of Bio-Pharma Employment on the County and California Economies***: The economic impact analysis for this county is based on the average industry employment between 2002 and the second quarter of 2009 for pharmaceutical manufacturing workers and 2007 to QII, 2009 for biotech R&D employees. The average level of pharmaceutical manufacturing employment in this county is 4,329 while average employment in the biotech R&D industry is 8,120. Given the size of this county, we assume that all employees reside in San Diego County. Consequently, the county and state-level impacts are based on these averages. The economic impact results summarized below are annual impacts. Additional results, explanations of the methods used, and suggestions on how the results can be used to educate the public and elected officials can be found in the specific sections of the body of the report.

  - ***Pharmaceutical Manufacturing***: The economic impact of the pharmaceutical manufacturing industry on the county economy is approximately $4.6 billion, 15,000 jobs, and about $34 million in local tax revenue. This impact represents about 3 percent of San Diego County GDP and about 0.8 percent of total county employment. On a per-worker basis, the impact is approximately $1 million in economic activity and about $7,900 in local tax revenue. Another pharmaceutical manufacturing job creates a total of 3.5 more jobs in San Diego. Another dollar's worth of pharmaceutical manufacturing production is associated with an additional $1.70 in local economic activity. The impact of pharmaceutical manufacturing in San Diego County on the California economy is approximately $6.0 billion, 19,500 jobs, and about $216 million in state and local taxes. This impact represents approximately 0.3 percent of state GDP and 0.1 percent of total state

employment. On a per-worker basis, the state-level impact is approximately $1.4 million in terms of state GDP and $50,000 in state and local taxes. Another pharmaceutical manufacturing job in San Diego County creates a total of 4.5 more jobs in the state. Another $1.00 in manufacturing production in the county contributes another $2.16 in state-wide economic activity.

- ***Biotechnology Research and Development***: The economic impact of the biotechnology research and development industry on the county economy is approximately $3.3 billion, 19,500 jobs, and about $33 million in local tax revenue. This impact represents about 2 percent of county GDP and about 1.0 percent of county employment. On a per-worker basis, the impact is approximately $410,000 in economic activity and about $4,000 in terms of local tax revenue. Another biotech R&D job creates a total of 2.4 more jobs in San Diego. Another $1.00 of pharmaceutical manufacturing production is associated with an additional $1.95 in local economic activity. The impact of biotechnology research and development in San Diego County on the California economy is approximately $4.0 billion, 22,500 jobs, and about $195 million in state and local taxes. This impact represents approximately 0.2 percent of California GDP and 0.1 percent of state employment. On a per-worker basis, the impact of each San Diego biotech R&D employee on the state economy is approximately $500,000 in terms of GDP and about $24,000 with respect to state and local taxes. Another biotech R&D job in San Diego creates a total of 2.8 more jobs in California. Another $1.00 of San Diego R&D output is associated with an additional $2.38 in economic activity in the state.

- ***Combined impact of pharmaceutical manufacturing and biotech R&D employment***: The combined impact of the two industries on the San Diego County economy is approximately $7.9 billion, about 34,000 jobs, and $66 million in local tax revenue. This impact represents approximately 4.6 percent of county GDP and about 1.7 percent of county employment. The combined effect of these San Diego County industries on the California economy is approximately $9.9 billion, 41,500 jobs, and $411 million in state and local taxes. This impact represents about 0.5 percent of California GDP and about 0.2 percent of state employment.

- ***San Mateo County: Impact of Bio-Pharma Employment on the County and California Economies***: The economic impact analysis for this county is based on the average industry employment between 2002 and 2003 for pharmaceutical manufacturing workers and 2007 to QII, 2009 for biotech R&D employees. More recent data for manufacturing employment is suppressed. For the county-level impact study, the employment data are further adjusted to include those workers who reside within the county. This adjustment provides for a more accurate and conservative estimate of the impact of the bio-pharma industry on the county economy because this impact is based on the value of output produced by county-resident employees. This adjustment is not

necessary for the state-level impact. Consequently, the state-level impact is based on unadjusted average employment. The average level of pharmaceutical manufacturing employment in this county is 4,976 of which approximately 2,886 are county residents. Average employment in the biotech R&D industry is 3,120 with 1,810 employees residing in the county. The economic impact results summarized below are annual impacts. Additional results, explanations of the methods used, and suggestions on how the results can be used to educate the public and elected officials can be found in the specific sections of the body of the report.

- ***Pharmaceutical manufacturing***: The economic impact of the pharmaceutical manufacturing industry on the San Mateo County economy is approximately $3.2 billion, 5,800 jobs, and about $17 million in local tax revenue. This impact represents approximately 5.4 percent of San Mateo County GDP and about 1.1 percent of total county employment. On a per-worker basis, the impact is approximately $1.1 million in terms of GDP and about $6,000 in terms of local tax revenue. Another pharmaceutical manufacturing job creates a total of 2 more jobs in San Mateo. Another $1.00 of pharmaceutical manufacturing production is associated with an additional $1.30 in county economic activity. The impact of pharmaceutical manufacturing in San Mateo County on the California economy is approximately $8.5 billion, 24,700 jobs, and about $331 million in state and local taxes. This impact represents approximately 0.4 percent of state GDP and 0.1 percent of total state employment. On a per-worker basis, the state-level impact is approximately $1.7 million in terms of GDP and $67,000 with respect to state and local taxes. Another pharmaceutical manufacturing job in San Mateo County creates a total of 5 more jobs in the state. Another $1.00 in manufacturing production in the county contributes another $1.96 in state-wide economic activity.

- ***Biotechnology Research and Development***. The economic impact of the biotechnology research and development industry on the county economy is approximately $548 million, 2,800 jobs, and about $4.5 million in local tax revenue. This impact represents about 0.9 percent of county GDP and about 0.6 percent of county employment. On a per-worker basis, the impact is approximately $303,000 in economic activity and about $2,500 in terms of local tax revenue. Another biotech R&D job creates a total of 1.5 more jobs in San Mateo. Another $1.00 of pharmaceutical manufacturing production is associated with an additional $1.44 in county economic activity. The impact of biotechnology research and development in San Mateo County on the California economy is approximately $1.5 billion, 8,700 jobs, and about $78 million in state and local taxes. This impact represents approximately 0.08 percent of California GDP and 0.04 percent of state employment. On a per-worker basis, the impact of each San Mateo biotech R&D employee on the state economy is approximately $500,000 in terms of GDP and about $25,000 with respect to state and local taxes.

Another biotech R&D job in San Mateo creates a total of 2.8 more jobs in California. Another $1.00 of San Mateo R&D output is associated with an additional $2.38 in economic activity in the California.

- ***Combined impact of pharmaceutical manufacturing and biotech R&D employment***: The combined impact of the two industries on the San Mateo County economy is approximately $3.8 billion, about 8,600 jobs, and $22 million in local taxes. This impact represents approximately 6.3 percent of county GDP and about 1.7 percent of county employment. The combined effect of these San Mateo County industries on the California economy is approximately $10 billion, 33,400 jobs, and $409 million in state and local taxes. This impact represents about 0.5 percent of California GDP and about 0.2 percent of state employment.

- ***Solano County: Impact of Bio-Pharma Employment on the County and California Economies***: The economic impact analysis for this county is based on the average industry employment between 2003 and the second quarter of 2009 for pharmaceutical manufacturing workers. For the county-level impact study, the employment data are further adjusted to include those workers who reside within the county. This adjustment provides for a more accurate and conservative estimate of the impact of the bio-pharma industry on the county economy because this impact is based on the value of output produced by county-resident employees. This adjustment is not necessary for the state-level impact. Consequently, the state-level impact is based on unadjusted average employment. Employment data for biotech R&D workers for this county are suppressed. Therefore, the impact for these employees is based on per-worker impacts. Interested parties, who are informed about the actual level of biotech R&D employment in this county, can use these per-worker results to estimate the total impact. The average level of pharmaceutical manufacturing employment in this county is 1,830 of which approximately 1,427 are county residents. The economic impact results summarized below are annual impacts. Additional results, explanations of the methods used, and suggestions on how the results can be used to educate the public and elected officials can be found in the specific sections of the body of the report.

  - ***Pharmaceutical manufacturing***: The economic impact of the pharmaceutical manufacturing industry on the Solano County economy is approximately $1.5 billion, 2,900 jobs, and about $6.6 million in local tax revenue. This impact represents approximately 10.4 percent of Solano County GDP and about 1.8 percent of total county employment. On a per-worker basis, the impact is approximately $1.1 million in terms of GDP and about $4,600 in terms of local tax revenue. Another pharmaceutical manufacturing job creates a total of 2 more jobs in Solano County. Another $1.00 of pharmaceutical manufacturing production is associated with an additional $1.24 in local economic activity. The impact of pharmaceutical manufacturing in Solano County on the California economy is approximately $3.1 billion, 9,000 jobs, and $117 million in state and local taxes. This impact represents approximately 0.2 percent of state GDP and 0.04 percent of total state

employment. On a per-worker basis, the state-level impact is approximately $1.7 million and $64,000 in state and local taxes. Another pharmaceutical manufacturing job in Solano County creates a total of 5 more jobs in the state. Another $1.00 in manufacturing production in the county contributes another $1.96 in state-wide economic activity.

- ***Biotechnology Research and Development***: The number of biotechnology R&D employees working outside of pharmaceutical manufacturing facilities in Solano County suppressed. Consequently, the impacts for this industry are reported on a per-worker basis. The economic impact of each biotechnology research and development employee on the county economy is approximately $333,000, 1.7 jobs, and about $2,100 in local tax revenue. The impact of each Solano County biotechnology research and development employee on the California economy is approximately $500,000, 2.4 jobs, and about $24,000 in state and local taxes.

- ***Ventura County: Impact of Bio-Pharma Employment on the County and California Economies***: Public information is not available for bio-pharmaceutical employment in Ventura County. Consequently, our impact analysis is based on data supplied by a major employer in the county (hereinafter, Company A). This company reports current employment of approximately 7,400. Eighty percent (5,920) are employed as biotech R&D workers and 20 percent (1,480) as pharmaceutical manufacturing employees. Seventy percent of these employees reside in Ventura County. So, our county-level impact is based on 1,036 manufacturing workers and 4,144 R&D employees. This adjustment provides for a more accurate and conservative estimate of the impact of the bio-pharma industry on the county economy because this impact is based on the value of output produced by county-resident employees. This adjustment is not necessary for the state-level impact. Consequently, the state-level impact is based on unadjusted average employment. Some bio-pharma companies employ contract workers who provide food, security, and other services. However, these employees are not included in publicly available employment data for pharmaceutical manufacturing, or biotechnology R&D. Omitting these workers results in industry impact results that are too low. Company A employs about 2,000 contract employees. The impact of these workers is described below. All of the impact results presented here are annual impacts. Additional results, explanations of the methods used, and suggestions on how the results can be used to educate the public and elected officials can be found in the specific sections of the body of the report.

  - ***Pharmaceutical manufacturing***: The economic impact of the pharmaceutical manufacturing employment for this company on the county economy is approximately $1.2 billion, 2,400 jobs, and about $5.5 million in local tax revenue. This impact represents approximately 3.2 percent of Ventura County GDP and about 0.6 percent of total county employment. On a per-worker basis, the impact is

approximately $1.1 million in terms of GDP and about $5,300 in terms of local tax revenue. Another pharmaceutical manufacturing job in this company creates a total of 2.3 more jobs in Ventura County. Another $1.00 of pharmaceutical manufacturing production by Company A is associated with an additional $1.30 in county economic activity. The impact of pharmaceutical manufacturing by Company A on the California economy is approximately $2.5 billion, 7,300 jobs, and about $95 million in state and local tax revenue. This impact represents approximately 0.1 percent of state GDP and 0.04 percent of total state employment. On a per-worker basis, the state-level impact is approximately $1.7 million in terms of California GDP and $64,000 in state and local taxes. Another pharmaceutical manufacturing job at Company A creates a total of 5 more jobs in the state. Another $1.00 in manufacturing production by Company A contributes another $1.96 in state-wide economic activity.

- ***Biotechnology Research and Development***: The economic impact of the biotechnology research and development employment of this company on the county economy is approximately $1.4 billion, 7,800 jobs, and $10 million in local tax revenue. This impact represents about 3.7 percent of county GDP and about 1.9 percent of county employment. On a per-worker basis, the impact is approximately $303,000 in economic activity and about $2,400 in terms of local tax revenue. Another biotech R&D job at Company A creates a total of 1.9 more jobs in Ventura County. Another $1.00 of pharmaceutical manufacturing production by this company is associated with an additional $1.59 in county economic activity. The impact of Company A's biotechnology research and development activity on the California economy is approximately $3.0 billion, 16,400 jobs, and $143 million in state and local taxes. This impact represents approximately 0.2 percent of California GDP and 0.08 percent of state employment. On a per-worker basis, the impact of each Company A biotech R&D employee on the state economy is approximately $500,000 in terms of GDP and about $24,000 with respect to state and local taxes. Another biotech R&D job at Company A creates a total of 2.8 more jobs in California. Another $1.00 of Company A biotech R&D output is associated with an additional $2.38 in economic activity in the state.

- ***Impact of Contract Employees***: The 2,000 contract employees for this company add about $170 million, 2,300 jobs, and $2.3 million in local taxes to the company-level impacts described above. This impact represents approximately 0.5 percent of Ventura County GDP and about 0.6 percent of total county employment. On a per-worker basis, the impact is approximately $85,000 in terms of GDP and about $1,100 in terms of local tax revenue. Another contract job at Company A creates a total of 1.2 more jobs in Ventura County. Another $1.00 of contract employment services at this company is associated with an additional $1.43 in county economic activity. The impact of contract employment

at Company A on the California economy is approximately $250 million, 2,700 jobs, and about $14.5 million in state and local taxes. This impact represents approximately 0.01 percent of state GDP and 0.01 percent of total state employment. On a per-worker basis, the impact is approximately $125,000 in terms of GDP and $7,300 with respect to state and local taxes. Another contract job at the company creates a total of 1.4 more jobs in the state. Another $1.00 in contract employment services at Company A contributes a total of $2.10 in state-wide economic activity.

- ***Combined impact of pharmaceutical manufacturing, biotechnology research and development, and contract employment***: The combined impact of Company A's pharmaceutical manufacturing, biotechnology research and development, and contract employment on the Ventura County economy is approximately $2.7 billion, 12,600 jobs, and $17.7 million in local taxes. This impact represents approximately 7.2 percent of county GDP and about 3 percent of county employment. The combined effect of this Ventura County employer on the California economy is approximately $5.5 billion, 26,500 jobs, and $252 million in state and local taxes. This impact represents about 0.3 percent of California GDP and about 0.1 percent of state employment.

- ***Overall Impact of Bio-Pharma Employment on the California Economy***: The state-level impact of bio-pharma employment is based on the average industry employment between 2002 and the second quarter of 2009. Over this period, pharmaceutical manufacturing employment in the state averaged 41,939 annually (this is approximately 3 percent of total manufacturing employment in the state). Biotech R&D employment averaged 20,598 over the period. Since some of these workers produce medicine and R&D services that are "consumed" within the state, we adjust total employment for the amount of manufacturing output and R&D services that are exported from California. With this adjustment, there are 36,906 pharmaceutical manufacturing workers and 18,126 biotech R&D employees engaged in producing medicines that are exported from California. Export activity is the basis of an economic impact as exports bring new dollars into the state. This infusion of funds generates additional economic activity in California. Making the adjustments described above yields more accurate and conservative impact results. The economic impact results summarized below are annual impacts. Additional results, explanations of the methods used, and suggestions on how the results can be used to educate the public and elected officials can be found in the specific sections of the body of the report.

  - ***Pharmaceutical manufacturing***: The economic impact of the pharmaceutical manufacturing industry on the state economy is approximately $66.3 billion, 196,000 jobs, and about $2.6 billion in state and local tax revenue. The impact of this industry accounts for approximately 3.5% of California GDP and about 0.9 percent of the state's workforce. On a per-worker basis, the impact is $1.8 million in terms of the economic activity and $70,500 in terms of the state and

local tax revenue impact. Another pharmaceutical manufacturing job in California creates a total of 5.4 more jobs in the state. Another $1.00 in pharmaceutical manufacturing production in the state contributes another $2.00 in state-wide economic activity.

- ***Biotechnology Research and Development***. The economic impact of biotechnology research and development employment on the state economy is approximately $9.1 billion, 50,300 jobs, and $454 million in state and local tax revenue. The impact of this industry accounts for approximately 0.5 percent of California GDP and about 0.2 percent of the state's workforce. On a per-worker basis, the impact is $500,000 in terms of the economic impact and $25,000 in terms of the state and local tax revenue impact. Another biotech R&D job in California creates a total of 2.8 more jobs in the state. Another $1.00 in biotech R&D in the state contributes another $2.38 in state-wide economic activity.

- ***Combined impact of pharmaceutical manufacturing and biotechnology research and development employment***: The combined impact of pharmaceutical manufacturing and biotech research and development employment is approximately $75 billion. This is about 4 percent of California GDP. The combined employment impact is approximately 245,000 jobs. This is about one percent of the state total. These sectors contribute approximately $3 billion in state and local tax revenue.

- ***Industry Supply Relationships and Cluster Analysis***: In this section we describe the supply relations between pharmaceutical manufacturers, between pharma manufacturers and the biotech research and development industry, and between the combined bio-pharma industry and other industries in California. The results reported below are based on the state-level analysis of the industry. To identify the supply relationships, we stimulated each sector separately (using IMPLAN) with a hypothetical $1 million increase in sales. This analysis provides insight into the characteristics of bio-pharma clusters (concentrations of interconnected companies and institutions in an area) and how clusters develop.

  - **Input-output analysis** reveals significant supplier relationships among pharmaceutical manufacturers, the biotechnology research and development industry, and the construction industry. For example, each $1 million increase in the production of medicinal and botanical manufacturing is associated with supply purchases from other pharmaceutical producers and the biotech R&D industry of $179,000. This industry also spends approximately $5,300 on maintenance and repair construction for each $1 million in value produced. Specifically, the medicinal and botanical manufacturing sector purchases supplies from its own industry, from the biological product and pharmaceutical preparations industries, and from bio-tech R&D. A similar $1 million increase in production of pharmaceutical preparation manufacturing is associated with supply purchases of $166,000 from other pharmaceutical manufacturers and the biotech R&D industry. This industry also spends approximately $4,500 on maintenance and repair construction for each $1 million in value produced. Specifically, the pharmaceutical preparation industry purchases supplies from its

own industry, from the biological product and medicinal/botanical manufacturing industries, and from bio-tech R&D. Each $1 million increase in the production of in-vitro diagnostic substance manufacturing is associated with the purchase of $222,000 in supplies from the biotech R&D, the pharmaceutical preparation manufacturing industry, and from biological product manufacturers. This industry also spends approximately $5,000 on maintenance and repair construction for each $1 million in value produced. Finally, a $1 million increase in the output of biological product manufacturing triggers the purchase of $243,000 in supplies from biological product, pharmaceutical preparation manufacturers, and from biotech R&D. This industry also spends approximately $6,300 on maintenance and repair construction for each $1 million in value produced.

- **Supply relationships** differ for the biotechnology research and development industry. This industry has strong supply relationships with the construction industry, other professional and scientific services, and credit sources. For example, each $1 million in R&D output stimulates a supply response of $190,000 in the real estate, building services, construction maintenance and repair, and the architectural and engineering services industries. Other technical, scientific, and credit sources experience a supply effect of approximately $77,000.

- **Clusters.** While supply relations between pharmaceutical manufacturers and biotech R&D firms are important to the development of the industry cluster, close proximity among manufacturers is not crucial. For example, only 37 percent of pharmaceutical manufacturing employment in the state is concentrated in the five selected counties. Local incentives and tax breaks play a large role in the location decision of the pharmaceutical manufacturing industry. There is some evidence that the need to be near a strategic partner plays a role in some location decisions.

- **Biotechnology research and development employment is geographically concentrated**. For example, about 88 percent of California biotech R&D workers (not employed in pharmaceutical manufacturing facilities) are located in the five selected counties. It is important for research scientists to locate near a critical mass of R&D workers. When a pharmaceutical product is not approved, research scientists are not moved to work on another product within the firm, but are typically released instead. Therefore, these workers face high unemployment risks and reside in areas where they can move between employers easily. Consequently, there is an advantage for biotech R&D firms to also locate in areas accessible to the R&D labor supply. However, this is not a concern for the pharmaceutical manufacturers. Once the product has been approved, it can be produced anywhere. Labor supply proximity is not an issue and location decisions for these firms are influenced more by local incentives and tax breaks.

- **Role of Bio-Pharmaceutical Infrastructure Providers**:
    - There is a strong inter-connectedness between the bio-pharma industry, building contractors, and the building trades. Because of the high value of the product, the time pressures during the product approval process and delivery to the market, downtime is devastating. Consequently quality and time are priorities in bio-pharma construction. Contractors and project management companies specialize in the industry and are selected because of their expertise. There are also unique relations between project owners and the building trades. For example, many union locals describe arrangements with the bio-pharma industry that are similar to project labor agreements where many of the usual union contractual arrangements are relaxed and flexibility provides for consistent employment and uninterrupted work on projects. For example, some union locals have "grown up" with the industry. The best construction workers are often retained after the completion of a project for ongoing renovation and may spend 20 to 25 years with a bio-pharma firm. In many instances when the needs of the industry require new construction techniques, a union local will provide the training to complete industry-specific tasks.

- **Economic Impact of Building Bio-Pharma Infrastructure**. We use the following case studies to illustrate the various impacts of building and maintaining bio-pharma infrastructure. While the economic impacts of operating bio-pharma facilities (described above) are annual or ongoing impacts, the economic impacts of building pharma infrastructure are one-time impacts.
    - ***Impacts of building with a project labor-local hire agreement***. A $900 million pharmaceutical manufacturing facility in Solano County was built with a project labor agreement (PLA) and a local hire arrangement. Consequently, 90 percent of construction was completed by Solano County workers. The impact of the local hire agreement on local economic activity, job creation, and county sales tax revenue was about 3.3 times larger relative to the typical arrangement with 30 percent of the work completed by county residents. For example, the county-level labor income impact associated with a higher percent of local employment was approximately $101 million (versus $30 million if 30 percent of work was local). About 752 local jobs were created and supported in the Solano County retail and service industries when 90 percent of the work was local (compared to 226 jobs if less of the work was completed by county residents). County sales tax revenue was approximately $63,000 with the local hire agreement and would have been closer to $19,000 if less of the work on this project was completed by local construction workers. The study also identifies the specific local retail and service industries that benefit from local hire agreements.
    - ***Impact of building a large pharmaceutical manufacturing facility on the California economy***. The construction of the $900 million facility in Solano County created about 6,700 jobs in the state, increased economic activity by about $2 billion, and resulted in an increase in state and local sales tax revenue of approximately $20.6 million. The impact per construction worker is approximately $1.7 million in terms of state GDP and $17,000 with respect to

the state and local sales tax revenue impact. The results from this project suggest that for each $1 million in pharmaceutical manufacturing construction, economic activity in California increases by $2.0 million.

- ***Impact of building a small biotechnology research and development facility on the San Mateo and California economies***. A $40 million facility was recently completed in San Mateo County. The project employed approximately 450 construction workers and created a total of 516 county jobs, increased county-level economic activity by $51.9 million, and increased local sales tax revenue by about $48,300. The impact per construction worker on the San Mateo County economy was $115,300 in terms of county-level GDP and $110 in terms of local tax revenue. Based on this project, each $1 million in biotechnology R&D construction activity is associated with an increase of $1.3 million in county-level economic activity. The impact of building this facility in California was about 700 state-wide jobs, $85.4 million in economic activity, and $954,000 in combined state and local sales tax revenue. The impact per construction worker is $190,000 in terms of the contribution to California GDP and $2,100 with respect to state and local tax revenue. Based on this project, each $1 million in biotechnology R&D construction contributes a total of $2.1 million in total economic activity for the state.

- ***Impact of ongoing employment of construction workers for maintenance and renovation***. An operating pharmaceutical manufacturing facility in Solano County employs about 70 construction workers annually for ongoing maintenance and renovation work. The county-level impact of this level of employment is about 100 total jobs, $14.3 million in additional economic activity, and $122,000 in local tax revenue. The impact per construction worker is about $204,000 with respect to county-level GDP and $1,700 in terms of local tax revenue. This impact is specific to Solano County, but the practice of retaining construction worker services after a project is completed is widespread. It is useful to consider the impact of these retained workers on the state economy. Seventy employed construction workers create and support a total of 136 jobs in the state, increase economic activity by $21.4 million, and increase state and local taxes by $1 million. Since the state-level impact is uniform across California, it is useful to calculate the per worker impacts. Each construction worker involved with ongoing maintenance and renovation of a pharmaceutical manufacturing facility contributes approximately $305,500 to state GDP and $15,400 to state and local tax revenue. One more construction worker involved in this type of work results in the creation of about 2 total jobs in California. Each $1 million in construction renovation is associated with $2.1 million more in state GDP.

- ***Potential impact of a pharmaceutical manufacturing location decision***. In 2005 a San Diego-based pharmaceutical manufacturing company decided to locate their new facility in Ohio. We estimate the impact of building and operating this facility *if* the project were located in California. The impact of building this pharmaceutical manufacturing facility would have created a total of approximately 3,900 jobs in the state, increased economic activity by about $916 million, and increased state and local sales taxes by $9.4 million. The

operation of this facility would have added about 2,400 jobs, $848 million in state-level economic activity, and $31 million in state and local taxes. There was interest on the part of southern Californian economic development officials to locate the plant in Imperial County. If the facility had been built in this county the estimated impact on employment would be about 136 jobs, $39 million in additional economic activity and about $12,800 in local sales tax revenue. The building impact is small for this small county because the local construction industry could not accommodate such a large project without the assistance of out-of-county contractors and construction workers. The operation of the facility in the county would add about 850 jobs, $480 million in economic activity, and $1.6 million in local tax revenue.

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Research Funding:

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Introduction

This report is divided into two parts. Part 1 presents an overview of the pharmaceutical, biopharmaceutical and biotech research and development industries in California as well as placing these industries in a national context. This section discusses some of the data and definition constraints facing analysts of these industries, and how we have approached these challenges. Part 1 presents data and trends in employment, skill requirements, wages, industrial organization and venture capital investment in these industries; plus, it provides a description and analysis of to what extent, how and why these industries cluster together into local communities. Finally, this section looks at the building and refurbishing of the infrastructure required by these industries. We describe for California who builds pharmaceutical, biopharmaceutical and biotech offices, labs and manufacturing faculties, and why.

In Part 2, this report provides a rigorous analysis of the local and state economic impact of these industries. We explain how economic impact analysis is done, and then we analyze the effect of these industries on local and state economic activity, employment and tax revenues. We focus our analysis on selected California counties where these industries are important. Thus, we provide specific employment and dollar impacts of these industries for Alameda, San Diego, San Mateo, Solano and Ventura counties including both the local and the statewide effects of each of these industries separately and combined in each of these counties. We pay additional attention to the economic impact of the construction (as compared to the operation) of these industries; and we provide specific case studies of the impact of building and operating biopharmaceutical manufacturing plants in California as opposed to out-of-state.

It will be seen that these are important and growing industries which typically cluster together, provide good jobs and stimulate considerable local economic activity, employment and tax revenues. Also, the building of this growing industry generates significant numbers of construction jobs; and interestingly, in combination with demands for construction in the high tech industry, this has created a specialized, cluster of predominately unionized and a highly skilled set of California construction companies geared to the specialized needs of this industry.

California has been fortunate and has done well in incubating, encouraging and facilitating this high-skilled, well-paid, technologically dynamic industry. In turn, this industry has, by clustering locally and availing itself of the various publicly supported universities and private higher education and research institutions, nurtured its own needs. Chief among these needs met have been the creation of locally dense scientific labor markets and locally qualified suppliers and builders. Together, these form a complex set of interconnected economic relationships which are among the strongest and most successful in the world. This report will provide specific estimates of the local economic impact of this complex of industries in California.

Part 1: Describing the Pharmaceutical, Biopharmaceutical and Biotech Industries of California

Industry definitions

Capitalism is a dynamic system which emphasizes and rewards technological change and product innovation. Thus, the shape of industries are always in constant flux as innovation, product development, technological change, company startups, mergers and acquisitions continually alter what is being made, how these products are produced, and who is doing the producing. So defining industries presents the daunting challenge of fixing in description and in statistics a continually moving target.

Our focus. Nonetheless, for practical purposes, fixing industrial activities within the confines of useful definitions is necessary in order to describe, measure and track economic activity. In studies similar to ours, the titles of the industries under study vary. Examples include: "Biotech and Life Science," "Bioscience Industries," "Biomedical Industry," "Biopharmaceutical Industry," "Biotechnology and Biomedical Devices Industry," and so on. [1] Our focus will be on the pharmaceutical, biopharmaceutical and biotechnology-research-and-development industries in California We will look at these three inter-related and inter-connected industries at both the state level (comparing California to other states) and at the level of selected local California counties where these industries are important. We will find that the lines between research, development and manufacturing are not sharp distinctions with often the same facility doing some of each type of work. Because research and development are done in order to eventually manufacture a product, government statistics will call facilities that do some production--manufacturing establishments-- even if considerable research and development takes place there as well. So we will look at what the government calls "pharmaceutical and medicine manufacturing" remembering that this can also include research and development. And we will look at what in government statistics is called "biotechnology research and development" as a separate category even though some biotech R&D activity will be recorded under "pharmaceutical (including biopharmaceutical) manufacturing."

Our focus is partially responding to a current convergence of pharmaceutical and biopharmaceutical activity through the merger of some biotechnology companies with pharmaceutical companies. And our focus is partially responding to the recent (since 2007) issuance of government data on employment,

[1] Literature related to this study include: Federal Reserve Bank of Dallas, San Antonio Branch, "Biotech and the San Antonio Economy," 2003; MassDevelopment and Massachusetts Alliance for Economic Development, "Biopharmaceuticals in Massachusetts," no date (this report treated biopharmaceutical as a subset of the life-sciences industry); "Bioscience: Leading the Way to a Stronger Economy, Connecticut's Bioscience Clusters-Sixth Annual Report," June 2001; Global Research, "Biotechnology and Biomedical Devices Industry Cluster, Labor Market Survey," 2004 (July); Milken Institute, "Biopharmaceutical Industry Contributions to State and U.S. Economy," October 2004; Economics Center for Education and Research, University of Cincinnati and the Center for Business and Economic Research, University of Kentucky, "Cincinnati USA Industry Cluster Profile: Biotechnology," August 2004; Tapan Munroe, Gary W Craft and David Hutton, "A Critical Analysis of the Local Biotechnology Industry Cluster in Alameda, Contra Costa and Solano Counties," June 27, 2002; Ross DeVol, Perry Wong, Junghoon Ki, Armen Bedroussian and Rob Koepp, "America's Biotech and Life Science Clusters; San Diego's Position and Economic Contributions," June 2004.

wages and output for a new industrial classification—"Research and Development in Biotechnology" (North American Industry Classification System or "NAICS" 541711). Again for practical reasons, when we look at local economies, we will look at counties because this is the primary unit for which government data are reported. But "local" economies actually can vary, sometimes being smaller than a county and sometimes larger. Due to limits in government data, we will not be able to go down to smaller than county level but we can combine counties.

The following briefly discusses the characteristics of these three closely related industries: pharmaceuticals, biopharmaceuticals and biotechnology R&D. Our data will differ from some previous studies due to various differences in how we and they have defined the specifics of the industry sectors to be studied. But partly the differences are associated with the ever evolving structure of the pharmaceutical and biopharmaceutical/biotech industries, themselves. So this report, like all previous, is a snapshot in time, freezing for the moment, an ever evolving and very important California industry.

Pharmaceutical and biopharmaceutical industries. The pharmaceutical industry consists of companies that develop and manufacture drugs licensed for use as medications.[2] Traditionally, these drugs were derived from chemical substances, and the pharmaceutical industry has its origins in the 19th Century as a spinoff from the chemical industry. The pharmaceutical industry is relatively mature with one consequence of that maturity being that most research and development of medical drugs is done "in-house" by the same companies that then manufacture these drugs. Thus, unlike biotechnology for which the government reports a distinct biotechnology R&D industrial sector (NAICS 541711), there is no separate R&D industrial sector for pharmaceuticals.

In the last 40 years there has emerged a related *bio*pharmaceutical industry. Biopharmaceutical companies discover, develop and commercialize "products for the prevention and cure of human, animal and plant diseases utilizing genetically modified or modified live or killed biologics."[3]

> Biopharmaceuticals are medical drugs…produced using biotechnology. They are proteins (including antibodies), nucleic acids (DNA, RNA or antisense oligonucleotides) used for therapeutic or in vivo diagnostic purposes, and are produced by means other than direct extraction from a native (non-engineered) biological source.[4]

Thus, biopharmaceuticals are distinct from both (on the one hand) chemical, small-molecule pharmaceutical medicines and herbal, non-engineered, plant-based medicines (on the other).

Many of those interviewed for this report made the distinction between small molecules and large molecules when discussing the difference between the pharmaceutical and biopharmaceutical

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[2] "Pharmaceutical industry," *Wikipedia*, http://en.wikipedia.org/wiki/Pharmaceutical_company (accessed June 25, 2010).

[3] Category: Biopharmaceuticals, "*Wikipedia*, http://en.wikipedia.org/wiki/Category:Biopharmaceuticals

[4] "Biopharmaceutical," http://en.wikipedia.org/wiki/Biopharmaceutical#Classification_of_biopharmaceuticals (accessed June 25, 2010).

industries.[5] Chemical molecules are small molecules and have traditionally been the basis for pharmaceutical drugs. Biological molecules are large molecules and have been the prime basis for biopharmaceutical drugs. Our interviewees emphasized that small molecules behave more predictably than do complex large molecules which makes the research, development and manufacture of biopharmaceuticals inherently more unpredictable and challenging.[6]

Table 1: Biological vs. Conventional and New Molecular Entity (NME) Drugs[7]

Biologics	Conventional and NME drugs
Large molecules (>5000 molecular weight)	Small molecules (~500 molecular weight)
Biotechnologically produced or isolated from living sources	Chemically synthesized
Complex structure/mixtures (tertiary structure, glycosylated)	Simple well-defined structure
High target specificity	Less target specificity
Generally parenteral administration (e.g., intravenous)	Oral administration possible (pills)
Can be antigenic*	Generally not or unpredictably antigenic

* Antigen is a substance that stimulates the production of an antibody.

Table 1 summarizes the basic differences between a biologic drug and a conventional chemical or new molecular entity (NME) drug.[8] These technical differences tend to make these two separate industries although in government statistics they are not necessarily separated.

Economic forces are bringing the medicine-biotechnology industry and the pharmaceutical industry closer together. Pharmaceutical research and development which is required prior to manufacturing and marketing of new conventional medicines entails substantial investment. But because biopharmaceutical drugs are more complex and less predictable, the R&D required to bring a biologic drug to market is typically even greater. So there is an intense demand for capital to finance biologic

[5] "The large majority of biopharmaceutical products are pharmaceuticals that are derived from life forms. Small molecule drugs are not typically regarded as biopharmaceutical in nature by the industry." "Biopharmaceutical," *Wikipedia*, http://en.wikipedia.org/wiki/Biopharmaceutical

[6] For instance: "In manufacturing of biological drugs, product quality is defined by the process …because no complete analysis of these complex molecules is possible….There is no further process optimization option parallel to production, which, in the case of small molecule productions, allows further process optimization." Sven Sommerfeld, Jochen Strube, "Challenges in biotechnology production—generic processes and process optimization for monoclonal antibodies," *Chemical Engineering and Processing,* 44 (2005) 1123–1137.

[7] This table is reproduced from: "Biotech, Lifting Big Pharma's prospects with biologics," MoneyTreeTM Report, PricewaterhouseCoopers and the National, May, 2009, p. 7, http://www.pwc.com/en_GX/gx/pharma-life-sciences/pdf/biotech-final.pdf (accessed June 25, 2010).

[8] "A [new molecular entity NME also known as a new chemical entity] NCE is a chemical molecule developed by the innovator company in the early drug discovery stage, which after undergoing clinical trials could translate into a drug that could be a cure for some disease." "New chemical entity," *Wikipedia*, http://en.wikipedia.org/wiki/New_chemical_entity (accessed June 25, 2010).

R&D. Traditionally this investment has come from venture capital in association often with small, start-up biotech companies. The synergy between venture capital and small, innovative biotech firms historically has reflected both the high risk and the innovative dynamism involved in developing biopharmaceuticals and other biotech products. But with the recession of 2007-2009 and the slow subsequent recovery, other sources of capital have been sought to continue to energize the biopharmaceutical industry. The pharmaceutical industry has been a primary source of recent new capital for biotechnological R&D through company mergers and acquisitions as well as partnerships with biopharmaceutical companies.

Pharmaceutical companies, themselves, have been attracted to biopharmaceutical companies and products for reasons of their own.

> The cash crunch and inhospitable IPO [initial public stock offering] climate intersect as pharmaceutical companies strive to fill product pipelines and larger biotech companies look to expand market share in biologic drugs….A broad appeal of biologics is not only their pipe-filling capability but also the potential difficulty for generic drug makers to replicate the original branded biologic, thus potentially extending the revenue stream, even after the biologic goes off patent. Manufacturing (or, rather, cell-or tissue-based growing) processes of the pioneer biologics drugs are, in general, far more difficult to duplicate by generic drug makers compared to chemically synthesized drugs.[9]

Thus, what technology had created as two separate industries, pharmaceutical medicines based on small molecules and biopharmaceutical medicines based on large molecules, economic forces are bringing closer together. However, due to the risks associated with discovering useful biopharmaceutical drugs, it may well be that a standalone segment of smaller biopharmaceutical startup companies allied with venture capital will continue indefinitely to populate a portion of this otherwise converging industry.

Biotechnology. The biotechnology industry as a whole is broader than the biopharmaceutical industry because biotechnology can also be applied to engineering, biofuel, technological and other useful applications in addition to medicinal drugs.[10] The North American Industry Classification System (NAICS) defines research and development in biotechnology as:

> … the study of the use of microorganisms and cellular and biomolecular processes to develop or alter living or non-living materials. This research and development in biotechnology may result in development of new biotechnology processes or in prototypes of new or genetically-altered products that may be reproduced, utilized, or implemented by various industries.[11]

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[9] "Biotech, Lifting Big Pharma's prospects with biologics," MoneyTreeTM Report, PricewaterhouseCoopers and the National, May, 2009, pp. 8-9, http://www.pwc.com/en_GX/gx/pharma-life-sciences/pdf/biotech-final.pdf (accessed June 25, 2010).

[10] "Biotechnology," *Wikipedia*, http://en.wikipedia.org/wiki/Biotechnology (accessed June 25, 2010).

[11] "2007 NAICS Definitions: 541711 Research and Development in Biotechnology," http://www.census.gov/naics/2007/def/ND541711.HTM (accessed June 25, 2010).

Earlier studies similar to ours were handicapped by government data which did not consistently report biotechnological R&D work under one industry classification. However, since 2007 the NAICS system separately identifies an industry sector (NAICS 541711) for biotechnology R&D. This will allow us to track data on standalone establishments that focus primarily on biotechnology R&D. This tracking is not without complications as a couple of examples will show.

Tracking pharmaceutical, biopharmaceutical and biotech R&D in government data. Amgen is an international biotechnology-based corporation with approximately 14,000 employees company-wide headquartered in Thousand Oaks, Ventura County, California. Amgen is the largest private employer in Ventura County; and at this facility, the company does biotechnological research and development along with manufacturing.[12] In government statistics, Amgen's Thousand Oaks facility is an "establishment" which in common parlance might be thought of as a "facility." A company can be (and often is) composed of many establishments or facilities. An establishment tends to be a single physical location, a place of employment and is classified within the NAICS system according to its "primary" business activity. "Primary" is a tricky word which we will discuss below. In Amgen's case, the company has many "establishments" (i.e. facilities) found in many locations including Thousand Oaks. According to government statistics, the "primary" activity of Amgen in Thousand Oaks is manufacturing.

"Primary" activity. When a facility or establishment is researching, developing and then manufacturing a biologic product in one place as Amgen does in Ventura County, NAICS will classify the "primary" activity as manufacturing even if many or even most employees are engaged in research or development or company-wide management. This is because R&D and management are seen as preliminary or auxiliary steps in the manufacturing process of the establishment (i.e. the facility). So Amgen in Ventura County will not be counted in biotechnology R&D (NAICS 541711) but rather in pharmaceutical (including biopharmaceutical) and medical manufacturing (NAICS 2354). This example shows that in government statistics, a lot of R&D activity is subsumed within manufacturing activity in biopharmaceuticals when you have all these activities combined in one establishment. This makes it hard to track R&D activity separately. Life gets even more complicated in non-government data covering the construction of these facilities when private statistics label a manufacturing plant as a research lab because the company that owns the facility emphasizes its research mission. Melding government and nongovernment data requires judicious assessments.

Nondisclosure. In addition to this problem of mixing R&D with manufacturing, also the government does not disclose data at the county level when it would reveal information about any one particular company. While there are clusters of similar companies to Amgen in the San Francisco Bay Area and in San Diego, Amgen is the big biotechnology fish in the small pond of Ventura county. So if one were to see government data on biomedical manufacturing (NAICS 2354) for Ventura County, or one of this industry's components such as "other biological product [medicinal] manufacturing" (NAICS 325414), one might very well see Amgen data or mostly Amgen data. Therefore, the government will not disclose these data at the Venture County level for privacy reason. Amgen Ventura County employment, wages and other economic data will show up combined with all other related companies at the California state

[12] "Amgen," *Wikipedia*, http://en.wikipedia.org/wiki/Amgen (accessed June 25, 2010).

level in government reports but not at the county level. Thus, Amgen in Ventura County, an archetypical biotechnology company, will not show up in biotechnology R&D data either at the county level or at the state level, nor will Amgen, the largest private employer in Ventura County, show up in medical manufacturing data at the Ventura County level although it will show up in state level data. When we look at county level data, we need to remember that in Ventura, a very important company's statistics will not be disclosed.

So we have issues of R&D coming under the heading of manufacturing and we have the issue of nondisclosure of data for privacy reasons. But fortunately for researchers, these problems often fortuitously disappear. Let us take another example for comparison. Pfizer is an archetypical international pharmaceutical manufacturing company.[13] Yet, Pfizer's San Diego County facility in La Jolla (an establishment in government terms) focuses primarily on biotechnology research and development.[14] Furthermore, Pfizer's La Jolla campus is only one of a large number of biotechnology R&D establishments located in San Diego County. So despite the fact that Pfizer internationally is one of the largest *manufacturers* of conventional chemically-based medicines, the Pfizer workers in La Jolla are classified (as one would want them to be) as *biotechnology R&D* workers (NAICS 541711); and despite the fact that Pfizer is one of the world's largest drug companies, these La Jolla workers' data are not suppressed due to privacy/disclosure problems, but rather these workers show up in San Diego biotechnology R&D data along with many other establishments. So in Ventura, we have a biotechnology company's facility showing up under other biological [medicinal] product manufacturing yet not disclosed at the country level while in San Diego we have a giant pharmaceutical company's facility showing up (correctly) as a biotechnology R&D establishment with the data disclosed at the county level.

Those not used to working with government and private economic statistics may find these complications dismaying; but surprisingly that is not generally the case. Once we know how these data are collected, we can make adjustments and/or weigh our results accordingly. Fixing a moving target is never easy. Getting down to the nitty gritty is not always easy. But as the reader will see, the numbers show that however we slice or dice the data, this is a well-paid, dynamic and important local industry in several counties in California. And as we shall see in the second half of this report, the presence and growth of pharmaceutical, biopharmaceutical and biotechnology research and development industries provides an important stimulus to the various local California economies in which they are found.

Investment in biotechnology

As stated above, biotechnology is proving to be a growth sector within the broader pharmaceutical industry. Figure 1 provides one measure of the growth of biotechnology in the U.S. by showing the total annual dollar amount of venture capital (VC) investment in biotechnology since 1995 presented in inflation-adjusted 2010 dollars. Additionally, Figure 1 shows biotech venture capital investment as a percent of total venture capital investment. In real inflation-adjusted dollar terms, new venture capital investment in biotech rose dramatically in the late 1990s but in relative terms, biotech venture capital

[13] "Pfizer ," http://en.wikipedia.org/wiki/Pfizer (accessed June 25, 2010).
[14] http://www.pfizer.com/research/rd_locations/la_jolla.jsp (accessed June 25, 2010).

investment declined as a percent of all venture capital investment during the dot-com boom as investor money poured into what is commonly called the "high tech" industries associated with computers and the internet.

After the recession of 2000, however, with the dot-com bust, in real, inflation-adjusted terms, biotech venture capital investment held steady but in relative terms, biotech investment rose from around 5% of all venture capital (VC) investment to about 15%. In the recent recession, biotech venture capital investment has fallen in real terms; but because biotech venture capital investment has not fallen as fast as other venture capital investment, biotech VC has recently risen to a 20% share of all venture capital investment in the U.S. What this means is that biotech continues to attract venture capital and is playing an increasingly important role in total venture capital investment despite the fact that the recent recession has reduced overall venture capital investment. As indicated above, new sources of investment in biotechnology are coming from the pharmaceutical industry not in the form of venture capital but rather in the form of mergers, acquisitions and partnerships. So we cannot see this new flow of investment by looking at VC data. Nonetheless, it is likely that total investment in biotechnology continues to increase in real, inflation-adjusted dollar terms, albeit more slowly since the recent recession.

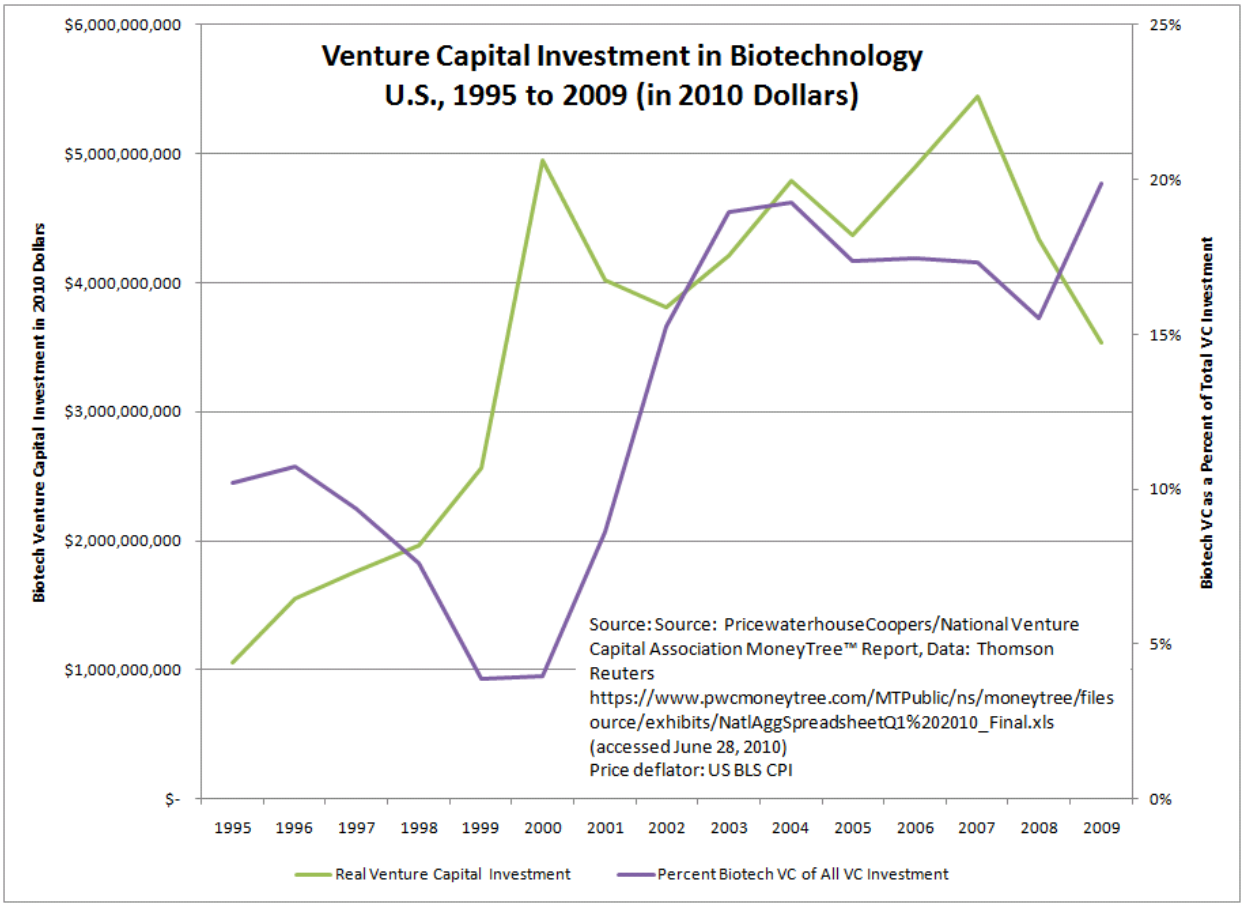


Figure 1: Venture Capital Investment in Biotechnology in Real, 2010 Dollars and as a Percent of Total U.S. Venture Capital Investment

California employment in pharmaceutical manufacturing and biotechnology

Since 1990, employment in pharmaceutical and medicine manufacturing in California has grown from around 25,000 workers to about 45,000 workers, an increase of approximately 80 percent. We cannot track employment in biotechnology research and development as clearly because this emerging industrial sector has only had its own NAICS government statistical classification since 2007. We can, however, approximate the increase in biotech R&D employment by following the R&D employment in physical, engineering and life science activity since 1990. This is the government super-category within which biotech R&D is a sub-category and into which biotech R&D workers were placed prior to 2007. In 2007, when we have data for biotech R&D, biotech comprised about 19% of all physical, engineering and life science R&D in California. Using that percentage, we approximate biotech R&D employment back to 1990 by simply multiplying 19% against the overall employment each year in R&D in the physical, engineering and life science sector. Doing this suggests that biotech R&D grew from about 15,000 employees in California in 1990 to about 20,000 in 2008. This growth rate of 33% is surely an underestimate because on our assumption that biotech R&D has been a constant 19% of physical, engineering and life science R&D since 1990. In all probability, biotech R&D likely started as a smaller percentage of physical, engineering and life science R&D (perhaps 5%) and grew to its current 19% share. This, of course, would mean that biotech R&D employment in California has grown faster than 33% between 1990 and 2008 (the last year for which full data are available). In any case, biotech R&D and pharmaceutical/medicine manufacturing together in 2008 accounted for about 65,000 workers in California and over the previous 18 years both sectors' employment grew rapidly.

Correspondingly, the number of establishments (i.e. facilities) in each sector also grew rapidly over the period with pharmaceutical/medicine manufacturing establishments growing from about 300 facilities to about 400 in California from 1990 to 2008, and using the same methodology as above, we estimate that the number of biotech R&D establishments growing from about 320 to about 550. (Remember "establishments" are not companies but rather facilities. One company may have only one establishment in California or it may have many establishments). These data also indicate that biotech R&D establishments are smaller than their manufacturing counterparts with about 550 biotech R&D establishments accounting for about 20,000 employees in 2008 while about 400 pharmaceutical/medicine manufacturing establishments accounted for about 45,000 employees in 2008. So an average pharmaceutical/medicine manufacturing establishment in 2008 employed about 110 workers while the average biotech R&D establishment employed about 35 workers.

The conclusions here are two: first, both these industry sectors are growing relatively rapidly in California in terms of employment and in terms of number of establishments. Second, if a biotech R&D facility is coming to town, it is likely to be a smaller establishment than if a pharmaceutical/medicine manufacturing plant is coming. Overall, in the last about 20 years, many new establishments of both types have been built in many local communities in California.

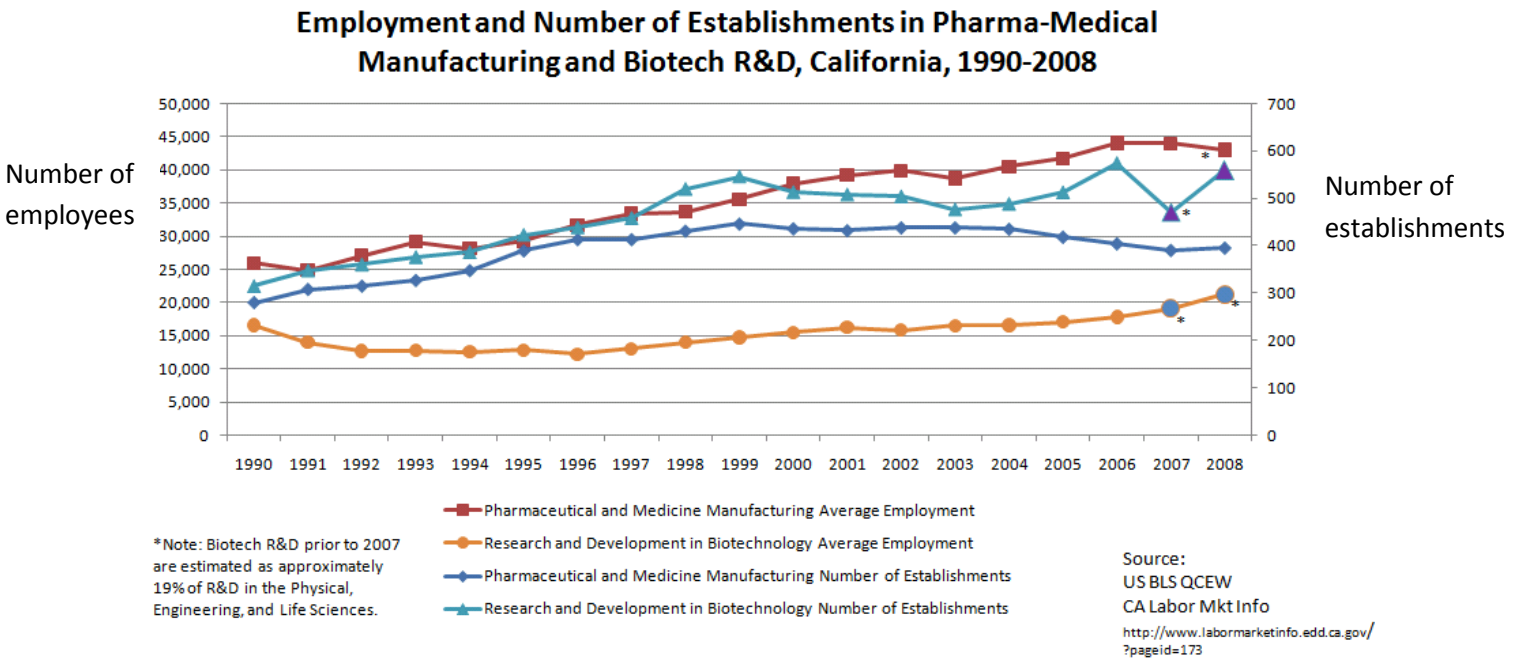


Figure 2: Employment and number of establishments in pharmaceutical/medicine manufacturing and biotechnology research and development in California, 1990 to 2008

The pharmaceutical/biopharmaceutical industry vs. the biomedical industry

This study examines the pharmaceutical/medicine manufacturing and biotechnology research & development industries. The California Healthcare Institute (CHI) regularly reports on the California "biomedical industry."[15] Our data will show lower levels of employment compared to the CHI biomedical industry data because the industry sector we focus on is a subset of the industry their data refer to. CHI's biomedical industry data include 1) biopharmaceuticals (essentially along with pharmaceuticals--our focus), 2) wholesale trade companies importing or exporting pharmaceuticals, medical devices, diagnostics and research reagents, 3) medical devices, instruments and diagnostic technologies, 4) laboratory services, and 5) basic academic research and training. This broader industry focus naturally yields a much larger level of employment in California.

But employment growth in the pharmaceutical and biopharmaceutical sectors we are examining tracks the CHI's chosen sectors closely. Figure 3 shows the CHI reported employment for 5 biomedical sectors compared to the 2 sectors discussed in this report. Employment for the 5-sector count is on the left vertical axis and rises from about 190,000 in 1990 to about 270,000 in 2008. The two sectors pharmaceutical manufacturing and biotech R&D rise from about 42,000 to about 65,000 over the same time period. The fact that these growth rates in employment are similar is not surprising. Much has been said regarding the tendency for biotechnology firms to geographically cluster and for pharmaceutical firms to similarly cluster. In fact, this industry even broadly construed as in the CHI data

[15] California Healthcare Institute, "California Biomedical Industry," Report (various years).

grows in tandem not only geographically but also over time. In considering policies to attract or retain either the narrowly construed biopharmaceutical sectors or the broadly construed biomedical industry, an understanding of this geographical and temporal clustering is useful.

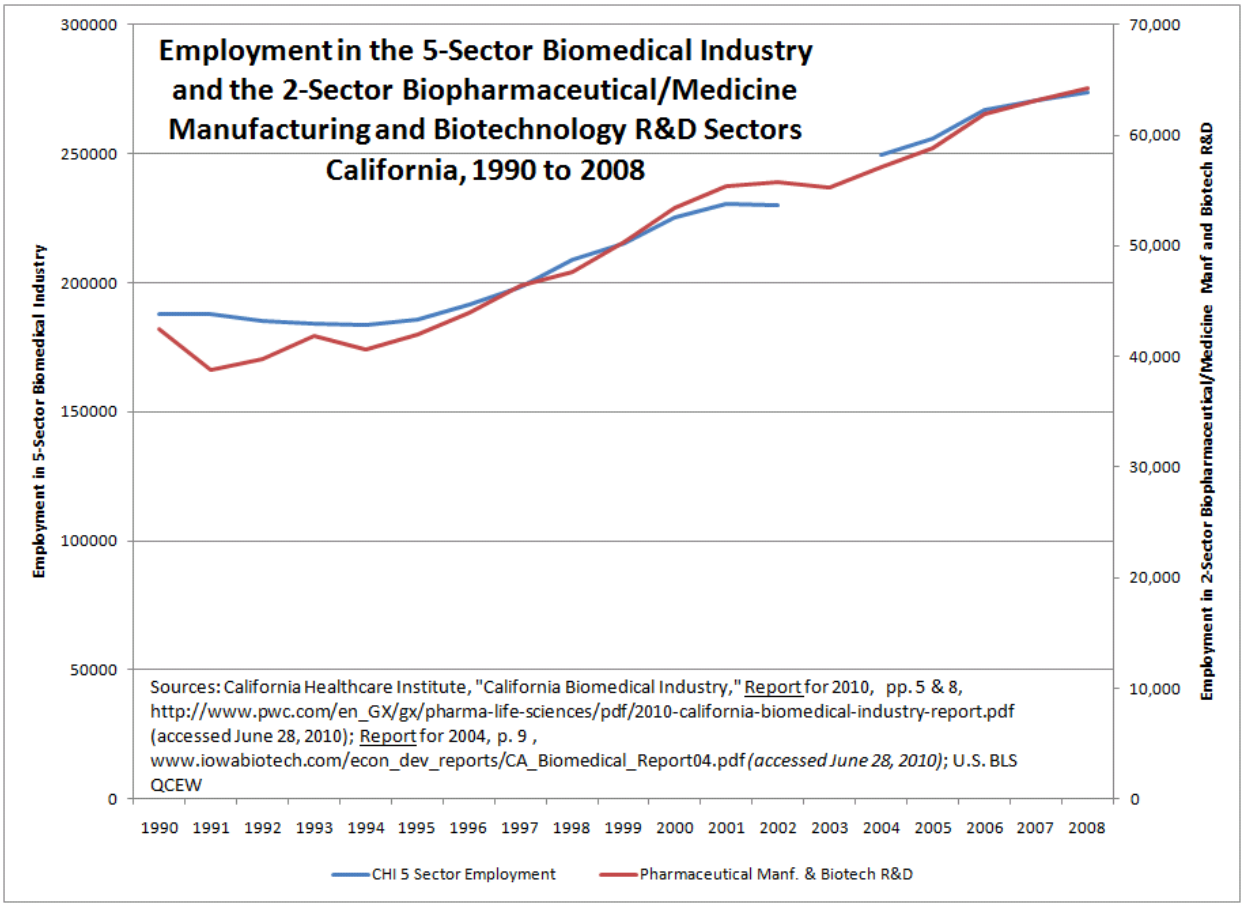
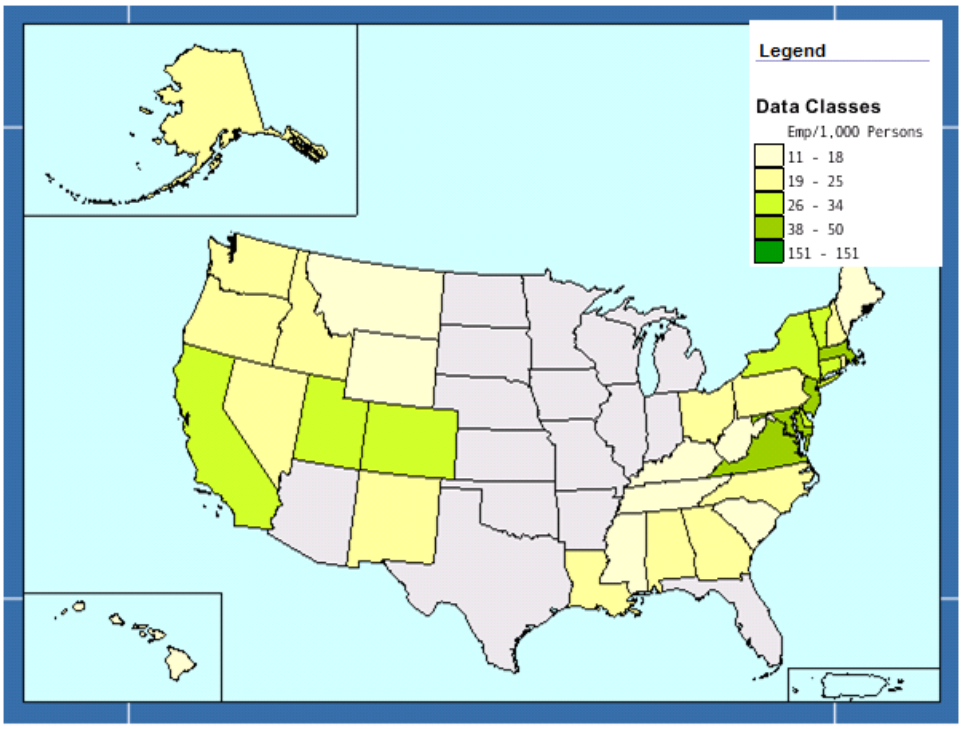


Figure 3: California employment in the 5-Sector biomedical industry reported by the California Healthcare Institute compared to employment in the pharmaceutical and biotechnology industries compared, 1990 to 2008

Clustering

Some industries spread evenly across the country and some industries cluster close together. Examples of widely spread industries include retail food and construction. Every community needs grocery stores and every community needs construction services. Furthermore, with some limited exceptions, food sales and construction have to be done in the local community. So these industries are found in almost every community.

Medicines, on the other hand, do not have to be produced locally to be consumed locally. Medicines can be researched, developed and manufactured at a distance and then shipped into the local community. So the economics of location for pharmaceutical and biopharmaceutical research, development and manufacturing are driven not by the need for local production/construction but by other factors associated with a variety of needs or requirements including those of research, finance, regulation and corporate organization.



Source: U.S. Bureau of the Census, 2007 Economic Census

Figure 4: Professional, Scientific & Technical Employment per 1000 Persons by State 2007

Research. First, let us consider the issue of research clustering. In general, scientific research in the United States concentrates in certain areas of the country. Figure 4 shows that California has from 26 to 34 professional, scientific and technical workers per 1000 employees and that this is more than many states but fewer than the several states in the run between Massachusetts to Virginia on the East Coast. Not all of the workers in this group are scientists, but the general pattern of clustering professional, scientific and technical workers in the U.S. reflects the concentrated presence of vibrant universities, research institutions and the satellite and spinoff companies that surround them. History, politics and economics all play a role in concentrating scientific and educational centers in certain parts of the country. The private universities in the Northeast and the public university system plus Stanford and the University of Southern California help California and the Northeast lead in the concentration of scientific, technical and professional workers. The synergistic interaction between institutions of higher learning and enterprises reliant upon the skilled labor trained by these schools creates a general pattern of clustering of scientific and professional work in the U.S.

Biotech R&D. Biotech research and development is much more concentrated in clusters than overall professional, scientific and technical employment in the U.S. Figure 5 shows that Massachusetts has the highest concentrated employment of biotech workers followed by California and then Pennsylvania, Maryland and North Carolina. For reasons that will be discussed below, there is a tendency for like to

attract like in scientific research, in general, and in pharmaceutical, biopharmaceutical and biotechnology research in particular.

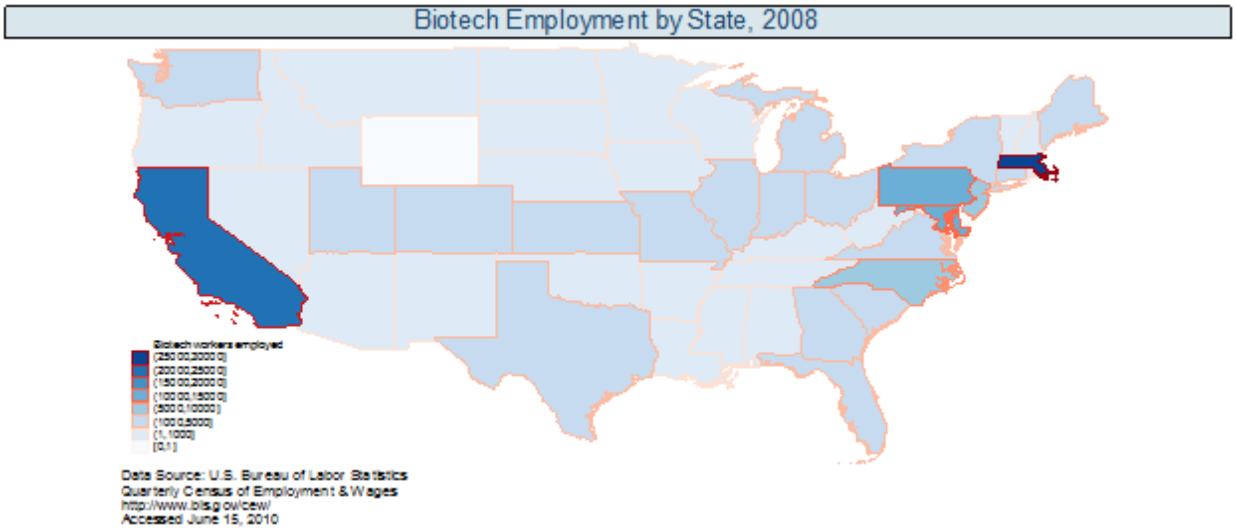


Figure 5: Biotechnology research and development employment by state, 2008

Bio-Pharma manufacturing. Pharmaceutical, biopharmaceutical and medicine manufacturing is more spread out compared to biotech research and development; but this type of manufacturing (including R&D that falls within this government statistical category) is still relatively clustered.

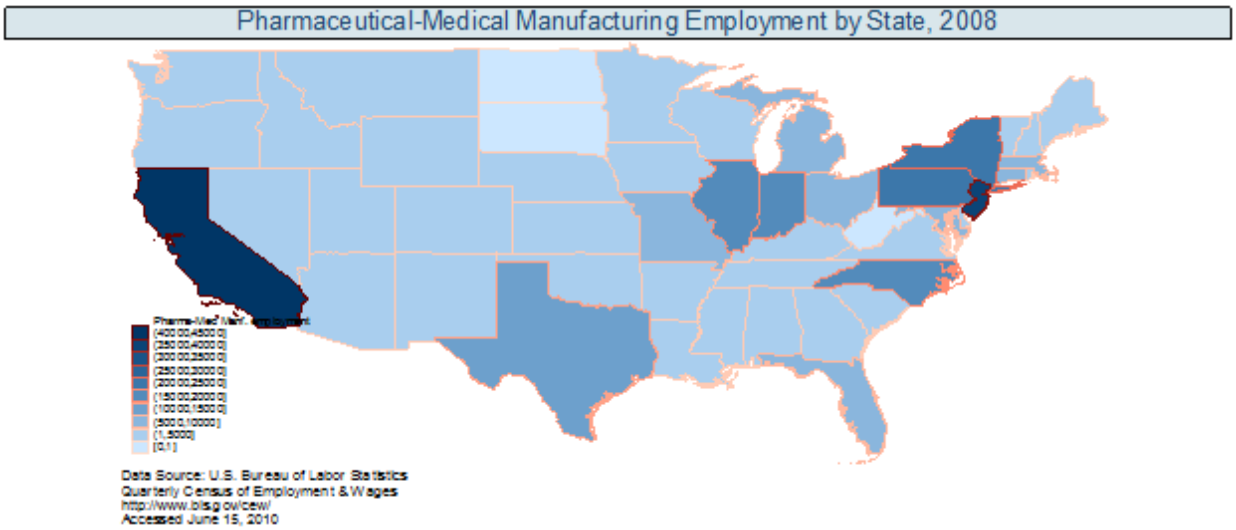


Figure 6: Pharmaceutical (including biopharmaceutical) and medicine manufacturing by state, 2008

Figure 6 shows that many of the states that are important for biotechnology research and development are also important states in pharmaceutical, biopharmaceutical and medicine manufacturing. This includes California, Pennsylvania and New Jersey. However, Massachusetts is stronger on the R&D side compared to manufacturing while Illinois, Indiana and Texas become important in manufacturing while they are not currently leading states in research and development.

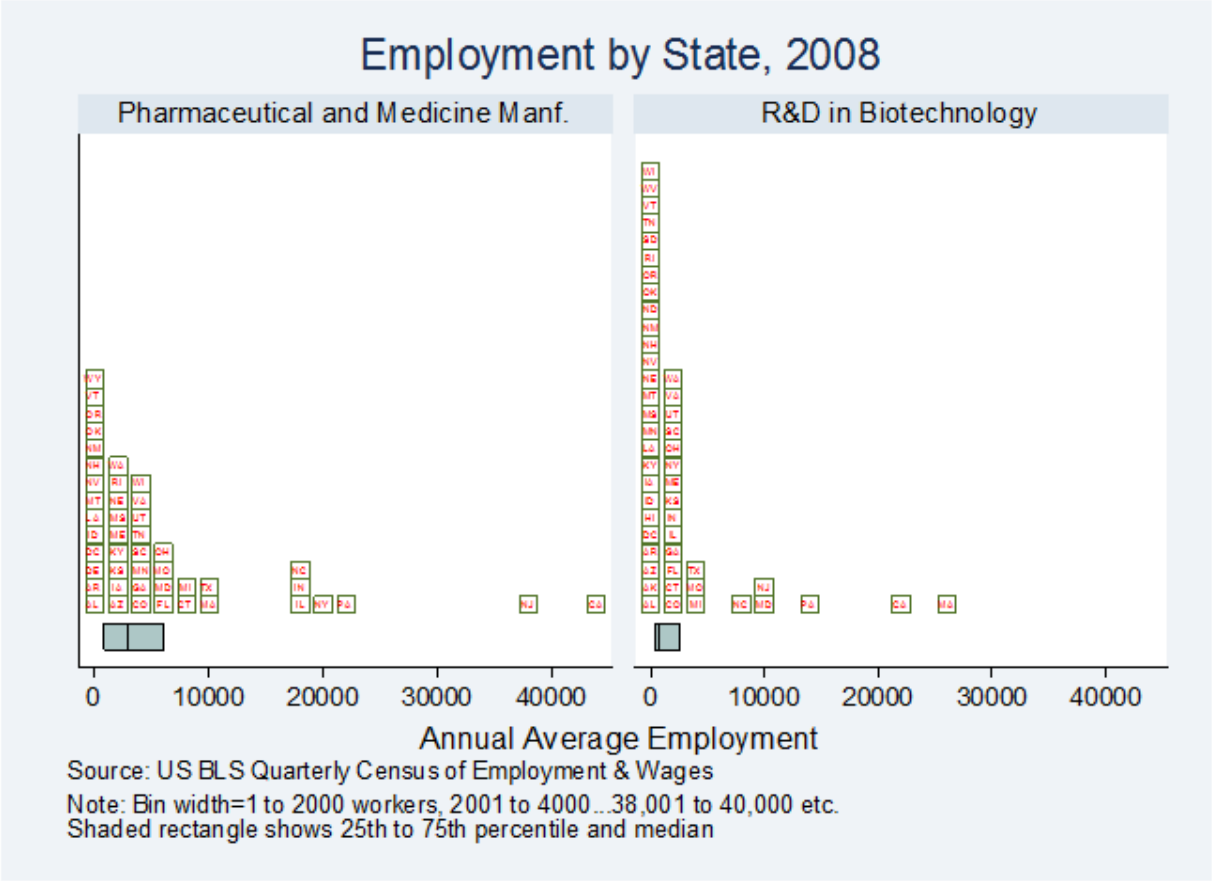


Figure 7: Clustering of employment in pharmaceutical and medicine manufacturing by state compared to biotechnology research and development, 2008

Clustering compared. Figure 7 compares the geographical dispersion of pharmaceutical (including biopharmaceutical) manufacturing to biotech R&D. The horizontal axis shows employment and each box represents a state. Only states with at least a total of 100 workers in the industry are included. The gray box at the bottom of each graph shows the dispersion from the 25th to 75th percentile in state employment in each industry with the vertical line in the box showing median state employment. There are seven states with manufacturing employment way above the 75th percentile with six states way above the 75th percentile in biotech R&D employment. California, Pennsylvania, New Jersey and North Carolina are found in both the group of seven manufacturing states and in the group of six R&D states. Massachusetts and Maryland are found in the group of six outlier research and development states but not found among the seven outlier manufacturing states. Illinois, Indiana and New York are found among the outlier manufacturing states that are not found among the outlier research and development

states. Thus, in both the case of pharmaceutical manufacturing and biotech R&D roughly a half dozen states account for much of the employment and about half of these outlier states are outliers on both sides, manufacturing and R&D.

The conclusions here are 1) both biopharmaceutical manufacturing and biotech research and development cluster to themselves in certain areas; 2) manufacturing and research also tend to cluster together in the same states (e.g. California, New Jersey), but you can have research without as much manufacturing (Massachusetts) or manufacturing without as much research (Texas). Manufacturing can break away from research once the product has been developed, clinically tried and received regulatory approval. But research may still be geographically tied to manufacturing when economies of scale do not justify setting up two establishments or when the manufacturing process and ongoing research overlap or interact with each other in ways justifying proximity.

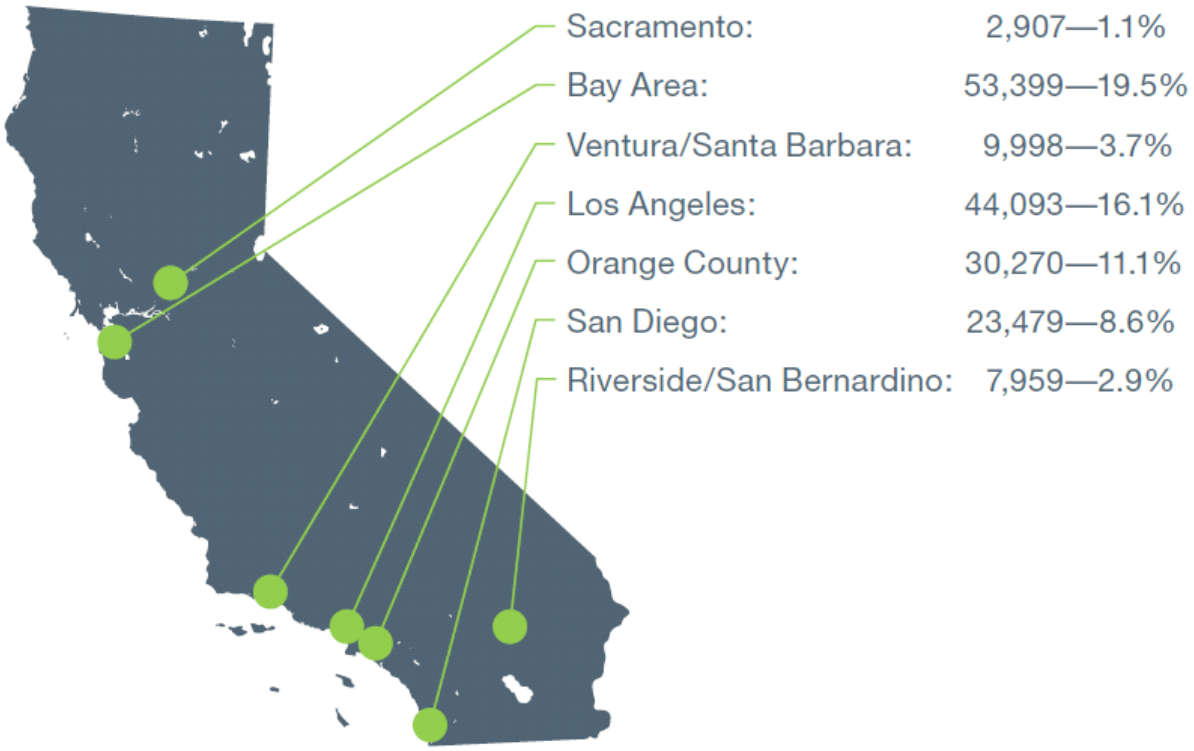


Figure 8: Employment and percent of total employment in the California biomedical industry by region, 2008: Source CHI California biomedical Industry, 2010 Report, p. 6

Clustering in California. We mentioned above the California Healthcare Institute's study of the biomedical industry of which the pharmaceutical/biopharmaceutical and biotech R&D sectors are a part. CHI shows (Figure 8) that within California almost 20% of the biomedical industry is employed in the Bay Area with about 30% in LA-Orange County-Riverside County and another almost 9% in San Diego. So this overall-larger industry clusters geographically for a variety of reasons including locating in

population centers. The industry we report on clusters tightly too reflecting to some extent population centers but also responding to a variety of scientific, educational, cultural and economic forces as well.

Figure 9 and Figure 10 show a similar clustering of the subsectors of pharmaceutical/medicine manufacturing and biotechnology R&D with two exceptions, one real and one apparent. In reality, San Diego is more important in the subsectors of pharmaceutical/medicine manufacturing and biotechnology R&D compared to the broader sectors that CHI examines. However, the seeming lesser importance of San Mateo and Ventura counties in these two subsectors is merely an artifact of government data not disclosing some data to protect the privacy of a limited number of large firms. The key point though is the fact that biotechnology R&D and to a lesser extent pharmaceutical manufacturing are drawn together to build alongside each other for a variety of reasons that we will briefly discuss.

Figure 9: Employment in pharmaceutical and medical manufacturing by region in California, 2008

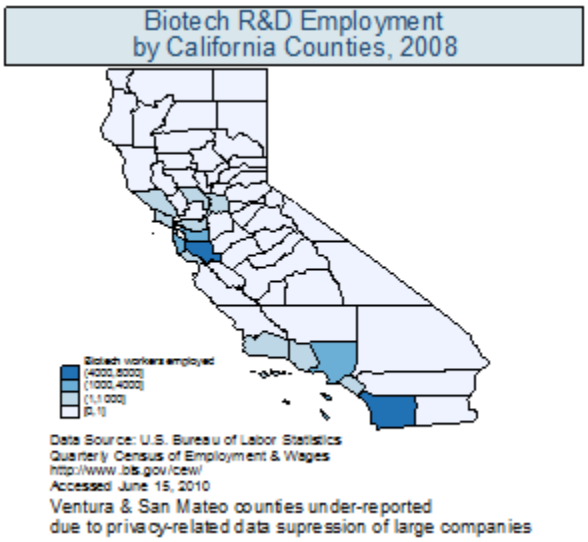


Figure 10: Employment in biotechnology R&D by region in California, 2008

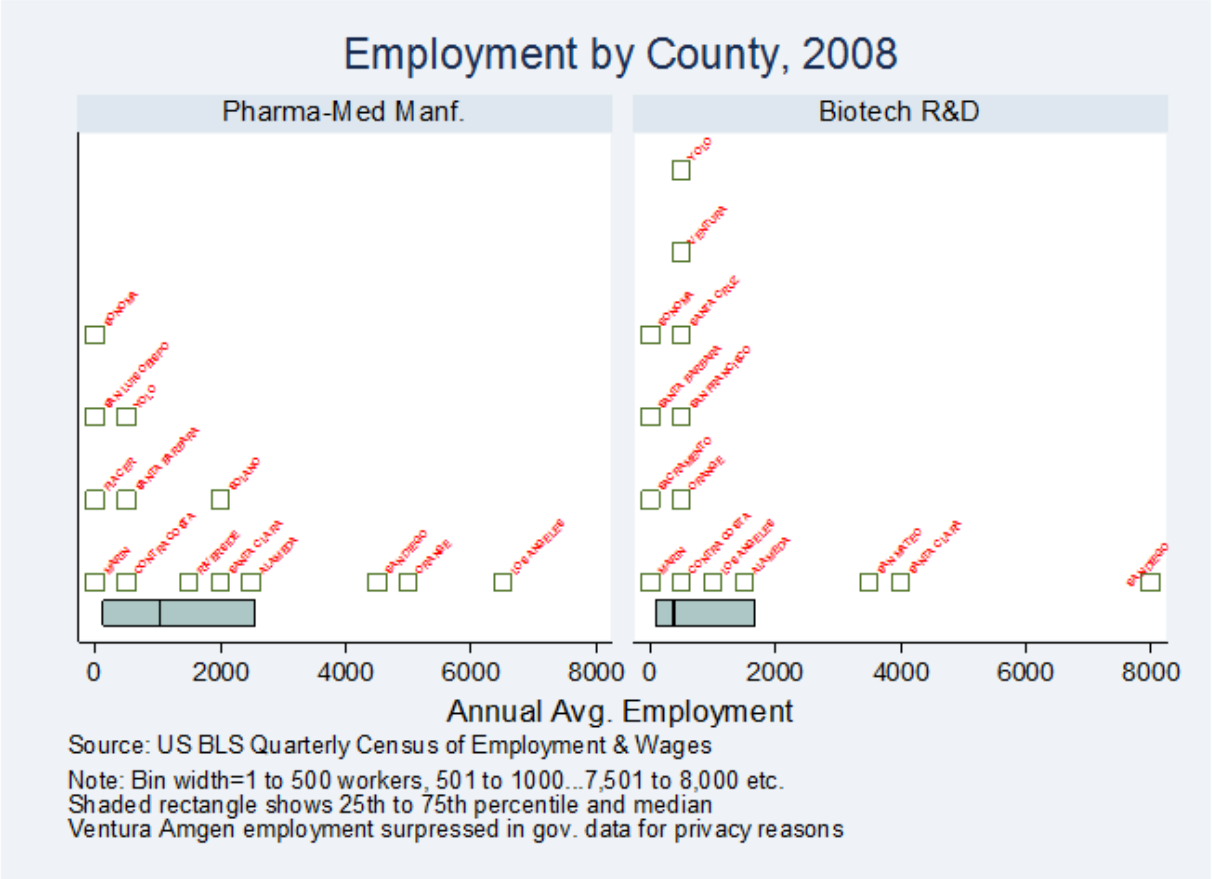


Figure 11: Clustering of employment in pharmaceutical and medicine manufacturing in California by county compared to biotechnology research and development, 2008

Data for California counties show clustering in pharmaceutical/biopharmaceutical manufacturing and biotech R&D that is reflective of both national patterns in these industries and reflective of the biomedical industry in California. There are three counties which are outliers above the 75th percentile in pharmaceutical (including biopharmaceutical) manufacturing and three outlier counties in biotech research and development. There is only one county that is an outlier in both and that is San Diego. LA and Orange Counties are the outliers in manufacturing that are not outliers in biotech R&D while San Mateo and Santa Clara counties are outliers in biotech R&D but not in pharmaceutical manufacturing. Ventura County should show up as important on the manufacturing side but does not due to the suppressing Amgen data for nondisclosure reasons. While our county data occasionally under-reports employment in these sectors due to nondisclosure/privacy restrictions, nonetheless, the general pattern of clustering in both manufacturing and in research and development in this industry means the reader should have a general understanding of the scientific, educational, cultural and economic reasons that induces these companies to often gather close to each other.

Reasons for Clustering

Clustering and uncertainty. Pharmaceuticals and biopharmaceuticals are very research-intensive products. Highly trained scientists provide the key workers needed to discover and develop new medicines. There is considerable uncertainty in the discovery process and many promising lines of research do not pan out. Biotechnology, in general, is fraught with uncertainty due partly to the newness of the science and partly due to the complexity and unpredictability tied to working with large molecules. This uncertainty plays an important scientific and economic role in inducing this industry to cluster.

Scientific communities manage uncertainty. From a scientific perspective, the biotechnology industry has tended to cluster around institutions of scientific research and higher education in order to capture the advantages of dense networks of scientific researchers. This is essentially an extended version of the traditional wisdom that two heads are better than one. In communities of scientists, ideas percolate; they bounce off each other. Information is available and shared (although once in the commercial context, ideas can also become proprietorial and protected). Locating biotech research and development establishments near universities or research centers helps companies share in the science being developed at those institutions even before results are published. Similarly, universities are increasingly facilitating taking knowledge developed in the scientific process and translating discoveries into practical commercial products. Thus, not only are biotech companies attracted to university and research-institution environments, but also biotech companies are created out of university and research-institution environments. The uncertainty of the scientific project related to biotechnology in particular makes embedding the biotech R&D establishment in a larger scientific community a way of managing that uncertainty.

Concentration improves information for venture capitalists. Clusters of biotech firms also make it easier for any particular company to obtain venture capital funds. Venture capitalists take substantial risks investing in biotechnology endeavors. Assessing these risks and the viability of any one company and its relative prospects compared to other companies is the venture capitalists' challenge. Having collections of companies side-by-side with the information and buzz that proximity facilitates, helps venture capitalists to chose which projects to invest in. This, in turn, will attract startup biotech companies to congregate where the action is in order to enhance their prospects of attracting venture capital.

Scientific labor market manages uncertainty. Where there is a critical mass of biotech R&D establishments, there is a tendency for other such establishments to be attracted to that location for the sake of the dense scientific community that the industry, itself, creates. Here, scientific and economic motivations converge. For example, a startup biotech firm may be attracted to a location that has many such firms in order to avail itself of the local labor market for scientific skills that the cluster of biotech firms has created. This is a way for the new firm to share in the knowledge community created not only by a nearby university but also by the industry itself.

Clustering of biotech firms also helps in attracting key scientific personnel as well as skilled auxiliary labor to the area. First of all, many scientists enjoy a community of scientists. Thus, biotech companies

locating in university communities populated by the employees of a cluster of science-based firms will have an advantage in attracting qualified scientific personnel. But beyond the cultural advantages of locating in a community of science-based firms, such communities create dense labor markets for science workers which helps not only to hire local talent but also helps in recruiting scientific talent from afar.

Biotech research is risky. When a line of research fails, biotech firms are forced to shut down that line of research endeavor and often lay off the involved workers. If the laid off workers are located in an area where comparable firms are doing research, their prospects of getting taken in by an alternative biotech company are enhanced. This saves these workers considerable economic and family-based moving costs. So a biotech company embedded in a cluster of biotech companies can say to the scientists that they seek to recruit from afar that if things do not work out, there are plenty of other employment opportunities for them in the local community they will have to move to. So by clustering together, biotech firms create a labor market that both allows them to hire locally (cutting their hiring costs) and also enhances their ability to hire from afar.

Clustering of pharmaceutical R&D. The clustering tendencies for biotech research and development apply (but to a lesser extent) to pharmaceutical research and development as well. Pharmaceutical R&D is a similarly scientifically intense process. While the science of small molecules may be more predictable than large molecule biotechnology, uncertainty is endemic to this research. So the underlying need to be within a scientific community for scientific, educational, cultural and economic reasons is prevalent in pharmaceutical research too. But perhaps not quite to the same extent partly due to the lesser role of venture capital as most pharmaceutical companies are large and capable of accessing alternative sources of investment funding. Also, because these companies are large, they have to some extent the ability to create their own scientific communities and cultures. Also, because they are large, when a particular line of research fails, employees may have alternative employment available within the company. There may be less need to locate where other companies can absorb workers. Nonetheless, pharmaceutical research and development also tends to geographically cluster but perhaps to a lesser extent.

Clustering of manufacturing. Manufacturing of pharmaceuticals and biopharmaceuticals clusters less than the research and development of these medicines. Once the product has been discovered and developed and approved and is ready for manufacturing, some of the scientific, cultural and economic reasons for clustering are gone or substantially reduced. Still, pharmaceutical and biopharmaceutical manufacturing is not spread evenly or randomly across the country. These are complex and challenging manufacturing processes, particularly in the case of biopharmaceuticals, which demand a relatively skilled and educated labor force and experienced managers as well as specialized suppliers, construction companies and maintenance services. Thus, there are advantages in locating manufacturing facilities where construction companies can build your facility to specifications without problems and on time (when time to market matters), suppliers can provide you with the specialized inputs needed for this specific type of manufacturing, manufacturing partners (if needed) are located at the ready and a trained and industry-experienced labor force is available. All these factors induce a fair amount of

clustering in the manufacturing arm of pharmaceutical and biopharmaceutical manufacturing even if this clustering is less than that of the research and development arm of this industry.

Occupations

In general, the occupations in the pharmaceutical manufacturing and biotech R&D industries provide good jobs. They pay well but they demand a significant level of skills and experience. The following provides a statistical description of these occupations in California.

Manufacturing occupations. Figure 12 shows the distribution of education and training requirements for the pharmaceutical (including biopharmaceutical) and medicine manufacturing industry in California in 2006. Forty-one percent of the jobs required a moderate amount (1 to 12 months) of on-the-job training. Another 13% required only short-term on-the-job training. Thus, slightly more than half (54%) of these manufacturing jobs required only on-the-job training of less than a year. The other almost half (46%) required significant amounts of on-the-job training, work experience, or formal education sometimes in combination. For instance, 16% of the jobs required a bachelors degree, another 7% required a bachelors degree plus work experience, 1% required a masters degree and an additional 8% required a Ph.D. So about one-third of the jobs in this manufacturing sector required a bachelors degree or higher. In addition to BA or higher degrees, 6% of the jobs in this sector require associate degrees so that in total, 38% of the jobs require more than a high school diploma while 62% require a high school degree often in combination with work experience and/or on-the-job training. (See Figure 13). This relatively high demand for formal education within a manufacturing sector is due to the fact that in many cases establishments in this sector combine manufacturing with research or testing in order to assure the quality of the product. Also the manufacturing process itself is complicated and demanding. These skill and educational demands lead to high wages.

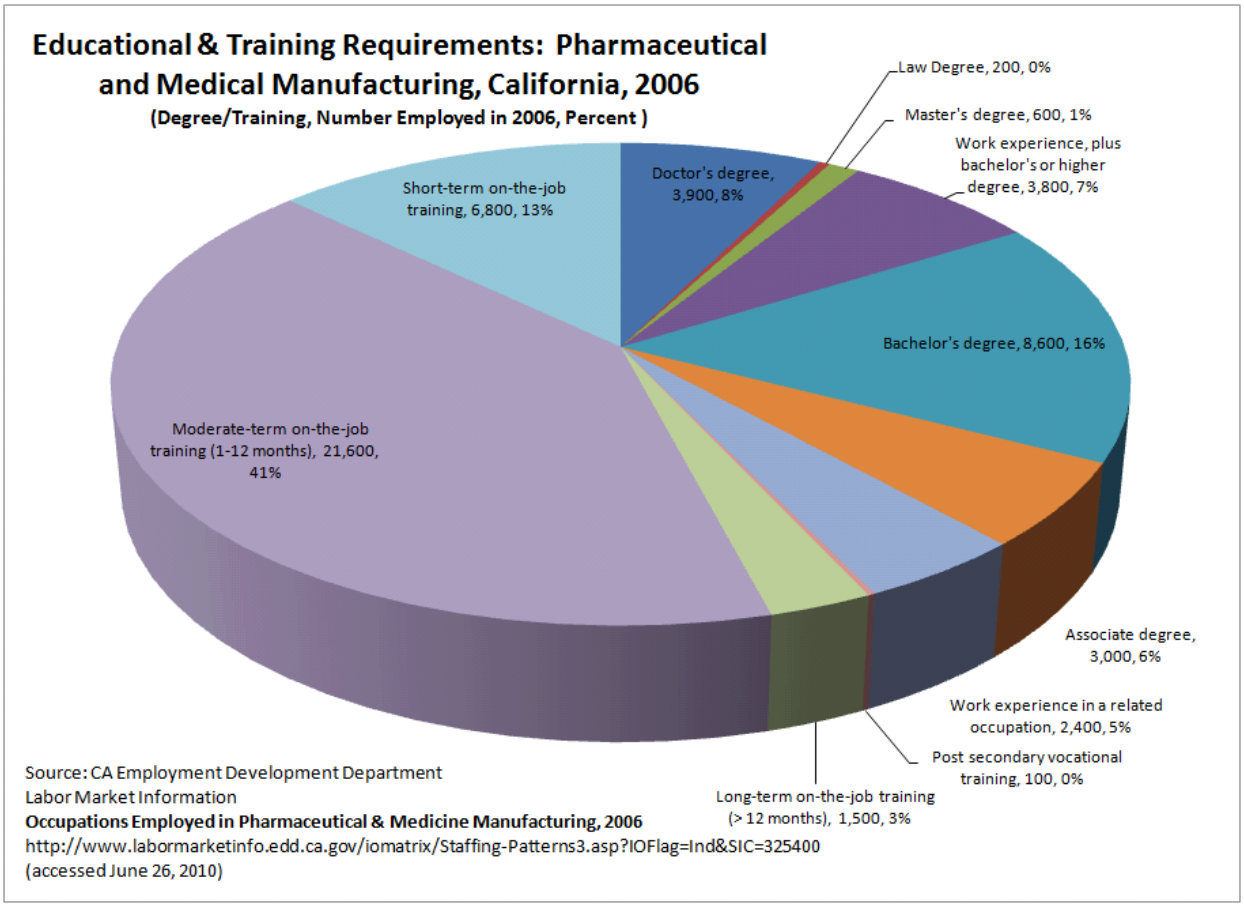


Figure 12: Educational and Training Requirements for California Pharmaceutical and Medicine Manufacturing, 2006

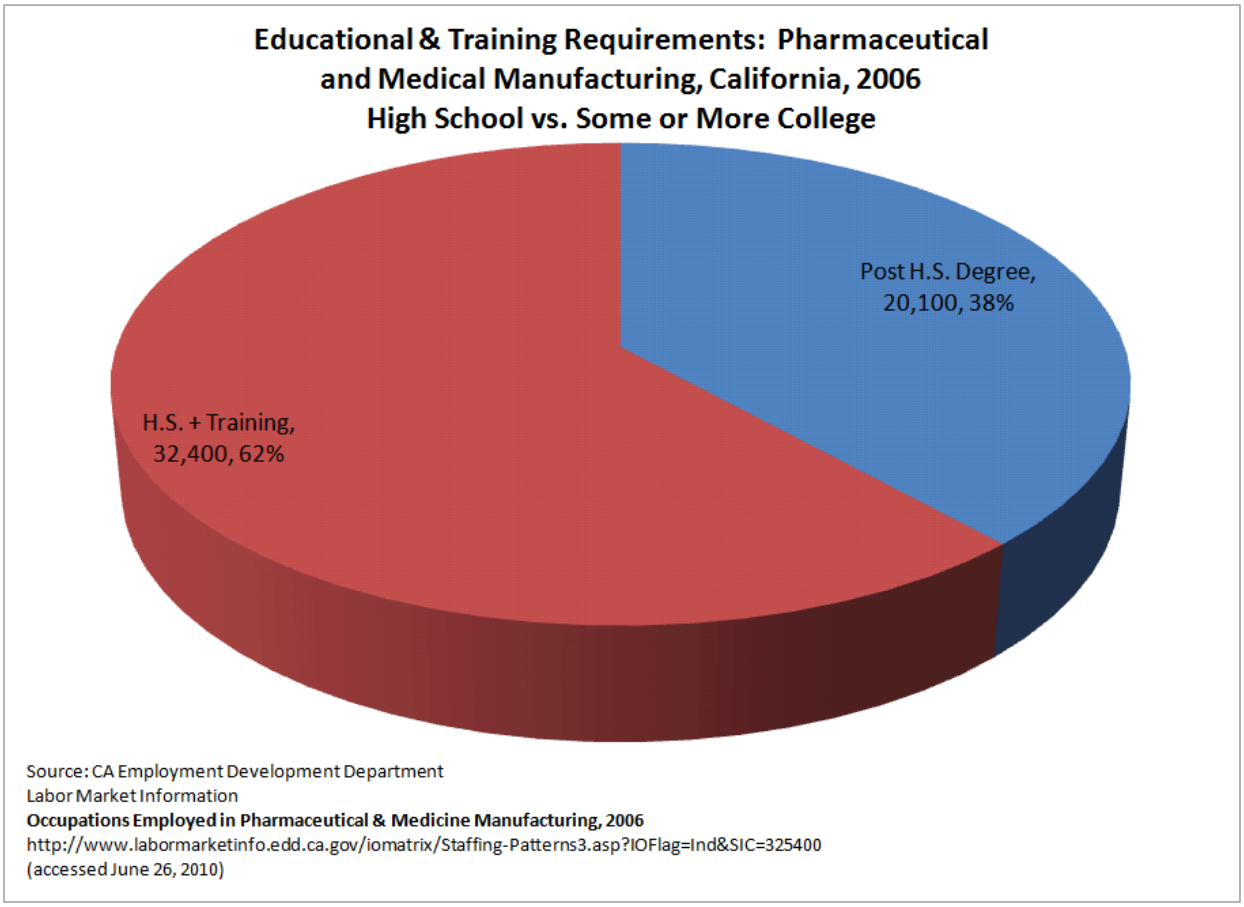


Figure 13: High school versus higher formal education requirements in the pharmaceutical and medicine manufacturing sector

Manufacturing income. Income in California pharmaceutical (including biopharmaceutical) and medicine manufacturing is well above the California average and that income advantage is growing in real, inflation-adjusted terms. Figure 14 shows that since 1990, income in pharmaceutical manufacturing in California has been above the overall California average income and that especially since the late 1990s this advantage has been growing. Today, the average worker in pharmaceutical and medicine manufacturing in California earns almost $110,000 per year. In real inflation-adjusted terms, this has grown over 50% since 1990. This high income reflects both the skills and educational attainment of this workforce and the demand for the medicines produced by this industry.

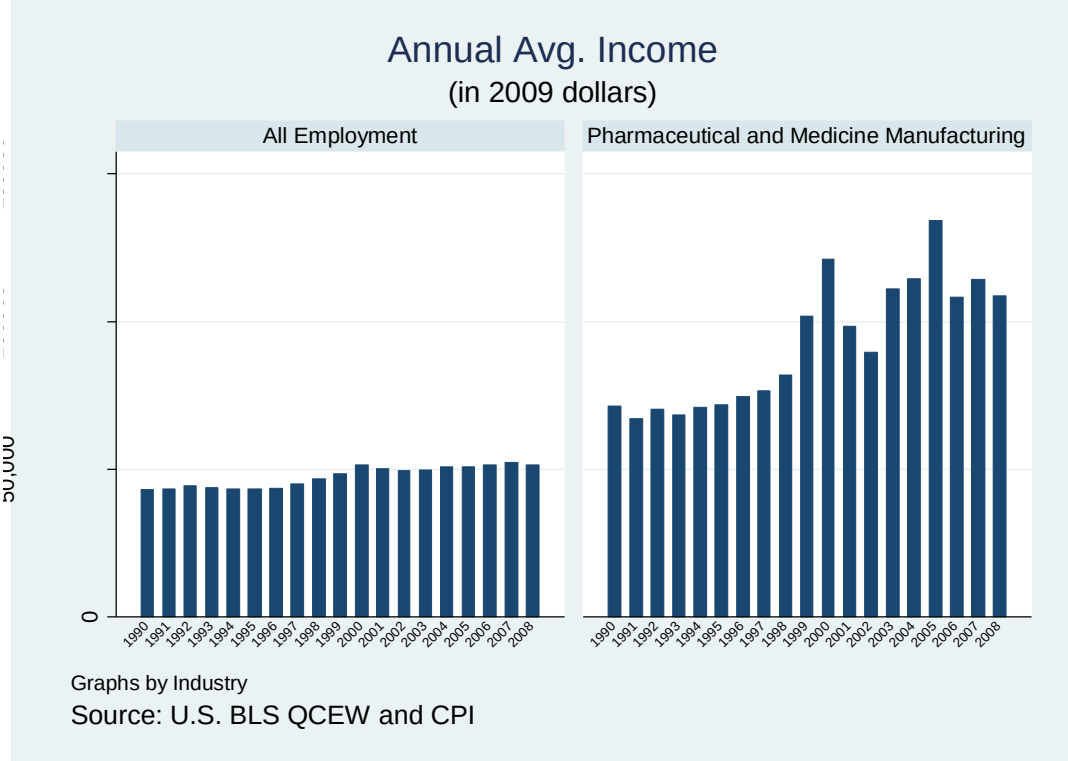


Figure 14: Average annual income from 1990 to 2008 in 2009 dollars for all California employment and the pharmaceutical and medicine manufacturing industry

shows that the high income in pharmaceutical manufacturing in California is not unusual. In 2008, California ranked fourth among states in average annual income in this industry behind New Jersey, Connecticut and Indiana and ahead of Illinois, Massachusetts, Georgia, Pennsylvania and all other states with this industry.

Table 2: Pharmaceutical and medicine manufacturing average income by rank, 2008[16]

Rank	State	Avg. Income (2008)
1	NJ	$129,562
2	CT	$125,701
3	IN	$116,988
4	**CA**	**$109,137**
5	IL	$108,881
6	MA	$101,543
7	GA	$98,221
8	PA	$97,681
9	MD	$97,152
10	TX	$91,957
11	NC	$87,057
12	RI	$85,984
13	CO	$85,839
14	MI	$81,350
15	DE	$81,133

R&D occupations. The educational and skill requirements for the biotechnology research and development industry are greater than that of pharmaceutical manufacturing. Unfortunately, we cannot drill down in the data to the detail needed to show these requirements specifically. However, biotech R&D (NAICS 541711) is a subset of the scientific research and development services industry (NAICS 5417) for which we do have educational and training requirements in California. Figure 15 shows that in 2006, the scientific research and development industry in California required that 10% of its workers have PhDs; another 3% needed masters degrees; 15% needed a bachelors and prior work experience; 25% needed bachelor degrees; and 11% needed associate degrees. In total, fully 74% of the workers in this industry needed educational degrees beyond high school. (See Figure 16).

[16] Source: U.S. BLS QCEW average annual income, 2008

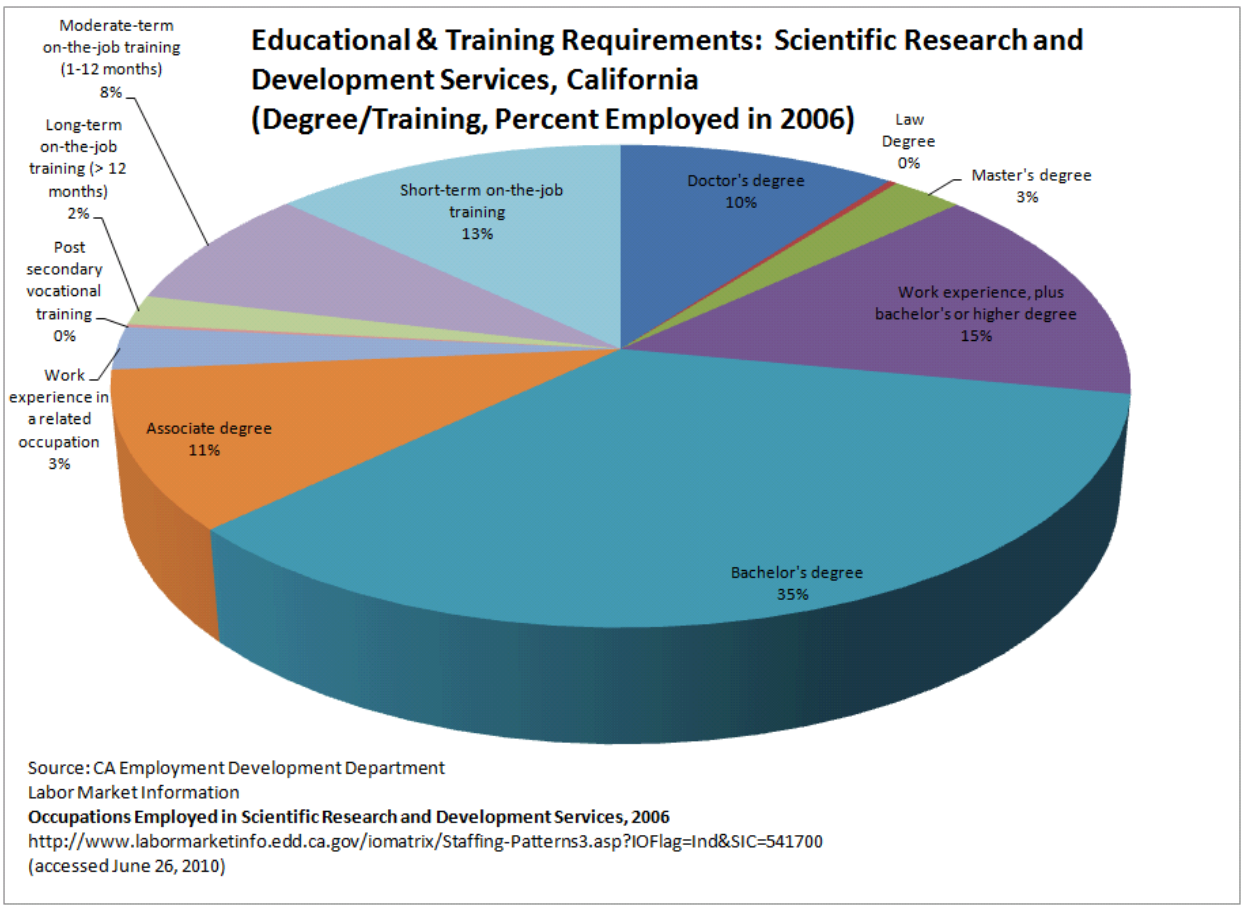


Figure 15: Educational and training requirements for the scientific research and development services, 2006 (Source: California Employment Development Department, Labor market Information--see usb drive D:\biotech\June 25 2010 CA occupations in 5417 Chart 1

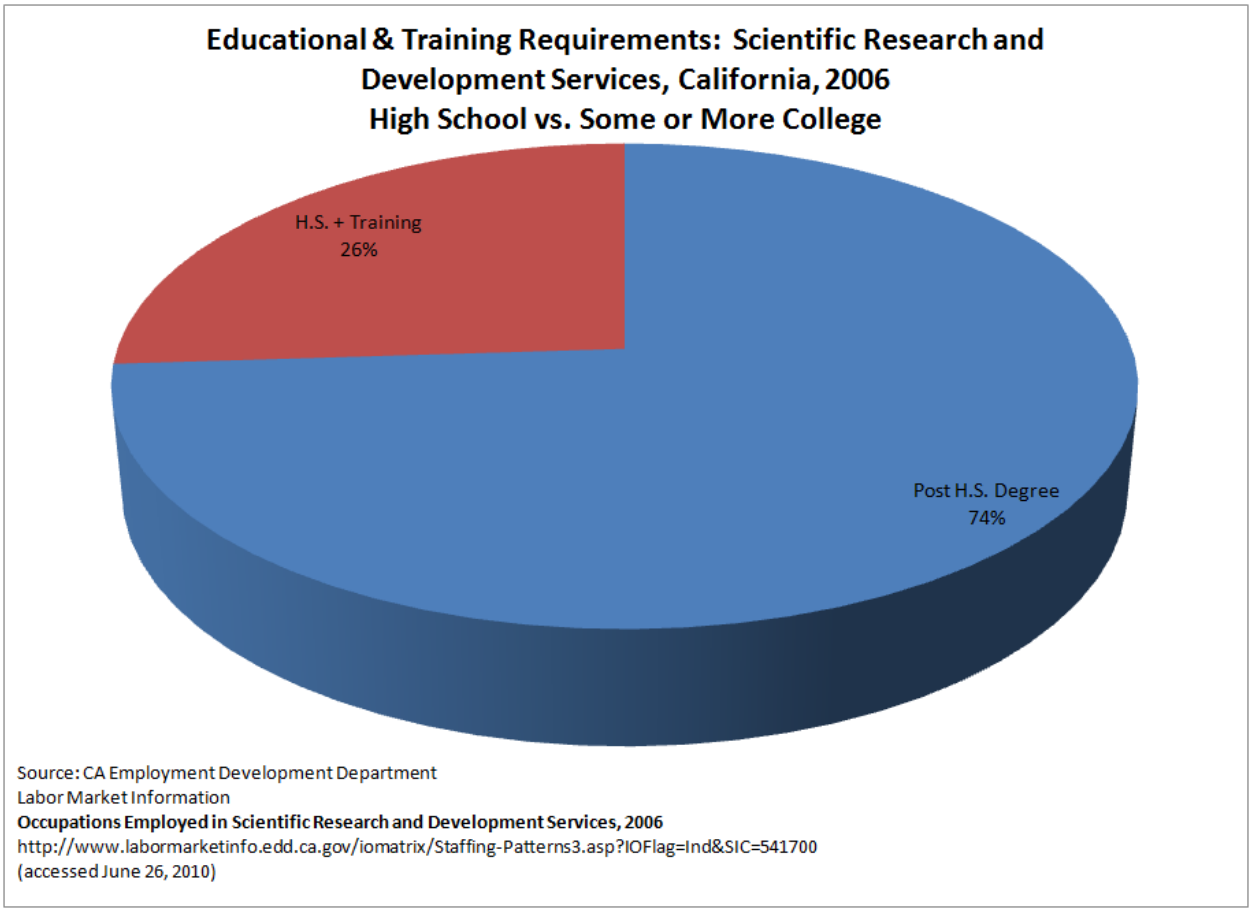


Figure 16: High school versus higher formal education requirements in the biotechnology research and development industry sector

R&D income. Income in California's biotechnology research and development sector is also well above the California average. Table 3 shows that in both 2007 and 2008, the biotechnology R&D sector averaged more than twice the annual income of the average Californian (in inflation adjusted 2009 dollars). We do not have data on biotech prior to 2007 so we cannot know whether the advantage seen currently has been growing. But interestingly, the wages in pharmaceutical, biopharmaceutical and medicine manufacturing and the wages in biotech R&D are both currently about $110,000 per year. Biotech has higher educational requirements yet the income in these two sectors is, on average, close to the same. Our interviews suggest that blue collar pharmaceutical manufacturing workers earn approximately $65,000 per year which taken with the data provided here indicates that white collar workers in pharmaceutical manufacturing are earning substantially higher incomes to average out at about $110,000. In R&D work, clerical labor is less well paid than the average while scientific labor is paid above these averages.

Table 3: Average annual income in California's biotechnology research and development industry and overall average income in California, 2007 & 2008 (in inflations adjusted 2009 dollars)

Avg. Annual Income (in 2009 dollars)		
	All California employment	Biotechnology research & development
2007	$52,292	$113,514
2008	$51,304	$109,403

Source: U.S. BLS QCEW

Building the Biopharmaceutical Infrastructure in California

The infrastructure which forms the bricks and mortar of the pharmaceutical and biotech industry in California entails from hundreds of millions to billions of dollars of construction per year. In a typical year, about 2000 construction workers are employed full-time building the infrastructure of this industry. Owners in the biotech and pharmaceutical industries require offices, laboratory and research facilities, prototype manufacturing mockups and full-blown manufacturing plants. In relative terms, this industry's construction requirements roughly equate to that of the high tech hardware industry in California.

Bio-Pharma and high tech hardware construction compared. Table 4 shows for 2007 the most actively building high tech and biopharmaceutical companies that are headquartered in California. The value of on-going construction (in millions of dollars) is shown for all types of construction done for these companies in that year anywhere in the U.S. (and not just California). In 2007 among this group Intel was most active building $2.7 billion of facilities across the U.S. Genentech and Amgen together were almost equal to Intel in capital construction. Overall, there were six California high tech firms which made it onto the list of the 425 most actively building companies across all industries in the U.S. in 2007 (the most recent available data) and eight California biopharmaceutical companies which made it into the top 425.[17] In round terms, these California high tech equipment companies built $4 billion in facilities that year while the California biopharmaceutical companies on the list built $3 billion in infrastructure across the U.S. We cannot tell from these data how much of that was built in California by these California companies. Also, companies in these industries not headquartered in California may well have been building in the state in 2007. Keeping in mind these data limitations, we conclude that in rough terms, for construction activity, these are similarly sized California industries.

[17] Staff, "The Top Owners," *Engineering News Record*, November 26, 2007, Vol. 259 No. 19, p. 16.

Table 4: California Biopharmaceutical and high tech hardware companies among the 425 U.S. owners building in 2007

Source: *Engineering News Record*

Rank in Top 425 Owners	Company	Headquarters	Industry	US Construction Value (in $millions) 2007
5	Intel Corp.	Santa Clara	Hightech equipment	$2,711
25	Genentech Inc.	South San Francisco	Biopharmaceutical	$1,291
27	Amgen Inc.	Thousand Oaks	Biopharmaceutical	$1,271
51	Advanced Micro Devices	Sunnyvale	Hightech equipment	$672
107	Spansion Inc.	Sunnyvale	Hightech equipment	$258
194	International Rectifier Corp.	El Segundo	Hightech equipment	$121
240	Watson Pharmaceuticals Inc.	Corona	Biopharmaceutical	$87
241	Amylin Pharmaceuticals Inc.	San Diego	Biopharmaceutical	$87
259	National Semiconductor Corp.	Santa Clara	Hightech equipment	$80
335	Abraxis Bioscience Inc.	Los Angeles	Biopharmaceutical	$50
339	Broadcom Corp.	Irvine	Hightech equipment	$48
360	PDL Biopharma Inc.	Fremont	Biopharmaceutical	$43
366	Invitrogen Corp.	Carlsbad	Biopharmaceutical	$40
371	Gilead Sciences Inc.	Foster City	Biopharmaceutical	$39

Laboratories, scientific testing and R&D construction in California. A second angle allowing us to look at construction of the pharmaceutical and biotech industry in California is to track the construction of laboratories, scientific testing and R&D facilities. This category will include some non biotech-pharmaceutical buildings but these data will be for California only and will be dominated by the biotech and pharmaceutical industries. (See Table 5)

Table 5: Value of construction starts for scientific laboratories, testing and R&D facilities in California, 1997 to June, 2010 (in inflation adjusted 2010 dollars) [18]

Year	Total Value of Construction Starts	Largest Project	Median Project	Number of Projects
1997	$730,952,812	$203,904,672	$773,019	123
1998	$2,024,505,827	$1,070,000,000	$722,015	161
1999	$586,984,141	$101,296,928	$731,276	93
2000	$389,221,602	$82,355,224	$3,294,209	23
2001	$399,683,169	$63,542,032	$3,942,234	41
2002	$410,775,822	$60,638,688	$731,911	101
2003	$377,146,110	$86,295,328	$1,185,750	84
2004	$1,298,858,936	$664,120,448	$991,679	85
2005	$766,510,515	$111,714,288	$719,775	73
2006	$574,643,824	$97,400,896	$1,829,967	54
2007	$547,082,926	$57,558,704	$2,872,701	57
2008	$1,576,284,958	$174,803,440	$2,381,380	74
2009	$540,053,088	$84,408,632	$791,712	75
2010 (to June)	$699,357,229	$117,000,000	$1,187,000	61

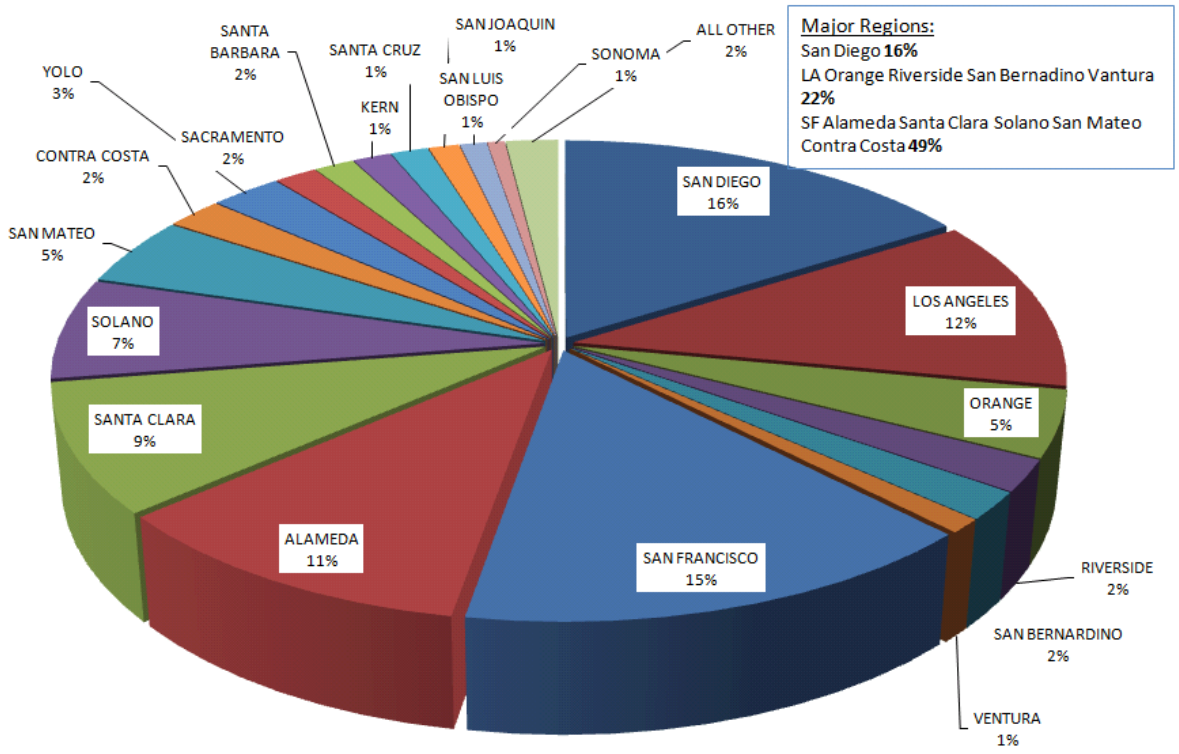
There are three main types of facilities needed by this industry--office space, R&D facilities and manufacturing plants. Table 5 shows in approximate terms the building of the R&D/lab facilities for pharmaceutical and biotech companies in California from 1997 to the middle of 2010. Steady construction at around $500 million per year (in inflation-adjusted 2010 dollars) is punctuated periodically by jumps to over a billion dollars to almost $2 billion in construction per year. In 1998 and in 2004, these jumps in construction activity were associated with two very big projects, one worth over a billion dollars itself and one coming in at over $600 million. These big projects involved more than R&D and in one case included corporate offices and in the other case included a biopharmaceutical manufacturing plant. The key point is that due to the steadfast demand for these biotech and pharmaceutical products, construction in this industry has not been as cyclical as some other parts of the construction industry. With the exception of 2008 and 1998, if we take the biggest project out of each year, the rest of this R&D construction comes in fairly steadily at about $500 million per year. Of course, the biggest, most complicated projects that come from time to time are also key building moments in the industry's history. And getting these projects done right and on time can spell success or disaster for important companies within the industry.

Data limitations prevent us from combining office construction with lab/R&D construction with manufacturing in this industry. But in rough terms, this industry builds on average about $1 billion in new or renovated facilities per year in California. Again in rough terms, this amount of construction activity will translate into about 2000 skilled construction workers per year building these facilities

[18] FW Dodge data from Project Plus

Location of Construction

Construction in recent years of labs and R&D facilities is concentrated somewhat more in the Bay Area compared to Southern California with San Diego being the most important of the Southern California economies. Figure 17 shows that the Bay Area counties of Alameda, Santa Clara, San Mateo, San Francisco, Contra Costa and Solano together accounted for almost half (49%) of all construction of lab, testing and R&D facilities over the period 1997 to June 2010. LA, Orange, Riverside, San Bernardino and Ventura counties accounted for 22% of lab-test-R&D construction and San Diego accounted for 16%. Not all these lab facilities were for pharmaceutical, biopharmaceutical or biotech companies. Some were university facilities and others were in the food, high tech or other industries. But this distribution shows where this type of building construction is concentrated in California with the Bay Area leading the way.



Total value of construction =$9.85 billion
Source: FW Dodge data from Project Plus

Percent Share of the Value of Constructing Lab, Testing and R&D Facilities, by County for 1997 to 2010

Figure 17: Percent share of the value of construction of laboratory, testing and research & development facilities by county, California, 1997 to June 2010 in inflation-adjusted, 2010 dollars

Figure 18 shows the share of lab-test-R&D construction done by general contractors in California over the period 1997 to June 2010. Two contractors, DPR, and Rudolph&Sletten together account for almost a third (31%) of all construction of these types of buildings in California. Ten general contractors account for 54% of this construction. All ten are union contractors.

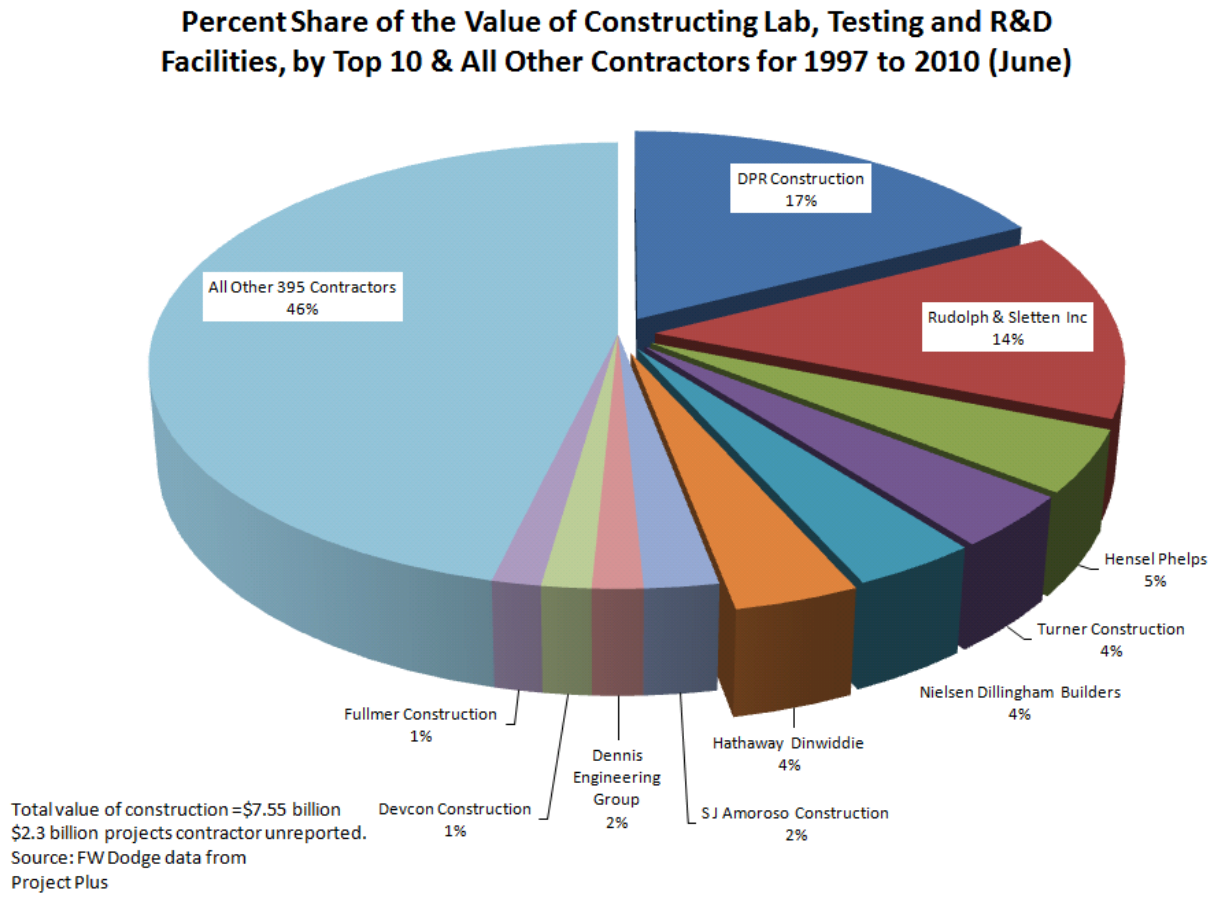


Figure 18: Percent share of general contractor work in constructing laboratory, testing and research & development facilities in California by contractor, 1997 to 2010

Clustering of construction capabilities. Pharmaceutical and biotech infrastructure ranges from general to highly specialized in its technical requirements. Office buildings are not unusual structures and most construction labor markets have the contractors and construction workers needed to build these facilities. Lab and testing facilities are more technical requiring more specialized contractors and workers. Pharmaceutical, biopharmaceutical and biotech manufacturing facilities are the most technical buildings requiring the most specialized contractors and workers capable of meeting both their technical and regulatory specifications. Setting aside the technical requirements of pharmaceutical and biotech infrastructure, these buildings have a significant economic requirement--namely that they be built right the first time, and on time. Profit in the bio-pharma and biotech industries is time-path dependent. Bringing a product to market according to schedule in a timely fashion is a key to economic success. So the contractors and workers who build and renovate the needed facilities play a key role in the overall strategic goals of these bio-pharma companies. This is why a limited set of construction general contractors do the majority of this work. These companies develop the experience and track record needed to insure the on-time, successful completion of each needed project. Experience, track record and reputation are central ingredients in bio-pharma construction.

The top ten general contractors are union contractors for similar cluster-economics reasons. Construction unions operate apprenticeship programs and post-apprenticeship training which embeds into the construction workforce skills and work responsibilities that are needed components to a successful on-time completion of major, complex or technically demanding projects. Especially as projects become bigger and more complex, skilled and experienced construction workers become needed inputs to successful projects.

Geographical clustering of bio-pharma companies, experienced contractors and union apprenticeship programs synergistically feed into each other. A critical mass of companies creates a specialized construction industry geared to meet the building demands of this industry. The unions respond by setting up curricula in their training programs to meet the specialized needs of laboratories or manufacturing facilities. The workers who build these facilities develop the experience needed to build anew the infrastructure needed by this industry. So just as there is a clustering of the bio-pharma industry for scientific, educational, cultural and labor market reasons, there is an additional reason--the biopharmaceutical/biotech/pharmaceutical industry, by clustering, creates an experienced and human-capital intensive construction industry which is better geared to meet the biopharma industry's infrastructure needs.

However, the biopharma industry is not big enough, nor does it build often enough, to create a specialized construction industry solely geared to its specific needs. Fortunately, the existence of a demand for similar lab facilities from higher education and the high tech industry gives the demand for this type of lab, manufacturing and technical construction greater heft. Figure 19 shows the percent of non-hospital work done by the two largest lab-test-R&D builders in California (DPR and Rudolph&Sletten) by owners served. The top eight owners are a mixture of biotech and high tech companies with universities rounding out the ninth and tenth spots. So not only does bio-pharma cluster together but it benefits from clustering near other industries with similar construction demands.

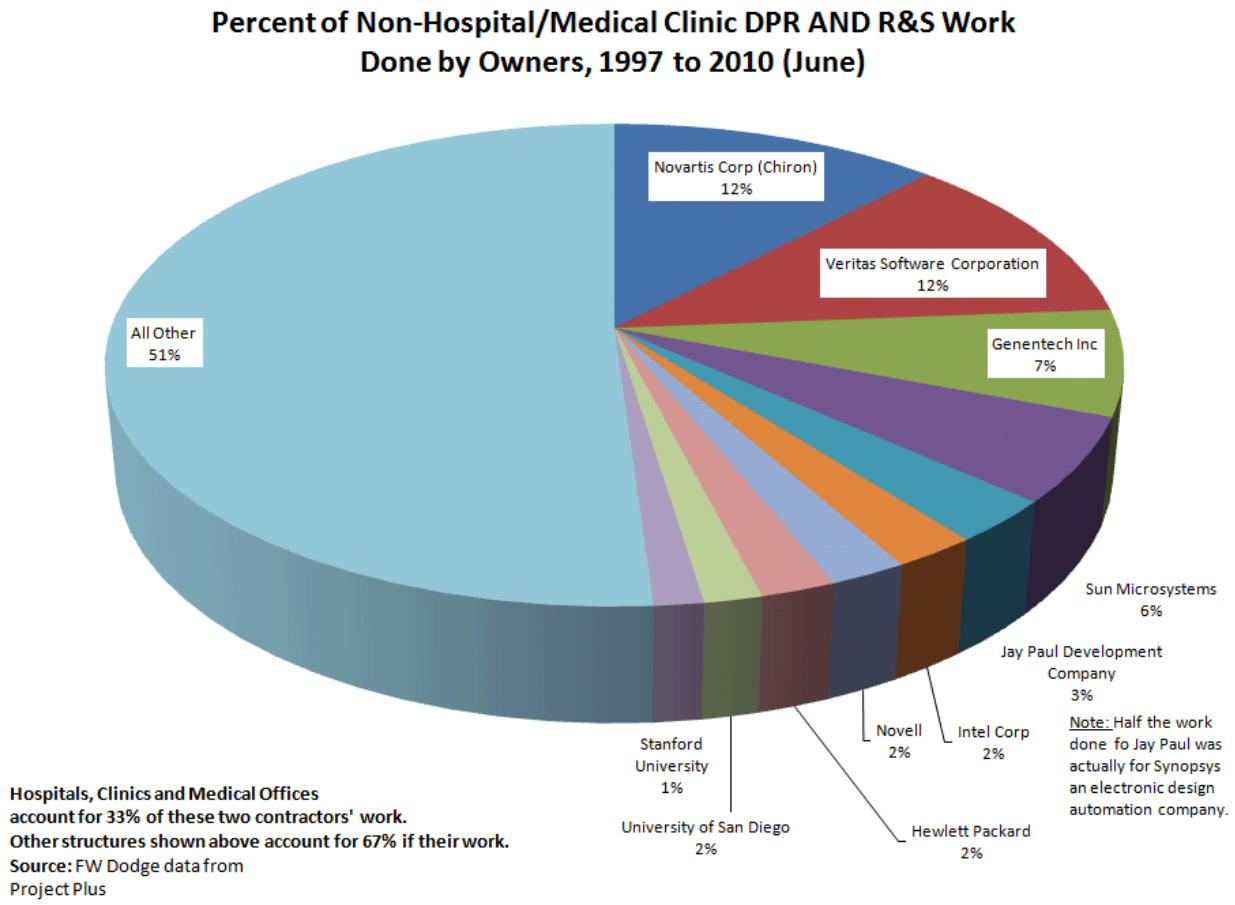


Figure 19: For DPR and Rudolph&Sletten in California, the share of non-hospital work by owner, 1997 to June 2010

Thus, the bio-pharma industry geographically clusters in order to pull together scientific knowledge and skills, venture capitalists and entrepreneurs, specialized contractors and skilled construction workers. This centering, primarily in the Bay Area and secondarily in San Diego and Ventura is designed to manage the risks and time costs of this dynamic industry.

Part 2: Economic Impact of the Building and Operating of the Pharmaceutical, Biopharmaceutical and Biotech R&D Industries

Understanding Economic Impact Analysis

This section provides basic information and terminology so the reader can fully understand and use the economic impact results that are presented in the following sections. An activity has an economic impact if it draws, or attracts "new" dollars into a region. When these "new" dollars are spent within the region, additional economic activity takes place. Pharmaceutical manufacturing jobs within a county provide a good illustration of this concept of an economic impact. The employees of this industry produce a good that is largely sold outside the county. Much of the revenue from the sale of these products is used to pay pharmaceutical manufacturing employees. A portion of this income is spent within the county as resident employees purchase local retail items, housing, and services. This additional spending creates more jobs in the local retail and service sectors. Using the terminology of regional economic development, pharmaceutical manufacturing jobs can be considered "primary", or "export" jobs since the locally manufactured product is sold in an out-of-county market. These primary jobs support and create additional "secondary jobs" in the local retail and service sectors.

In addition to primary or export jobs creating secondary jobs through the wages these primary workers spend locally, the pharmaceutical company, itself, will purchase services locally as inputs to their own business activities. This too will create local secondary jobs and local business activity. Not all inputs purchased by the pharmaceutical company will be locally produced. Some may be imports from outside the local economy. However, one very important local industry stimulated by the pharmaceutical company is the local construction industry. The pharmaceutical industry requires office, warehouse, laboratory, and manufacturing facilities. These facilities will have to be built in the economy where the pharmaceutical company locates. The construction workers hired to build this industry's infrastructure will spend much of their income locally not unlike the directly hired workers of the pharmaceutical company. This, of course, will depend upon whether the construction workers, themselves, are local or whether they have traveled in from the outside. Outside construction workers will still spend some of their earnings locally, but not as much as local construction workers who have homes and families in the area.

The discussion above suggests that an economic impact of an activity on a region involves "direct" and "induced" impacts. Now we are using the language of economic impact analysis. Returning to our example of pharmaceutical manufacturing, the direct impact of this activity on a county is the primary jobs associated with manufacturing. As the income from these jobs is spent locally, additional economic activity is induced, or secondary jobs are created. So far we can identify the economic impact of pharmaceutical manufacturing as the sum of the direct and induced portions. That is, when a pharmaceutical company decides to locate in a county, the economic impact of this activity on the county is the sum of the direct jobs associated with the manufacture of pharmaceuticals and the induced jobs that are created and supported by the income and spending of the pharmaceutical employees.

The relation between the direct and induced portions of an economic impact suggests a multiplier process. This process is often referred to as a "ripple effect" where the initial, direct spending of an activity induces additional local spending that is multiplied as it ripples through the region. It is useful to have a measure of this multiplier process. Multipliers are usually reported in terms of employment, or value of output. For example, an employment multiplier of 2.5 means that if one more primary, or export job is created within the region, the total increase in employment will be 2.5 jobs. This example also indicates that each primary job supports 1.5 more local secondary jobs.

Another way of measuring the economic impact of an activity is to use an output multiplier. For example, a multiplier of 1.25 means that one more dollar of output creates another $0.25 in economic activity within the region (for a total of $1.25). Both of these employment and output multiplier examples can also be scaled. That is, the same multiplier can be used if the incremental change is 100 more employees, or $1 million more in the value of output. This can be useful to inform the public, local economic development officials, or local politicians of the economic benefits or costs of a positive or negative change in the exporting industry. For example, if a local pharmaceutical manufacturer expects to hire an additional 100 employees, we can use the hypothetical multiplier above (2.5) to estimate the total employment impact on the local economy (250 jobs). Direct employment in this example is 100 jobs. The other 150 jobs are induced by the local spending of the direct employees. The employment multiplier can also work in reverse. If a plant shuts down with the loss of 100 direct jobs, the eventual total jobs lost (in this hypothetical example) would be 250 jobs due to the loss of 100 primary jobs and an additional 150 secondary jobs.

The same applies to an output multiplier. If a pharmaceutical manufacturer expects sales to increase by $1 million, local economic activity will increase by a multiple or in this example by $1.25 million. One million dollars constitute the direct spending with $250,000 in induced economic activity. This process works in reverse as well if the company faced a loss of $1 million in revenues. Regardless of the application, these multiplier examples illustrate how an economic impact can be thought of as the sum of direct and induced portions. We can view the impact in terms of either jobs or value of output.

The size of the region under consideration will influence the size of the multipliers. Generally, the larger the region geographically or economically, the larger the multiplier. This makes sense because a larger region does a better job of a capturing, or retaining the direct spending of an activity. For example, consider the impact of a pharmaceutical manufacturing facility on Solano County. When these manufacturing employees are paid from the proceeds of "exported" pharmaceutical goods, they spend a portion of this income within Solano County. But, another portion leaks out as some of the income is spent in other counties, or even in other states. If the worker goes to Alameda County to buy a car or buys a book on Amazon instead of at a local book store, that amount of the worker's income is not spent locally and does not generate additional local business activity or jobs. If the car is bought locally or the worker goes to the local book store or restaurant etc., then the worker's spending is captured locally stimulating local business and employment.

If we consider the impact of Solano County pharmaceutical manufacturing on the state of California, the measured impact will be larger compared to Solano County alone because a much smaller portion of

employee income leaks out of the state compared to out of the county. So, when we examine the impact of the pharmaceutical industry at the county level, the impact will be smaller than the impact at the state level. Economically "bigger" counties will be better able to capture the stimulus from export jobs compared to economically "smaller" counties. (Think of it this way: if the county does not have a car dealership, it is out of the running for the worker's transportation spending. A geographically small county is economically big to the extent that it has a dense set of retailers, real estate, and service providers to meet the worker's needs locally.) Thus, county-level multipliers are smaller than state-level multipliers, and economically smaller counties have smaller multipliers compared to economically larger counties.

So far, we have considered the economic impact of pharmaceutical manufacturing as the sum of *direct* and *induced* impacts. We can now extend our understanding to include *indirect* impacts using as an example, the measurement of the impact of biotech research and development employees. First, the indirect impact can be thought of as a company-supplier impact while the induced can be thought of as the worker-supplier impact. When local pharmaceutical manufacturers produce and sell products for consumption outside the county, the industry pays local employees and purchases local supplies. When the local pharmaceutical supply network is stimulated, more additional local purchases are made with a similar multiplier process described above. The company-supplier or indirect impact contributes to local economic activity and to the overall impact of the industry. Thus, the direct employment impact is the workers hired by the pharmaceutical company; the induced employment impact is the workers hired by the restaurants, real estate agencies, grocery stores etc. that locally supply the workers with their needs; and the indirect employment impact is the local workers hired by business services that supply the pharmaceutical company with its needs. So, a completely defined economic impact study will include the direct, induced, and indirect impact of a change in the export industry's business measured either in terms of the employment impact or the output impact.

Thus far we have used the example of pharmaceutical manufacturing jobs to illustrate the economic impact of the industry on a region. This example fits the classic definition of an economic impact because manufacturing workers produce a good that is sold outside the region. Similarly, biotech research and development employees have an impact on a region based on the creations of local jobs and more local spending. For example, when a R&D facility moves to a county, jobs are created, research workers move to the area, receive an income of which a portion is spent locally. This creates and supports additional, secondary jobs in the county. So, research workers have an economic impact and multiplier effect similar to that of manufacturing workers. Another way to envision the economic impact of research workers would be to consider what would happen to the local economy if a research facility were to shut down, or leave the area. There would be a loss of research jobs within the county and a decrease in local spending. The secondary jobs that were supported by the spending of research workers would decrease. This example illustrates that the multiplier process works both ways. That is, multipliers can have a positive or negative effect on an economy, depending on whether jobs are created locally, or lost.

IMPLAN Input-Output Software

The key to estimating an economic impact is to apply the appropriate multipliers. There are two widely used sources of multipliers: the RIMS II multipliers available from the Bureau of Economic Analysis and the IMPLAN software. While there are advantages of either method, the IMPLAN software is better suited for the specific research questions involved in the present study. IMPLAN (IMpact analysis for PLANning) was originally developed by the U.S. Department of Agriculture to assist the Forest Service with land and resource management planning. The Minnesota IMPLAN Group (MIG) started work on the model and data in the mid-1980s at the University of Minnesota. The software was privatized in 1993 and made available for public use. The software contains an input-output model with data available at the zip-code, county, state, and national levels.

Input-output analysis measures the inter-industry relationships within an economy. Specifically, input-output analysis is a means of measuring the monetary, or market transactions between businesses and between businesses and consumers. This framework allows for the examination of a change in one sector on the entire economy. In this way, input-output analysis is able to measure the multiplier, or ripple effect, as an initial change in one industry stimulates additional transactions between other businesses and households. In addition to capturing market transactions within an economy, IMPLAN also measures social accounting, or non-market flows such as tax payments by individuals and businesses, government transfers, and transfers between individuals. The benefit of these social accounts is that they provide estimations of federal, state, and local taxes associated with an economic impact. Specifically, IMPLAN provides estimates of total state and local taxes from employee compensation, indirect business taxes (sales, property, etc.), households (income, property, motor vehicle, etc.) and corporations (dividends and profits). We combine the IMPLAN tax estimates with information and data from the California State Board of Equalization to provide estimates of county-level taxes (business and residential property taxes and the portion of sales tax that remains within a county). State-level tax impacts will be larger since we are able to identify indirect business taxes as well as taxes on employee compensation, households, and corporations. The ability to measure tax effects is unique to the IMPLAN software. Other methods, such as the RIMS II multipliers are not able to measure tax impacts associated with economic impacts.

IMPLAN is a secondary input-output model that relies on data collected from other sources. For example, the inter-industry transaction information comes from a primary input-output study that collects data directly from a survey of industries. The RIMS II multipliers are derived from a primary input-output model (the U.S. Bureau of Economic Analysis Benchmark Input-Output Study). Primary input-output models at the state or local level are rare due to the high cost of building such a model for a small area. In essence, IMPLAN uses national-level inter-industry transactions that are applied to county or state-level data.

There are several benefits to the IMPLAN software. This model provides the employment and output multipliers that we described previously. These multipliers are based on direct, induced, and indirect effects. The input-output features of the software also trace the backward linkages, or supply relationships between industries. This feature allows us to identify those industries that have a supply relationship with the pharmaceutical manufacturing and biotechnology research and development

industries. This information is very important in terms of the local economic development consequences of the industry. For example, if a community wishes to expand its existing local pharmaceutical industry, it will need to develop supply relations for this industry.

There is an important caveat to keep in mind when interpreting economic impact results. This type of analysis provides an estimate of the upper end, or maximum amount of the impact. This is true of an impact based on the IMPLAN software, or RIMS II multipliers. Impact analysis is based on the assumption that supply constraints are not present. This means that production and other costs within a region do not change when economic activity changes. If costs rise with an increase in economic activity, prices will also increase and absorb some of the economic stimulation and activity. Consequently, the estimated impact will sometimes be larger than the actual impact the region experiences. However, if costs and prices do not change with the level of economic activity, the estimated impact will be very close to the actual impact that the region experiences. This implies that the magnitude of an economic impact depends on current economic conditions. For example, if the local economy is depressed, or if an expansion does not cause rising costs and prices, the estimated impact will be close to the actual impact that is experienced in the region. However, if the local economy is functioning close to full capacity and additional economic activity will be associated with rising local costs and prices, the measured impact may be too high. However, given the depressed economic conditions that prevail throughout California at the time of this report, we expect our estimated results to reflect those experienced in the region. Thus, all studies such as ours have a shelf life due to two basic factors: 1) as industries are constantly evolving, government statistical categories for industries have to evolve and change; and 2) the estimated effects of regional impact studies such as ours will be close to spot on in an economic downturn and increasingly an over estimate as the economy moves into the boom.

Our impact study is based on publicly available county and state-level employment data for pharmaceutical manufacturing and biotechnology research industries. These data are described in general terms above and in more detail in the following section. Consequently, our results are reproducible. Other researchers using the same data and the same computer program should reach the same or closely similar results. However, we customize our IMPLAN models in a few ways other researchers need to know about in order to replicate our results. We include inflation-adjusted to today's dollars of industry-specific measures of output per worker from the 2007 *U.S. Economic Census* published by the Bureau of the Census. These output per worker measures are presented in Table 12 below. These data are used to calculate the direct value of output that is associated with a given level of employment. For example, if a county has 100 pharmaceutical preparation manufacturing employees and output per worker is $1 million, then the corresponding value of output for this level of employment is $100 million. Since output per worker is based on yearly annual production, the direct employment impacts reported below are job-year impacts. We also adjust county-level employment data for the percent of workers who reside within the county. Data on the percent of local workers is obtained from individual counties or from the Census. Finally, we use the internal IMPLAN estimates of inflation and report our results in 2010 dollars. With our procedures made clear, let us take a detailed look at government industry definitions. (For the less technically inclined, this section may be skipped

and the general discussion above will suffice. These readers should rejoin us at the section on the Quarterly Census of Employment and Wages below.)

Description of the Pharmaceutical Manufacturing and Biotech Research and Development Employment Data

Our impact analysis is based on the number of employees involved in biotechnology research and development and pharmaceutical and medicine manufacturing in Alameda, San Diego, San Mateo, Solano, and Ventura counties. Specifically, we collect employment data from the Bureau of Labor Statistics (BLS) for the North American Industry Classification System (NAICS) codes 541711 (for biotechnology research and development workers) and 3254 (for pharmaceutical and medicine manufacturing employment). The formal definitions used by the BLS are reported below:

Research and Development in Biotechnology (NAICS code 541711): This U.S. industry comprises establishments primarily engaged in conducting biotechnology research and experimental development. Biotechnology research and experimental development involves the study of the use of microorganisms and cellular and biomolecular processes to develop or alter living or non-living materials. This research and development in biotechnology may result in development of new biotechnology processes or in prototypes of new or genetically-altered products that may be reproduced, utilized, or implemented by various industries.

The NAICS code for biotechnology research and development was introduced in 2007. This replaces NAICS code 5417102 that was used in the 2004 study by the Milken Institute.[19] The new code provides a more precise measure of workers involved in the biotechnology field. Previous industry codes measured research and development employment in life sciences that included biotechnology and other areas. Since these data are new for 2007, we are only able to provide a limited historical trend in employment. The NAICS classification identifies biotech R&D workers who are employed in a separate research facility. If biotech R&D workers are employed in a pharmaceutical manufacturing facility, the BLS includes these research workers in the total for manufacturing employment. So, the employment data presented below may under-report the level of biotech R& D employment in a county since the measure does not include those research workers employed at pharmaceutical manufacturing facilities.

The BLS reports four sub-categories under pharmaceutical and medicine manufacturing for the NAICS code 3254. The overall category for NAICS 3254 and the sub-categories are described below:

Pharmaceutical and Medicine Manufacturing (NAICS 3254) : This industry comprises establishments primarily engaged in one or more of the following: (1) manufacturing biological and medicinal products; (2) processing (i.e., grading, grinding, and milling) botanical drugs and herbs; (3) isolating active medicinal principals from botanical drugs and herbs; and (4) manufacturing pharmaceutical products intended for internal and external consumption in such forms as ampoules, tablets, capsules, vials, ointments, powders, solutions, and suspensions.

[19] See "Biopharmaceutical Industry Contributions to State and U.S. Economies." Milken Institute, October 2004.

Medicinal and Botanical Manufacturing (NAICS 325411): This U.S. industry comprises establishments primarily engaged in (1) manufacturing uncompounded medicinal chemicals and their derivatives (i.e., generally for use by pharmaceutical preparation manufacturers) and/or (2) grading, grinding, and milling uncompounded botanicals.

Pharmaceutical Preparation Manufacturing (NAICS 325412) : This U.S. industry comprises establishments primarily engaged in manufacturing in-vivo diagnostic substances and pharmaceutical preparations (except biological) intended for internal and external consumption in dose forms, such as ampoules, tablets, capsules, vials, ointments, powders, solutions, and suspensions.

In-Vitro Diagnostic Substance Manufacturing (NAICS 325413): This U.S. industry comprises establishments primarily engaged in manufacturing in-vitro (i.e., not taken internally) diagnostic substances, such as chemical, biological, or radioactive substances. The substances are used for diagnostic tests that are performed in test tubes, petri dishes, machines, and other diagnostic test-type devices.

Biological Product (except Diagnostic) Manufacturing (NAICS 325414): This U.S. industry comprises establishments primarily engaged in manufacturing vaccines, toxoids, blood fractions, and culture media of plant or animal origin (except diagnostic).

Quarterly Census of Employment and Wages. Our impact analysis is also based on employment data collected by the Quarterly Census of Employment and Wages (QCEW) of the U.S. Bureau of Labor Statistics. Because of time lags in collecting and reporting these data, the most recent employment figures are from the second quarter of 2009. To account for the employment effects of economic expansions and contractions, our impact results are based on the average level of employment for the period in which data are collected. Additionally, some pharmaceutical and biotechnology firms also employ "badged," or contract employees that provide on-site food, security, and other services to the firm. Unfortunately, contract employees, are not included in the BLS employment data for those employed in manufacturing and R&D establishments. Yet, these contract employees contribute to the overall impact of the firm. In most cases we are unable to accurately measure the number of ancillary, or contract workers employed in the bio-pharma industry within a county. The omission of these employees means that (holding other factors constant) our economic impact estimates are too low. The exception to this is our impact analysis for Ventura County where we include a measure of contract employment gained from interviews to illustrate a more comprehensive impact of the industry. In the following section we report summary statistics for research and development workers and pharmaceutical and medicine manufacturing workers employed in the Alameda, San Diego, San Mateo, Solano, and Ventura counties.

Employment of R&D Workers. Employment and wage data for biotechnology research and development workers are reported in Table 6, Table 7 and

Table 8 below. Because the NAICS code for these workers was introduced in 2007, we only have data for three time periods, annual data for 2007 and 2008 and the first two quarters of 2009. These data

indicate that San Diego County leads the other counties in terms of employment with 8,921 research and development employees in 2009. Again, this is biotech R&D employment that occurs in research facilities only and does not include R&D employment in manufacturing establishments. For example, in Ventura County in 2007 and 2008, there were 382 and 371 R&D workers employed in research facilities that were separate from manufacturing campuses. Our data for 2009 were provided by a major employer in the county (hereinafter, Company A) that presently employs 5,920 R&D workers. These research workers are employed at a manufacturing facility, so they are included in the employment data in that industry. Our economic impact analysis for Ventura County that is presented below is based on the employment figures provided by Company A. San Mateo County ranks third in the employment of these workers (with 3,350) followed by Alameda County R&D workers (with 1,265). Please remember that R&D workers at establishments (facilities) that are categorized as a manufacturing facilities will be counted as manufacturing workers.

Table 6: County and State Average Employment for Research and Development in Biotechnology (NAICS code 541711)

County	2007	2008	2009 (QII)	Average Employment
Alameda	2,131	1,684	1,265	1,693
San Diego	7,482	7,903	8,921	8,102
San Mateo	2,542	3,466	3,350	3,120
Solano	ND	ND	ND	–
Ventura	382	371	5,920*	5,920*
State Average Employment	19,134	21,249	21,412	20,598

ND: not disclosable. Source: Quarterly Census of Employment and Wages. * Current employment data provided by "Company A" of Ventura County.

Employment data is suppressed by the BLS if the number of establishments is so small that individual companies, and corresponding confidential wage and employment data, may be revealed. (See discussion of this above.) Consequently, employment data for research workers are not available for Solano County. Data collected from other sources indicate that Solano County has very few separately identified R&D workers. A report from the Solano County Economic Development Office indicates that about 1 percent of the counties life science employment is in biotech R&D.[20]

The employment data reported in Table 6 indicate that biotech R&D employment within a county can change significantly over time. For example, employment fell from 2,131 in Alameda County in 2007 to 1,265 in 2009. On the other hand, R&D employment increased from 7,482 to 8,921 over the same period in San Diego County. Several reasons account for employment fluctuations. First, and perhaps foremost, when a line of research fails to show promising results, it may be shut down with the consequent layoff of workers within the establishment engaged in that particular scientific inquiry. Employment at the county level may vary from year to year as firms move into or out of the area. The downturn in economic activity may also contribute to employment change over the period associated

[20] See "Solano County Life Science Cluster." Solano Economic Development Corporation. Prepared by Collaborative Economics, February 2009, http://www.co.solano.ca.us/civica/filebank/blobdload.asp?BlobID=5418.

with the loss of funding or the failure of new funding to be forthcoming. Similarly, the product cycle may also affect the employment of biotech R&D workers employed within a county; that is as a product moves from R&D to manufacturing; the R&D workers might get laid off. Given these various sources of employment fluctuations over time, we base our economic impacts on the average level of R&D employment over the period of available data at the time of this report, namely 2007 to the second quarter of 2009. The exception is the Ventura County impact that is based on current employment figures for a major employer in this county gathered via interviews.

The average level of employment for the selected counties is 88 percent of the average biotech R&D employment for California as a whole. This supports the notion that biotech R&D employment is clustered in a few counties and is geographically concentrated. For example, 65 percent of the employment in this industry is concentrated in Ventura and San Diego Counties.

Data on the number of biotech research and development facilities that are separate from manufacturing facilities are reported in Table 7. The trend in the number of establishments mirrors the trend in employment with San Diego having the most employers of research and development workers. Solano County has too few establishments to report employment and wage data. Fluctuations in the number of R&D establishments vary from year to year for the same reasons R&D employment changes.

Table 7: Number of Establishments in County, Research and Development in Biotechnology (NAICS code 541711)

County	2007	2008	2009 (QII)
Alameda	38	43	40
San Diego	116	129	168
San Mateo	43	59	71
Solano	1	2	ND
Ventura	8	11	12
State Total	470	558	NA

ND: not disclosable. Source: Quarterly Census of Employment and Wages

Average annual salary data are reported in Table 8. Data are not available for 2009 because we only have data for the first half of the year. In terms of average annual pay, research workers in San Mateo earn the most ($140,000), though these figures are not adjusted for differences in cost of living between counties. All research workers across the state earned, on average, about $110,000 in 2008 ($99,000, omitting San Mateo County). Average annual pay increased in San Diego, San Mateo, and Ventura counties from 2007 to 2008, but decreased in Alameda County. Clearly, this is a relatively well paid industry particularly recalling that these averages include all workers in these establishments and not just the scientific researchers.

Table 8: Average Annual Pay, Research and Development in Biotechnology (NAICS code 541711)

County	2007	2008

Alameda	$109,687	$104,217
San Diego	$92,496	$100,137
San Mateo	$132,477	$140,163
Solano	ND	ND
Ventura	$88,459	$92,530
State Average Annual Pay	$109,707	$109,794

ND: not disclosable. Source: Quarterly Census of Employment and Wages

Employment and wage data for pharmaceutical and medicine manufacturing workers are reported in

Table 9, Table 10 and

Table 11. These data trace earnings and employment data from 2002 to the second quarter of 2009. Data from 2009 indicate that San Diego County leads the others with respect to both research and manufacturing employment. But, the manufacturing employment figures may include biotech R&D employees that work at manufacturing facilities. Due to the high number of pharmaceutical manufacturing workers in this county, we are able to report employment in each of the subcategories for this sector. For example, of the 4,859 manufacturing workers employed in San Diego in 2009, 179 were employed in medicinal and botanical manufacturing, 853 are employed in pharmaceutical preparations manufacturing, 3,215 work in the in-vitro diagnostic substance sector, and 612 are employed in biological product manufacturing. While current data are not available for San Mateo, data from 2003 indicate that this county has a substantial number of manufacturing employees. Alameda ranks higher than Solano County in terms of manufacturing employment. Data for Ventura County indicate high levels of manufacturing employment for 2003, but these figures likely include R&D employees that are also employed at manufacturing facilities in the county. Data provided by Company A for Ventura County indicate separate manufacturing employment of 1,480 workers in 2010. These data are used to estimate the economic impact for this sector for Ventura County. Data from 2002 to 2009 indicate that manufacturing employment in Alameda County fell over the period, but has climbed back to 2002 levels. Manufacturing employment has increased over the period in San Diego and Solano counties. These fluctuations are due to changes in the business and product cycles. As a consequence of the yearly fluctuations in county-level employment, our economic impact for pharmaceutical manufacturing employment is based on the averages over the 2002 to 2009 period. The exceptions are the manufacturing impacts for Ventura County that are based on the current employment figures for Company A, Solano County where the average employment is based on the 2003 to 2009 period, and San Mateo County average employment between 2002 and 2003.

Table 9: Employment, Pharmaceutical and Medicine Manufacturing (NAICS code 3254)

County	2002	2003	2004	2005	2006	2007	2008	2009 (QII)	Average Employment
Alameda	2,676	2,796	2,629	2,483	2,482	2,749	2,560	2,638	2,627
San Diego	4,843	4,363	4,153	4,153	4,348	4,479	4,656	4,859	4,482
San Mateo	4,810	5,141	ND	ND	ND	ND	ND	ND	–
Solano	ND	1,503	1,737	1,863	1,954	1,970	1,878	1,903	1,830
Ventura	5,135	5,840	ND	ND	ND	ND	ND	1,480*	1,480*
State Average	39,990	38,713	40,501	41,743	44,047	43,971	43,035	43,600	41,950

ND: not disclosable. Source: Quarterly Census of Employment and Wages. * Data from Ventura County Company A (manufacturing employment separated from R&D employment).

The average employment data for the selected counties indicates that 37% of the total pharmaceutical manufacturing employment in the state is concentrated in these counties. While biotech R&D employment tends to be concentrated in a few counties, the manufacturing side tends to be geographically dispersed. For example, 42 percent of manufacturing employment is located in Los Angeles, Orange, and Santa Cruz Counties.

Data on the number of pharmaceutical manufacturing establishments are reported in Table 10. San Diego has the most manufacturing establishments, but the number of firms has decreased over time. The number of establishments in the other counties has remained relatively stable over the period, even though the number decreased state-wide.

Table 10: Number of Establishments in County, Pharmaceutical and Medicine Manufacturing (NAICS code 3254)

County	2002	2003	2004	2005	2006	2007	2008	2009 (QII)
Alameda	25	26	26	24	21	23	20	23
San Diego	75	72	69	68	71	73	69	67
San Mateo	18	21	22	21	21	19	23	ND
Solano	ND	7	6	6	7	8	7	7
Ventura	12	11	12	11	10	9	8	ND
State Average	438	438	435	418	404	390	395	NA

ND: not disclosable. Source: Quarterly Census of Employment and Wages

Data reported in

Table 11 indicate that on average, manufacturing workers earned between $83,000 and $142,000 annually in 2008. Manufacturing workers in Solano earn the most, while workers in San Diego earn the least. State average wages in this industry have increased from 2001 to 2008.

Table 11: Average Annual Pay, Pharmaceutical and Medicine Manufacturing (NAICS code 3254)

County	2001	2002	2003	2004	2005	2006	2007	2008
Alameda	$75,865	$77,182	$76,667	$82,357	$82,494	$85,215	$87,424	$94,284
San Diego	$58,042	$56,904	$60,133	$73,806	$78,327	$80,645	$88,473	$83,248
San Mateo	$99,833	$88,648	$192,872	ND	ND	ND	ND	ND
Solano	$76,958	ND	$57,785	$66,302	$74,677	$76,534	$104,988	$142,141
Ventura	$152,023	$135,417	$151,279	ND	ND	ND	ND	ND
State Average	$81,257	$75,049	$95,163	$100,828	$122,209	$101,704	$110,363	$109,137

ND: not disclosable. Source: Quarterly Census of Employment and Wages

We report data on output per worker for pharmaceutical manufacturing employees and for biotech research and development workers in

Table 12. These data are national averages for each manufacturing sub-sector and are available from the 2007 Economic Census. At this time, regional and state-level data on industry output per worker are not available, so we use the national data for our impact analysis. Output per worker for manufacturing employees is based on the value of shipments, plus, end-of-year inventories, minus, beginning-of-year inventories. According to the Economic Census, total employment in the nation for the overall category of pharmaceutical manufacturing employment was 250,377 in 2007. We use the IMPLAN forecast of inflation to report output per worker measures in 2010 dollars. The data for 2010 are used in our customization of the IMPLAN model. Output per worker for R&D workers is defined as biotech R&D sales per worker.

Table 12: National Employment and Output per Worker for Pharmaceutical and Medicine Manufacturing Categories

Category	Percent of Total Industry Employment	Output per worker (2007 dollars)	Output per worker (2010 dollars)
Medicinal and Botanical Manufacturing	9.5% (23,848)	$513,000	$540,000
Pharmaceutical Preparation Manufacturing	63.7% (159,420)	$951,000	$1,000,000
In-Vitro Diagnostic Substance Manufacturing	12.2% (30,548)	$461,00	$485,000
Biological Product (except Diagnostic) Manufacturing	14.6% (36,557)	$748,000	$790,000
Industry Average Output per Worker- Pharmaceutical Manufacturing	–	–	$703,750
Weighted Average Output per Worker-Pharmaceutical Manufacturing*	–	–	$870,700
Output per Worker-Biotech Research and Development	100%	$199,000	$210,000

Sources: 2007 Economic Census and IMPLAN. * Weights based on distribution of employment among subsectors.

These data indicate that, while the average contribution of each manufacturing worker is high, those involved in pharmaceutical preparation manufacturing have the highest output per worker ($1,000,000 in 2010 dollars). These data indicate that pharmaceutical manufacturing workers will have a large economic impact because these workers produce a very valuable product that is exported from the counties. As a point of contrast, output per worker for biotech R&D employees is $210,000 in 2010 dollars.

At the national level, pharmaceutical preparations manufacturing employees are the dominant employment category within the pharmaceutical and medicine manufacturing sector. These workers make up approximately 64 percent of those employed in pharmaceutical manufacturing. Biological product manufacturing employs about 15 percent of industry workers followed by in-vitro diagnostic substance manufacturing with 12 percent and medicinal and botanical with 9.5 percent.

Data from Table 13 report pharmaceutical preparations employment as a percent of total pharmaceutical and medicine manufacturing employment for available counties. The distribution varies across the selected counties (data are not available for San Mateo and Ventura counties). Pharmaceutical preparation employment is above the national average in Alameda and Solano counties. Manufacturing employment is distributed differently across the four sub-categories within pharmaceutical and medicine manufacturing in San Diego County. So, pharmaceutical preparations employment consists of only 20 percent of the total for this county. The dominant manufacturer in San Diego County is in-vitro diagnostic substance manufacturing with 66 percent of pharmaceutical

manufacturing employment. Due to disclosure restrictions, we are unable to report detailed employment breakdowns for the other counties.

Table 13: Distribution of Pharmaceutical Manufacturing Employment Within Selected Counties

County	Percent Pharmaceutical Manufacturing Employment in Pharmaceutical Preparation Manufacturing
Alameda County*	72%
San Diego	18%
Solano	86%

Source: 2009 Quarterly Census of Employment and Wages. * Data for 2007

Economic Impact Results for Selected Counties

In this section we report the economic impact results for biotechnology research and development workers and for those employed as pharmaceutical and medicine manufacturing employees. These employment impacts are based on average employment levels over the 2002-2009 period, with the exception of the Ventura County impact that is based on current firm-level employment data. County employment data are further adjusted to measure the impact of those workers who reside within the county.[21] The results report the impact of these workers on the county and state economies and are reported in 2010 dollars.

Alameda: County–Level Economic Impact Results

Data reported in Table 9 above indicate that the average level of pharmaceutical manufacturing employment between 2002 and 2009 is 2,627. Data from the 2000 Census indicate that 66 percent of those employed in Alameda County reside within the county. This suggests that approximately 1,734 pharmaceutical manufacturing workers reside in Alameda County. Similarly, the average level of biotech R&D employment for this county is 1,693 over the period. If 66 percent are county residents, our impact is based on 1,117 R&D employees. All impact results presented below are annual impacts.

Economic Impact of Pharmaceutical and Medicine Manufacturing Employment

The impact of resident Alameda County pharmaceutical manufacturing employment is reported below. The employment multiplier is 3.096 indicating that one more manufacturing job supports an additional 2.096 other jobs in the county. Or, one more pharmaceutical manufacturing job creates a total of 3,096 secondary jobs in the county. So, the 1,734 manufacturing jobs are responsible for a total of 5,368 jobs in Alameda County. The output multiplier is 1.466 suggesting that each dollar of manufacturing output results in a total of $1.47 in economic activity for the county.

We use the weighted industry national average output per worker ($870,700) for pharmaceutical manufacturing workers to derive the dollar value of employing 1,734 workers in the county. Or, the

[21] See "County-to-County Commute Patterns," Employment Development Department, State of California, December 2008; http://www.labormarketinfo.edd.ca.gov/article.asp?articleid=530

dollar value of the 1,734 manufacturing workers is approximately $1.509 billion (1,734 x $870,700). Given the output multiplier described above, the total economic impact of pharmaceutical manufacturing employment in dollar terms for the county is over $2.2 billion (1.466 x $1.509 billion). This is 2.5 percent of the county total economic activity. On a per worker bases, the impact of each worker is approximately $1.3 million. As stated above, the impact for manufacturing workers is high because the output for each of these workers that is exported from the county is high. The economic activity generated by these manufacturing employees contributes approximately $16 million in county property and sales taxes. On a per worker basis, the impact on the local tax base is about $9,000 per employee.

Table 14: Economic Impact of Pharmaceutical and Medicine Manufacturing Employment on Alameda County.

Impact Category (2010 Dollars)	Direct Effect	Multiplier	Total Economic Impact
Employment	1,734	3.096	5,368
Output	$1,509,794,000	1.466	$2,214,040,000
Output Impact per Employee	–	–	$1,277,000
Local Tax Impact*	–	–	$15,596,000
Local Tax Impact per Employee	–	–	$8,994

Sources: Quarterly Census of Employment and Wages and IMPLAN (2010 dollars). * The county-level tax impact is based on business and residential property taxes and that portion of sales taxes that remain in the county.

Economic Impact of Biotechnology Research and Development Employment

The impact of biotechnology R&D employment in Alameda County is reported below in Table 15. We use the national average ($210,000) for sales per worker to determine the value of output for these workers. The employment multiplier of 1.985 suggests that each R&D job supports about one more job in the county. Or, an additional R&D job results in a total of approximately 2 more county jobs. This multiplier indicates that the 1,117 resident R&D jobs are associated with a total of 2,217 jobs in Alameda County. Using the national industry average output per worker ($210,000) the dollar value of employing 1,117 R&D workers is approximately $234 billion ($210,000 x 1,117). The output multiplier of 1.751

indicates that the total dollar impact of R&D employment for the county is approximately $410 million. On a per worker basis, another R&D job contributes approximately $368,000 to the county economy. The economic activity associated with biotech R&D employment contributes about $4 million in local sales and property taxes. Or, each R&D job contributes about $3,500 to the local tax base.

Table 15: Economic Impact of Biotechnology Research and Development Employment on Alameda County.

Impact Category (2010 Dollars)	Direct Effect	Multiplier	Total Economic Impact
Employment	1,117	1.985	2,217
Output	$234,570,000	1.751	$410,667,000
Output Impact per Employee	–	–	$368,000
Local Tax Impact*	–	–	$3,940,000
Local Tax Impact per Employee	–	–	$3,530

Sources: Quarterly Census of Employment and Wages and IMPLAN (2010 dollars). * The county-level tax impact is based on business and residential property taxes and that portion of sales taxes that remain in the county.

Combined Impact of Pharmaceutical and Medicine Manufacturing and Biotechnology Research and Development Employment on the Alameda County Economy

The combined impact of pharmaceutical manufacturing employment and biotech R&D jobs in the Alameda County economy is approximately $2.6 billion. That is about 3 percent of total county economic activity. The combined impact in terms of jobs is about 7,500. This is about 0.9 percent of total county employment. This economic activity generates approximately $20 million in local property and sales taxes.

Suggestions on How to Use the County-Level Impact Results

The total impact described above can be used to educate the public, local economic development officials, and local politicians about the importance of the pharmaceutical manufacturing and biotech R&D employment to the Alameda County economy. The multipliers and per-worker impacts are also useful in providing information regarding changes to the industry in the future. These multipliers are

specific to Alameda County and can be used to estimate the impact of changes in employment or industry output. For example, if 100 new biotech R&D employees are to be hired in the county, the impact on total county employment will be about 200 jobs (100 new jobs x employment multiplier 1.985). Or, if pharmaceutical manufacturing output rises by $1 million, the total impact on the county will be approximately $1.47 million ($1 million x output multiplier 1.466). Multipliers can be applied to negative changes as well. For example, if 100 R&D employees are laid off, total employment in the county will decrease by approximately 200 total jobs.

The per-worker impacts can be used in similar ways. For example, if pharmaceutical manufacturing employment is expected to increase by 100 workers, the impact on the county economy will be about $128 million (100 new employees x $1.277 million per worker). The corresponding tax impact of these new manufacturing employees will be about $900,000 in new county sales and property taxes (100 new jobs x $9,000 tax impact per worker). The multipliers and per-worker impacts will change over time as prices and worker productivity change. So, the use of these results will be most accurate within a few years of this study.

Alameda: State-Level Economic Impact Results

While the county-level impacts were adjusted for resident employment, the state-level impacts are based on the average employment levels over the 2002-2009 period. That is, the impact of Alameda County pharmaceutical manufacturing employment on the state of California is based on 2,627 employees. Similarly, the impact of Alameda County biotech R&D employment is based on 1,693 jobs.

Economic Impact of Alameda County Pharmaceutical and Medicine Manufacturing Employment on the California Economy

Like the county-level impact, we use the national weighted average ($870,700) for output per worker to determine the value of production for these workers. The multipliers are larger for the state-level impact because larger economies do a better job of retaining, or capturing the spending that is induced by pharmaceutical employment. This means that manufacturing jobs in Alameda County support and create more additional jobs when the impact is measured at the state level. For example, an additional manufacturing job in Alameda County supports an additional 4.959 more local jobs in California. (See Table 16.) Or, the 2,627 jobs in Alameda County create and support and total of 13,026 jobs in the state. The output multiplier of 1.959 indicates that one more dollar of manufacturing output in Alameda County results in an increase in state-level economic activity of $1.96. Or, the direct value of output associated with employing 2,627 manufacturing workers in Alameda County ($ 2.287 billion) increases economic activity in the state by approximately $4.5 billion. On a per-worker basis, the economic impact of an additional manufacturing worker in Alameda County contributes about $1.7 million to the state economy. The tax impact on the state associated with the employment of 2,627 manufacturing employees in Alameda County is about $168 million, or approximately $64,000 per employee.

Table 16: Economic Impact of Alameda County Pharmaceutical and Medicine Manufacturing Employment on California.

Impact Category (2010 Dollars)	Direct Effect	Multiplier	Total Economic Impact
Employment	2,627	4.959	13,026
Output	$2,287,329,000	1.959	$4,479,466,000
Output Impact per Employee	–	–	$1,705,000
State and Local Tax Impact*	–	–	$168,177,000
Local Tax Impact per Employee	–	–	$64,000

Sources: Quarterly Census of Employment and Wages and IMPLAN (2010 dollars). * The state and local tax impact is a comprehensive impact that is based on indirect business taxes (including sales and property taxes) as well as taxes collected from households, corporations, and employee compensation.

Economic Impact of Alameda County Biotechnology Research and Development Employment on the California Economy

The impact of Alameda County biotech R&D employment (Table 17is based on the average number of employees for the 2002-2009 period. Like the county-level impact, we use the national average ($210,000) for sales per worker to determine the value of output for these workers. The employment multiplier indicates that, considered at the state level, one more R&D job in Alameda County creates and supports another 1.798 jobs in the state. Or, another R&D job in this county creates a total of 2.798 jobs in California. The 1,693 jobs in Alameda County create a total of 4,737 jobs in the state. In dollar terms, the economic impact of this level of R&D employment is approximately $851 million. The impact of another worker on the state economy is about $500,000, or $24,000 in terms of the tax impact. The total impact of Alameda County R&D employment on state and local taxes is approximately $41 million.

Table 17: Economic Impact of Alameda County Biotechnology Research and Development Employment on California.

Impact Category (2010 Dollars)	Direct Effect	Multiplier	Total Economic Impact
Employment	1,693	2.798	4,737
Output	$355,535,000	2.40	$851,833,000
Output Impact per Employee	–	–	$503,000
State and Local Tax Impact*	–	–	$41,484,000
Local Tax Impact per Employee	–	–	$24,500

Sources: Quarterly Census of Employment and Wages and IMPLAN (2010 dollars). * The state and local tax impact is a comprehensive impact that is based on indirect business taxes (including sales and property taxes) as well as taxes collected from households, corporations, and employee compensation.

Combined Impact of Alameda County Pharmaceutical and Medicine Manufacturing and Biotechnology Research and Development Employment on the California Economy

The combined impact of Alameda County pharmaceutical manufacturing employment and biotech R&D jobs on the California economy is approximately $5.3 billion. That is about 0.3 percent of state economic activity. The combined impact in terms of jobs is about 17,700. This is about 0.1 percent of total California employment. This economic activity generates approximately $210 million in state and local tax revenue.

Suggestions on How to Use the State-Level Impact Results

The total results can be used to educate state-level officials regarding the impact of pharmaceutical manufacturing and biotech research in Alameda County on the California economy. As was the case above, the multipliers and per worker impacts can be used to inform interested parties about the consequences of changes in the industry. For example, if an Alameda County pharmaceutical manufacturer expects to hire 100 new employees, the impact on the state will be about 500 more jobs. Or, if this firm experiences an increase of $1 million in sales, the impact on the state will be about $1.96 million. The 100 new manufacturing workers will increase economic activity by approximately $170 million and state and local taxes will increase by about $6,400,000. The multipliers and per worker impacts can also be used to derive similar information for changes in R&D employment. For example, if 100 more R&D workers are to be hired in Alameda County, the employment impact on the state will be

about 280 new jobs. The impact of these workers in dollar terms would be about $50 million. The impact of these workers on state and local taxes would be approximately $2.5 million.

San Diego: County–Level Economic Impact Results

Economic Impact of Pharmaceutical and Medicine Manufacturing Employment

As noted above, San Diego has the largest reported concentration of pharmaceutical manufacturing and research and development workers of the five counties. San Diego also has the most diversified manufacturing employment. For example, over the 2002-2009 period, average employment in medicine and botanical manufacturing was 255; the pharmaceutical preparations sector employed an average of 812 while in-vitro diagnostic substance manufacturing had the highest average employment of 2,585. The biological product sector in this county had an average employment level of 677. The economic impact for pharmaceutical manufacturing is based on the total for these sectors (4,329). The county also has an average of 8,120 biotech research and development employees from 2007 to 2009. Given the size of the county, we assume that all employees reside within county limits. Consequently, all are considered involved in export activity. All impact results presented below are annual impacts.

The impact for all pharmaceutical and medicine manufacturing employees is reported below. (Table 18) The employment multiplier of 3.510 indicates that each manufacturing job in the county supports an additional 2.510 local jobs. Or, the total job impact of the 4,329 manufacturing workers is 15,194 total jobs in the county. The direct output value of 4,329 pharmaceutical manufacturing workers is $2.7 billion. With an output multiplier of 1.682, the total economic impact of these workers on the county in dollar terms is approximately $4.6 billion. This is about 3 percent of the county's total economic activity. On a per-worker basis, the impact of each employee is approximately $1million. As stated above, we can expect pharmaceutical manufacturing employees to have a substantial economic impact because of the high output per worker and the high value of products that are exported from the county. The economic activity generated by manufacturing employees contributes approximately $34 million in property taxes and sales taxes retained by the county. On a per-worker basis, the impact on the local tax base is about $7,900 per employee.

Table 18: Economic Impact of Pharmaceutical and Medicine Manufacturing Employment on San Diego County.

Impact Category (2010 Dollars)	Direct Effect	Multiplier	Total Economic Impact
Employment	4,329	3.510	15,194
Output	$2,738,000,000	1.682	$4,606,000,000
Output Impact per Employee	–	–	$1,064,000
Local Tax Impact*	–	–	$34,144,000
Local Tax Impact per Employee	–	–	$7,890

Sources: Quarterly Census of Employment and Wages and IMPLAN (2010 dollars). * The county-level tax impact is based on business and residential property taxes and that portion of sales taxes that remain in the county.

Impact of Biotechnology Research and Development Employment

The impact of biotechnology research and development employment is reported in Table 19. We use the national average ($210,000) for sales per worker to determine the value of output for these R&D employees. The employment results indicate that each research job supports another 1.408 local jobs, or the 8,102 employees create and support an additional 19,510 jobs in the county. The corresponding output value of the employment if 8,102 research workers is approximately $1.7 billion. With an output multiplier of 1.953, the total impact is approximately $3.3 billion and represents about 2 percent of economic activity in San Diego County. On a per-employee basis, the impact of each worker is approximately $410,000. The impact per worker for R&D employees is smaller than that for manufacturing workers because the output per worker is lower for research workers. The economic activity associated with research and development employment generates about $32 million in tax revenue for the county. The tax impact per employee is $4,050.

Table 19: Economic Impact of Biotechnology Research and Development Employment on San Diego County.

Impact Category (2010 Dollars)	Direct Effect	Multiplier	Total Economic Impact
Employment	8,102	2.408	19,510
Output ($)	$1,701,000,000	1.953	$3,323,000,000
Output Impact per Employee	–	–	$410,000
Local Tax Impact*	–	–	$32,813,000
Local Tax Impact per Employee	–	–	$4,050

Sources: Quarterly Census of Employment and Wages and IMPLAN (2010 dollars). * The county-level tax impact is based on business and residential property taxes and that portion of sales taxes that remain in the county.

Combined Impact of Pharmaceutical and Medicine Manufacturing and Biotechnology Research and Development Employment on the San Diego County Economy

The combined impact of pharmaceutical manufacturing and research jobs on the San Diego County economy is approximately $7.9 billion. This is about 4.6 percent of county economic activity. The combined impact in terms of employment is about 34,000 local jobs that is approximately 1.8 percent of total employment for the county. This economic activity generates approximately $66 million in local sales and property taxes.

Suggestions on How to Use the County-Level Impact Results

The total impacts described above are of use in educating the public, local economic development officials, and local politicians about the importance of pharmaceutical manufacturing and biotechnology research employment to the San Diego County economy. The multipliers and per-worker impacts can be used to provide information regarding changes to the industry in the future. These multipliers are specific to the respective industry and to San Diego County and can be used to estimate the impacts of changes in employment or local industry output. These impacts can be measured by multiplying the employment (or output) change by the appropriate multiplier. For example, if 100 new pharmaceutical manufacturing employees are to be hired in the county, the impact on total local job creation in the county will be about 351 more jobs. Or, the output multiplier can be used to estimate the impact on the economy of an increase in research activity by a company. For example, if a research firm expects sales to increase by $1,000,000, the impact on the San Diego economy will increase by a multiple of 1.682, or about $1.7 million. Multipliers are can be applied to positive or negative changes. That is, if the sales of a research firm decrease by $1 million, local economic activity will decrease by $1.95 million.

The per-worker impacts can be used in a similar way. For example, if pharmaceutical manufacturing employment is expected to increase by 100 workers, the impact on the county economy will be about $106 million. The corresponding tax impact of the 100 new manufacturing employees will be about $789,000. The multipliers and per-worker impacts will change over time as prices and the productivity of pharmaceutical manufacturing workers change. So, the use of these results will be most accurate within a few years of this study.

San Diego: State-Level Economic Impact Results

Economic Impact of Pharmaceutical and Medicine Manufacturing Employment

The multipliers are larger for the state-level impact because larger economies do a better job of retaining, or capturing the spending that is induced by pharmaceutical employment. This means that manufacturing jobs in San Diego support and create more additional jobs when the impact is measured at the state-level. (See Table 20.) For example, each manufacturing job supports an additional 3.501 jobs in California. Or, the 4,329 jobs in San Diego County are responsible for about 19,000 in the state. The corresponding output value of this economic impact is approximately $5.9 billion and represents about 0.3 percent of economic activity in the state. The impact of each San Diego manufacturing worker on the state economy is about $1.4 million. The economic activity from the employment of these workers creates a total of $216 million in combined state and local taxes. The tax impact on a per-worker basis is approximately $50,000.

Table 20: Economic Impact of San Diego County Pharmaceutical and Medicine Manufacturing Employment on the California Economy.

Impact Category (2010 Dollars)	Direct Effect	Multiplier	Total Economic Impact
Employment	4,329	4.501	19,486
Output ($)	$2,738,000,000	2.157	$5,905,000,000
Output Impact per Employee	–	–	$1,364,000
State and Local Tax Impact*	–	–	$216,000,000
State and Local Tax Impact per Employee	–	–	$49,800

Sources: Quarterly Census of Employment and Wages and IMPLAN (2010 dollars). * The state and local tax impact is a comprehensive impact that is based on indirect business taxes (including sales and property taxes) as well as taxes collected from households, corporations, and employee compensation.

Impact of Biotechnology Research and Development Employment

Because multipliers are larger for larger economies, the impact of research workers on the state economy is larger than the county impact. For example, the employment multiplier of 2.776 indicates that each research job in San Diego supports another 1.776 other jobs in the state. The total number of jobs created by the 8,102 biotech research workers employed in San Diego is about 23,000 state-wide. The dollar value of this impact is approximately $4.0 billion. (Table 21) This is about 0.2 percent of California economic activity. The impact per worker is $500,000. The corresponding impact on total state and local taxes is about $195 million, or $24,000 per employee.

Table 21: Economic Impact of San Diego County Biotechnology Research and Development Employment on the California Economy.

Impact Category (2010 Dollars)	Direct Effect	Multiplier	Total Economic Impact
Employment	8,102	2.776	22,491
Output ($)	$1,701,000,000	2.379	$4,048,000,000
Output Impact per Employee	–	–	$500,000
State and Local Tax Impact*	–	–	$195,300,000
Local Tax Impact per Employee	–	–	$24,100

Sources: Quarterly Census of Employment and Wages and IMPLAN (2010 dollars). * The state and local tax impact is a comprehensive impact that is based on indirect business taxes (including sales and property taxes) as well as taxes collected from households, corporations, and employee compensation.

Combined Impact of San Diego County Pharmaceutical and Medicine Manufacturing and Biotechnology Research and Development Employment on the California Economy

The combined impact of San Diego pharmaceutical manufacturing and biotech research employment on the state economy is approximately 42,000 jobs (about 0.2 percent of the state's total employment), or about $9.9 billion (or 0.5 percent of California's GDP), and $411 million in state and local taxes.

Suggestions on How to Use the State-Level Impact Results

The total results can be used to educate state-level officials regarding the impact of pharmaceutical manufacturing and biotech research in San Diego on the California economy. As was the case above, the multipliers and per worker impacts can be used to inform interested parties about the consequences of changes in the industry. For example, if a San Diego pharmaceutical manufacturer expects to hire 100 new employees, the impact on the state will be 450 more jobs. Or, if this firm experiences and increase of $1 million in sales, the impact on the state will be about $2.2 million. The 100 new workers will increase economic activity by approximately $1.4 million and state and local taxes will increase by about $5,000,000.

San Mateo: County-Level Economic Impact Results

Economic Impact of Pharmaceutical and Manufacturing Employment

Current data on pharmaceutical manufacturing employment in San Mateo County is not available. The most recent data is for the 2002-2003 period when average employment was 4,976. Data from the Census suggests that 58% of employees in this county reside in the San Mateo. So, the estimated impact is based on the 2,886 resident workers. (Table 22) Since the impact of San Mateo pharmaceutical manufacturing workers is based on average employment data from 2002 and 2003, the per-worker impact described below may be more useful in calculating the economic contribution of current workers. For those who have information on current manufacturing employment in the county, the per-worker impacts can be used to derive the applicable economic impact. All impact results presented below are annual impacts.

The impact of our estimated 2,886 pharmaceutical and medicine manufacturing employees is reported below. The employment multiplier of 2.004 indicates that each manufacturing job in the county supports an additional 1.004 local jobs. Or, the total job impact of the 2,886 manufacturing workers is 5,783 total jobs in the county. We use the national weighted average ($870,700) for output per worker to determine the value of production for these workers. So, the direct output value of 2,886 pharmaceutical manufacturing workers is $2.5 million (2,886 x $870,700). With an output multiplier of 1.290, the total economic impact of these workers on the county in dollar terms is approximately $3.2 billion. On a per-worker basis, the impact of each employee is approximately $1.1 million. We can expect pharmaceutical manufacturing employees to have a substantial economic impact because of the high output per worker and the high value of products that are exported from the county. The economic activity generated by manufacturing employees contributes approximately $17 million in property taxes and sales taxes retained by the county. On a per-worker basis, the impact on the local tax base is about $6,000 per employee.

Table 22: Economic Impact of Pharmaceutical and Medicine Manufacturing Employment on San Mateo County.

Impact Category (2010 Dollars)	Direct Effect	Multiplier	Total Economic Impact
Employment	2,886	2.004	5,783
Output	$2,512,840,000	1.290	$3,240,900,000
Output Impact per Employee	–	–	$1,123,000
Local Tax Impact*	–	–	$17,310,000
Local Tax Impact per Employee	–	–	$6,000

Sources: Quarterly Census of Employment and Wages and IMPLAN (2010 dollars). * The county-level tax impact is based on business and residential property taxes and that portion of sales taxes that remain in the county.

Impact of Biotechnology Research and Development Employment

The impact of biotechnology research and development employment is reported in the table below. The average level of R&D employment in San Mateo County between 2007 and 2009 was 3,120. Census data indicates that 58% of these workers reside within the county, so the employment impact is based on 1,810 resident workers.

The employment results indicate that each research job supports another 0.548 local jobs, or the 1,810 resident employees create and support an additional 2,801 jobs in the county. (Table 23) We use the national weighted average ($210,000) for output per worker to determine the value of production for these workers. The corresponding output value of the employment of 1,810 research workers is approximately $380 million (1,810 x $210,000). With an output multiplier of 1.442, the total impact is approximately $548 million. On a per-employee basis, the impact of each worker is approximately $303,000. The impact per worker for R&D employees is smaller than that for manufacturing workers because the output per worker is lower for research workers. The economic activity associated with research and development employment generates about $4.5 million in tax revenue for the county. The tax impact per employee is $2,500.

Table 23: Economic Impact of Biotechnology Research and Development Employment on San Mateo County.

Impact Category (2010 Dollars)	Direct Effect	Multiplier	Total Economic Impact
Employment	1,810	1.548	2,801
Output	$380,100,000	1.442	$548,192,000
Output Impact per Employee	–	–	$302,900
Local Tax Impact*	–	–	$4,476,000
Local Tax Impact per Employee	–	–	$2,470

Sources: Quarterly Census of Employment and Wages and IMPLAN (2010 dollars). * The county-level tax impact is based on business and residential property taxes and that portion of sales taxes that remain in the county.

Combined Impact of Pharmaceutical and Medicine Manufacturing and Biotechnology Research and Development Employment on the San Mateo County Economy

The combined impact of pharmaceutical manufacturing and research jobs on the San Mateo County economy is approximately $3.8 billion. This impact represents 6.3 percent of county GDP. The combined impact in terms of employment is about 8,600 local jobs. This represents about 1.7 percent of county employment. This economic activity generates approximately $21.8 million in local sales and property taxes.

Suggestions on How to Use the County-Level Impact Results

The total impacts described above are of use in educating the public, local economic development officials, and local politicians about the importance of pharmaceutical manufacturing and biotechnology research employment to the San Mateo county economy. The multipliers and per-worker impacts can be used to provide information regarding changes to the industry in the future. These multipliers are specific to the respective industry and to San Mateo County and can be used to estimate the impacts of changes in employment or local industry output. These impacts can be measured by multiplying the employment (or output) change by the appropriate multiplier. For example, if 100 new pharmaceutical manufacturing employees are to be hired in the county, the impact on total local job creation in the county will be about 200 more jobs. Or, the output multiplier can be used to estimate the impact on the economy of an increase in research activity by a company. For example, if a research firm expects sales to increase by $1,000,000, the impact on the San Mateo economy will increase by a multiple of 1.442, or

about $1.4 million. Multipliers are can be applied to positive or negative changes. That is, if the sales of a research firm decrease by $1 million, local economic activity will decrease by $1.4 million.

The per-worker impacts can be used in a similar way. For example, if pharmaceutical manufacturing employment is expected to increase by 100 workers, the impact on the county economy will be about $112 million. The corresponding tax impact of the 100 new manufacturing employees will be about $600,000. The multipliers and per-worker impacts will change over time as prices and the productivity of pharmaceutical manufacturing workers change. So, the use of these results will be most accurate within a few years of this study.

San Mateo: State-Level Economic Impact Results

Economic Impact of Pharmaceutical and Medicine Manufacturing Employment

The state-level impact is based on the average levels of employment and is not adjusted for the percent residing in San Mateo County. Consequently, the pharmaceutical manufacturing impact is based on 4,976 employees and the biotech R&D impact is based on 3,120 workers. (Table 24) The multipliers are larger for the state-level impact because larger economies do a better job of retaining, or capturing the spending that is induced by pharmaceutical employment. This means that manufacturing jobs in San Mateo support and create more additional jobs when the impact is measured at the state-level. For example, each manufacturing job supports an additional 3.958 jobs in California. Or, the 4,976 jobs in San Mateo County are responsible for about 24,673 in the state. We use the national weighted average ($870,700) for output per worker to determine the value of production for these workers. So, the direct output value for the corresponding level of employment is approximately $4.3 billion (4,976 x $870,700). The economic impact is approximately $8.5 billion. The impact of each San Mateo manufacturing worker on the state economy is about $1.7 million. The economic activity from the employment of these workers creates a total of $331 million in combined state and local taxes. The tax impact on a per-worker basis is approximately $67,000.

Table 24: Economic Impact of San Mateo Pharmaceutical and Medicine Manufacturing Employment on the California Economy.

Impact Category (2010 Dollars)	Direct Effect	Multiplier	Total Economic Impact
Employment	4,976	4.958	24,673
Output	$4,332,603,000	1.958	$8,484,896,000
Output Impact per Employee	–	–	$1,705,000
State and Local Tax Impact*	–	–	$331,036,000
Local Tax Impact per Employee	–	–	$66,500

Sources: Quarterly Census of Employment and Wages and IMPLAN (2010 dollars). * The state and local tax impact is a comprehensive impact that is based on indirect business taxes (including sales and property taxes) as well as taxes collected from households, corporations, and employee compensation.

Impact of Biotechnology Research and Development Employment

Because multipliers are larger for larger economies, the impact of research workers on the state economy is larger than the county impact. For example, the employment multiplier of 2.776 indicates that each research job in San Mateo supports another 1.776 other jobs in the state. (Table 25) The total number of jobs created by the 3,120 biotech research workers employed in San Mateo is about 8,700 state-wide. We use the national weighted average ($210,000) for sales per worker to determine the value of production for these workers. So the direct value of output for these workers is about $655 million (3,120 x $210,000). The overall economic impact of this direct level of output is approximately $1.6 billion. The impact per worker is about $500,000. The corresponding impact on total state and local taxes is about $78 million, or $25,000 per employee.

Table 25: Economic Impact of San Mateo County Biotechnology Research and Development on the California Economy.

Impact Category (2010 Dollars)	Direct Effect	Multiplier	Total Economic Impact
Employment	3,120	2.776	8,660
Output	$655,200,000	2.379	$1,558,593,000
Output Impact per Employee	–	–	$499,550
State and Local Tax Impact*	–	–	$78,131,000
Local Tax Impact per Employee	–	–	$25,000

Sources: Quarterly Census of Employment and Wages and IMPLAN (2010 dollars). * The state and local tax impact is a comprehensive impact that is based on indirect business taxes (including sales and property taxes) as well as taxes collected from households, corporations, and employee compensation.

Combined Impact of San Mateo County Pharmaceutical and Medicine Manufacturing and Biotechnology Research and Development Employment on the California Economy

The combined impact of San Mateo pharmaceutical manufacturing and biotech research employment on the state economy is approximately 33,000 jobs, $10 billion in terms of state GDP, and $409 million in state and local taxes.

Suggestions on How to Use the State-Level Impact Results

The total results can be used to educate state-level officials regarding the impact of pharmaceutical manufacturing and biotech research in San Mateo on the California economy. As was the case above, the multipliers and per worker impacts can be used to inform interested parties about the consequences of changes in the industry. For example, if a San Mateo pharmaceutical manufacturer expects to hire 100 new employees, the impact on the state will be about 500 more jobs. Or, if this firm experiences and increase of $1 million in sales, the impact on the state will be about $1.96 million. The 100 new workers will increase economic activity by approximately $170 million and state and local taxes will increase by about $6,650,000.

Solano: County-Level Economic Impact Results

Economic Impact of Pharmaceutical and Manufacturing Employment and Suggestions on How to Use the Impact Results

Public data are not available that separately identifies biotechnology research and development employees that work outside of Solano County pharmaceutical manufacturing facilities. A report on the Solano County life sciences cluster indicates that 1 percent of the county's life sciences employment is employed in biotech R&D.[22] As a consequence, we report the impact for these employees on a per worker basis. Interested parties, who are informed about the actual level of biotech R&D employment in the county, can use these per worker results to estimate the impact. The county has an average of 1,830 pharmaceutical manufacturing workers between 2003 and 2009. We use the national weighted average ($870,700) for output per worker to determine the value of production for these workers. Seventy-eight percent of these workers (1,427) reside in the county.[23] All impact results presented below are annual impacts.

The impact for all pharmaceutical and medicine manufacturing employees is reported below. The employment multiplier of 2.014 indicates that each manufacturing job in the county supports an additional 1.014 local jobs. Or, the total job impact of the 1,427 manufacturing workers is 2,874 total jobs in the county. (Table 26) The direct dollar value of the employment of 1,427 manufacturing workers is $1.2 billion (1,427 x $870,700). With an output multiplier of 1.236, the total economic impact of these workers on the county in dollar terms is approximately $1.5 billion (1.236 x $1.2 billion). This is about 10.4 percent of the county's total economic activity. On a per-worker basis, the impact of each employee is approximately $1 million. As stated above, we can expect pharmaceutical manufacturing employees to have a substantial economic impact because of the high output per worker and the high value of products that are exported from the county. The economic activity generated by manufacturing employees contributes approximately $6.6 million in local taxes. On a per-worker basis, the impact on the local tax base is about $4,600 per employee.

While the overall impact results reveal the effect of manufacturing employment on the county, the per-worker impacts can be used to inform local development officials and politicians about changes in the local industry. For example, if a Solano County pharmaceutical manufacturer expects to hire 100 new employees, local economic activity would increase by approximately $107 million. Local tax revenue would increase by about $463,000 and local employment would increase by approximately 200 jobs.

[22] See: www.solanocounty.com/lifesciencecluster
[23] See: http://www.solanocounty.com/SubApp/SolanoIndex/website/index.html

Table 26: Economic Impact of Pharmaceutical and Medicine Manufacturing Employment on the Solano County Economy.

Impact Category (2010 Dollars)	Direct Effect	Multiplier	Total Economic Impact
Employment	1,427	2.014	2,874
Output ($)	$1,242,000,000	1.236	$1,535,000,000
Output Impact per Employee	–	–	$1,076,000
Local Tax Impact*	–	–	$6,603,000
Local Tax Impact per Employee	–	–	$4,627

Sources: Quarterly Census of Employment and Wages and IMPLAN (2010 dollars). * The county-level tax impact is based on business and residential property taxes and that portion of sales taxes that remain in the county.

Per worker Economic Impact of Biotechnology Research and Development Employment and Suggestions on How to Use the Impact Results

The data reported below indicate that another biotech R&D employee in Solano County contributes about $333,000 to the local economy. (Table 27) The tax impact per R&D worker is about $2,100 and the employment multiplier indicates that hiring another R&D worker creates a total of 1.7 jobs in the county. These data can be scaled. That is, if an employer in the county hires 100 more R&D workers, local economic activity will increase by approximately $3,330,000. Local taxes will increase by about $213,000 and total employment will increase by approximately 172 jobs.

Table 27: Economic Impact of Biotechnology Research and Development Employment on the Solano County Economy.

Impact Category (2010 Dollars)	Total Economic Impact
Output Impact per Employee	$333,000
Local Tax Impact per Employee*	$2,127
Employment Multiplier	1.718

Sources: Quarterly Census of Employment and Wages and IMPLAN. * The county-level tax impact is based on business and residential property taxes and that portion of sales taxes that remain in the county.

Solano: State-Level Economic Impact Results

Economic Impact of Pharmaceutical and Medicine Employment

The multipliers are larger for the state-level impact because larger economies do a better job of retaining, or capturing the spending that is induced by pharmaceutical employment. This means that manufacturing jobs in Solano support and create more additional jobs when the impact is measured at the state-level. For example, each manufacturing job supports an additional 3.958 jobs in California. Or, the 1,830 jobs in Solano County are responsible for about 9,073 in the state. (Table 28) As was the case with the county-level impact, we use the national weighted average ($870,700) for output per worker to determine the value of production for these workers. So, the corresponding dollar value of this level of employment is approximately $1.6 billion (1,830 x $870,700). The total impact of this level of production on the county economy is about $3.1 billion ($1.6 billion x 1.958). The impact of each Solano manufacturing worker on the state economy is about $1.7 million. The economic activity from the employment of these workers creates a total of $117 million in state and local taxes. The tax impact on a per-worker basis is approximately $64,000.

Table 28: Economic Impact of Solano County Pharmaceutical and Medicine Manufacturing Employment on the California Economy.

Impact Category (2010 Dollars)	Direct Effect	Multiplier	Total Economic Impact
Employment	1,830	4.958	9,073
Output ($)	$1,593,000,000	1.958	$3,120,000,000
Output Impact per Employee	–	–	$1,705,000
State and Local Tax Impact*	–	–	$117,120,000
State and Local Tax Impact per Employee	–	–	$64,000

Sources: Quarterly Census of Employment and Wages and IMPLAN. * The state and local tax impact is a comprehensive impact that is based on indirect business taxes (including sales and property taxes) as well as taxes collected from households, corporations, and employee compensation.

Suggestions on How to Use the State-Level Pharmaceutical Manufacturing Impact Results

The total results can be used to educate state-level officials regarding the impact of pharmaceutical manufacturing and biotech research in Solano on the California economy. The multipliers and per worker impacts can be used to inform interested parties about the consequences of changes in the industry. For example, if a Solano County pharmaceutical manufacturer expects to hire 100 new employees, the impact on the state will be about 500 more jobs. Or, if this firm experiences an increase of $1 million in sales, the impact on the state will be about $1.96 million. The 100 new workers will increase economic activity by approximately $170 million and state and local taxes will increase by about $6,400,000.

Per worker Economic Impact of Biotechnology Research and Development Employment and Suggestions on How to Use the Impact Results

The data reported below indicate that another biotech R&D employee in Solano County contributes about $500,000 to the local economy. (Table 29) The tax impact per R&D worker is about $24,000 and the employment multiplier indicates that hiring another R&D worker creates a total of 2.379 jobs in the county. These data can be scaled. That is, if an employer in the county hires 100 more R&D workers, state economic activity will increase by approximately $5,000,000. Local taxes will increase by about $2,400,000 and total employment will increase by approximately 240 jobs.

Table 29: Economic Impact of Solano County Biotechnology Research and Development Employment on the California Economy.

Impact Category (2010 Dollars)	Total Economic Impact
Output Impact per Employee	$500,000
State and Local Tax Impact per Employee*	$24,100
Employment Multiplier	2.379

Sources: Quarterly Census of Employment and Wages and IMPLAN. * The state and local tax impact is a comprehensive impact that is based on indirect business taxes (including sales and property taxes) as well as taxes collected from households, corporations, and employee compensation.

Ventura: County-Level Economic Impact Results

Economic Impact of Pharmaceutical and Manufacturing Employment

Public data are not available for pharmaceutical employment in Ventura County. Consequently, our impact analysis is based on data supplied by a major employer in the county (Company A). This company reports current employment of approximately 7,400. Eighty percent (5,920) are employed as biotech R&D workers and 20 percent (1,480) as pharmaceutical manufacturing employees. Seventy percent of these employees reside in Ventura County. So, our county-level impact is based on 1,036 manufacturing workers and 4,144 R&D employees. (Table 30) All impact results presented below are annual impacts.

The impact for 1,036 pharmaceutical and medicine manufacturing employees is reported below. The employment multiplier of 2.336 indicates that each manufacturing job in the county supports an additional 1.336 local jobs. Or, the total job impact of the 1,036 manufacturing workers is 2,420 total jobs in the county. We use the national weighted average ($870,700) for output per worker to determine the value of production for these Ventura County employees. So, the direct dollar value of the employment of 1,036 manufacturing workers is $900 million (1,036 x $870,700). With an output multiplier of 1.293, the total economic impact of these workers on the county in dollar terms is approximately $1.16 billion (1.293 x $902 million). This is about 3 percent of the county's total economic activity. On a per-worker basis, the impact of each employee is approximately $1.1million. As stated above, we can expect pharmaceutical manufacturing employees to have a substantial economic

impact because of the high output per worker and the high value of products that are exported from the county. The economic activity generated by manufacturing employees contributes approximately $5.5 million in local taxes. On a per-worker basis, the impact on the local tax base is about $5,300 per employee. Data from the California State Board of Equalization indicates that the state sales tax rate is equal to the Ventura County rate; consequently, the county does not retain a portion of sales taxes. So, the tax impacts reported above are based on local property taxes.

Table 30: Economic Impact of Company A Pharmaceutical and Medicine Manufacturing Employment on the Ventura County Economy.

Impact Category (2010 Dollars)	Direct Effect	Multiplier	Total Economic Impact
Employment	1,036	2.336	2,420
Output ($)	$902,000,000	1.293	$1,166,000,000
Output Impact per Employee	–	–	$1,125,000
Local Tax Impact*	–	–	$5,536,000
State and Local Tax Impact per Employee	–	–	$5,344

Sources: Quarterly Census of Employment and Wages and IMPLAN (2010 dollars). * The county-level tax impact is based on business and residential property taxes and that portion of sales taxes that remain in the county.

Impact of Biotechnology Research and Development Employment

The impact of biotechnology research and development employment is reported in the table below. The employment multiplier indicates that the 4,144 resident employees create and support a total of 7,842 jobs in the county. (Table 31) We use the national average ($210,000) for sales per worker to determine the value of output for these workers. So, the corresponding dollar value of the employment of 4,144 research workers is approximately $870 million (4,144 x $210,000). With an output multiplier of 1.587, the total impact is approximately $1.4 billion (1.587 x $870 million) representing about 3 percent of economic activity in Ventura County. On a per-employee basis, the impact of each worker is approximately $333,000. The economic activity associated with research and development employment generates about $10 million in tax revenue for the county. The tax impact per employee is $2,400.

Table 31: Economic Impact of Company A Biotechnology Research and Development Employment on the Ventura County Economy.

Impact Category (2010 Dollars)	Direct Effect	Multiplier	Total Economic Impact
Employment	4,144	1.892	7,842
Output ($)	$870,000,000	1.587	$1,381,000,000
Output Impact per Employee	–	–	$333,000
Local Tax Impact*	–	–	$9,973,000
Local Tax Impact per Employee	–	–	$2,400

Sources: Quarterly Census of Employment and Wages and IMPLAN. * The county-level tax impact is based on business and residential property taxes and that portion of sales taxes that remain in the county.

Impact of Company A Contract Employees

As mentioned previously, many pharmaceutical and biotech companies employ contract workers to provide food, security, and other services to the company. While these employees contribute to the economic impact of the firms, they are not included in the BLS employment categories for the bio-pharma industries. So omitting these employees yields impact measures that are too low. The exception is the impact for Venture County where contract employment is available. Company A employs approximately 2,000 contract employees to provide food, security, scientific and other services. (Table 32) The impact of these workers on the Ventura County economy is reported below. The employment multiplier indicates that these 2,000 contract jobs create and support a total of 2,339 jobs in the county. The corresponding impact in dollar terms is about $170 million, or $85,000 per worker. The economic activity associated with the employment of these workers creates an additional $2.3 million in local tax revenue, or about $1,100 per worker.

Table 32: Economic Impact of Company A Contract Employment on the Ventura County Economy.

Impact Category (2010 Dollars)	Direct Effect	Multiplier	Total Economic Impact
Employment	2,000	1.170	2,339
Output ($)	$119,215,000	1.428	$170,226,000
Output Impact per Employee	–	–	$85,000
Local Tax Impact*	–	–	$2,254,500
Local Tax Impact per Employee	–	–	$1,130

Sources: Quarterly Census of Employment and Wages and IMPLAN. * The county-level tax impact is based on business and residential property taxes and that portion of sales taxes that remain in the county.

Combined Impact of Pharmaceutical and Medicine Manufacturing, Biotechnology Research and Development, and Contract Employment on the Ventura County Economy

The combined impact of pharmaceutical manufacturing and research jobs on the Ventura County economy is approximately $2.7 billion. This is approximately 7% of county economic activity. The combined impact in terms of employment is about 12,600 local jobs which is approximately 3 percent of total employment for the county. This economic activity generates approximately $17.7 million in property taxes. Data from the California State Board of Equalization indicates that Ventura County's sales tax rate is the same as the state rate. Consequently, the measured local tax impact is based on local property taxes.

Suggestions on How to Use the County-Level Impact Results

The total impacts described above are of use in educating the public, local economic development officials, and local politicians about the importance of pharmaceutical manufacturing and biotechnology research employment to the Ventura County economy. The multipliers and per-worker impacts can be used to provide information regarding changes to the industry in the future. These multipliers are specific to the respective industry and to Ventura County and can be used to estimate the impacts of changes in employment or sales. These impacts can be measured by multiplying the employment (or output) change by the appropriate multiplier. For example, if Company A hires 100 new biotech R&D employees, the impact on local employment will be about 190 more jobs, county-wide. The output multiplier can be used to estimate the impact on the economy of an increase in research activity by the

company. For example, if Company A expects sales to increase by $1,000,000, the impact on the Ventura economy will increase by a multiple of 1.587, or about $1.59 million. Multipliers are can be applied to positive or negative changes. That is, if Company A decreases employment by 100 R&D workers, local employment will decrease by approximately 190 jobs.

The per-worker impacts can be used in a similar way. For example, if pharmaceutical manufacturing employment is expected to increase by 100 workers, the impact on the county economy will be about $112.5 million. The corresponding tax impact of the 100 new manufacturing employees will be about $534,000. The multipliers and per-worker impacts will change over time as prices and the productivity of pharmaceutical manufacturing workers change. So, the use of these results will be most accurate within a few years of this study.

Ventura: State-Level Economic Impact Results

Economic Impact of Pharmaceutical and Medicine Manufacturing Employment

The multipliers are larger for the state-level impact because larger economies do a better job of retaining, or capturing the spending that is induced by pharmaceutical employment. This means that manufacturing jobs in Ventura support and create more additional jobs when the impact is measured at the state-level. For example, each manufacturing job supports an additional 3.959 jobs in California. Or, the 1,480 jobs in Ventura County are responsible for about 7,339 in the state. (Table 33) We use the national weighted average ($870,700) for output per worker to determine the value of production for these workers. So, the corresponding dollar value of 1,480 employees is approximately $1.3 billion (1,480 x $870,700). The total impact of this level of production on the state economy is about 2.5 billion ($1.3 billion x 1.958. The impact of each Ventura manufacturing worker on the state economy is about $1.7 million. The economic activity from the employment of these workers creates a total of $95 million in state and local taxes. The tax impact on a per-worker basis is approximately $64,000.

Table 33: Economic Impact of Company A Pharmaceutical and Medicine Manufacturing Employment on the California Economy.

Impact Category (2010 Dollars)	Direct Effect	Multiplier	Total Economic Impact
Employment	1,480	4.959	7,339
Output ($)	$1,289,000,000	1.958	$2,524,000,000
Output Impact per Employee	–	–	$1,705,000
State and Local Tax Impact*	–	–	$94,748,000
State and Local Tax Impact per Employee	–	–	$64,000

Sources: Quarterly Census of Employment and Wages and IMPLAN (2010 dollars). * The state and local tax impact is a comprehensive impact that is based on indirect business taxes (including sales and property taxes) as well as taxes collected from households, corporations, and employee compensation.

Impact of Biotechnology Research and Development Employment

Because multipliers are larger for larger economies, the impact of research workers on the state economy is larger than the county impact. For example, the employment multiplier of 2.776 indicates that each research job in Ventura supports another 1.776 other jobs in the state. The total number of jobs created by the 5,920 biotech research workers employed in the county is about 16,000 state-wide. (Table 34) We use the national weighted average ($210,000) for output per worker to determine the value of production for these workers. So, the value of output for the 5,920 R&D workers is $1.2 billion (5,920 x $210,000). The dollar value of this impact is approximately $2.9 billion ($1.2 billion x 2.379). The impact per worker is $500,000. The corresponding impact on total state and local taxes is about $142 million, or $24,000 per employee.

Table 34: Economic Impact of Company A Biotechnology Research and Development Employment on the California Economy.

Impact Category (2010 Dollars)	Direct Effect	Multiplier	Total Economic Impact
Employment	5,920	2.776	16,431
Output ($)	$1,243,000,000	2.379	$2,957,000,000
Output Impact per Employee	–	–	$500,000
State and Local Tax Impact*	–	–	$142,660,000
Local Tax Impact per Employee	–	–	$24,100

Sources: Quarterly Census of Employment and Wages and IMPLAN (2010 dollars). The state and local tax impact is a comprehensive impact that is based on indirect business taxes (including sales and property taxes) as well as taxes collected from households, corporations, and employee compensation.

Impact of Biotechnology Contract Employment

Company A also employs approximately 2,000 contract employees that provide food, security, and other services. The impact of these workers on the Ventura County economy is described below. The employment multiplier of 1.356 suggests that each contract job supports another 0.3 more jobs in the county, or that these 2,000 jobs create and support an additional 2,713 total county jobs. (Table 35) The economic impact associated with this level of employment is approximately $250 million, or $125,000 per worker. This economic activity associated with the employment of these workers contributes an additional $14.5 million in local tax revenue. The tax contribution per contract job at Company A is approximately $7,300.

Table 35: Economic Impact of Company A Contract Employment on the California Economy.

Impact Category (2010 Dollars)	Direct Effect	Multiplier	Total Economic Impact
Employment	2,000	1.356	2,713
Output ($)	$119,215,000	2.093	$249,540,000
Output Impact per Employee	–	–	$124,800
State and Local Tax Impact	–	–	$14,534,000
Local Tax Impact per Employee	–	–	$7,300

Sources: Quarterly Census of Employment and Wages and IMPLAN. * The state and local tax impact is a comprehensive impact that is based on indirect business taxes (including sales and property taxes) as well as taxes collected from households, corporations, and employee compensation.

Combined Impact of Ventura County Pharmaceutical and Medicine Manufacturing, Biotechnology Research and Development, and Contract Employment on the California Economy

The combined impact of Ventura pharmaceutical manufacturing, biotech research, and contract employment on the state economy is approximately 26,500 jobs (about 0.1 percent of the state's total employment), or about $5.5 billion (or 0.2 percent of California's GDP), and $252 million in state and local taxes.

Suggestions on How to Use the State-Level Impact Results

The total results can be used to educate state-level officials regarding the impact of pharmaceutical manufacturing and biotech research on the California economy. As was the case above, the multipliers

and per worker impacts can be used to inform interested parties about the consequences of changes in the industry. For example, if Company A expects to hire 100 new R&D employees, the impact on the state will be about 280 more jobs, state-wide. Or, if this firm experiences and increase of $1 million in R&D sales, the impact on the state will be about $2.38 million, in terms of GDP. The 100 new workers will increase and local taxes will increase by about $2,410,000.

California: Overall Industry-Level Economic Impact of Pharmaceutical and Medicine Manufacturing and Biotechnology Employment on the California Economy

Economic Impact of Pharmaceutical and Medicine Manufacturing Employment

Between 2002 and the second quarter of 2009, average pharmaceutical manufacturing employment in the state averaged 41,939 which is approximately 3 percent of total manufacturing employment in the state. Most of these workers are employed in pharmaceuticals preparation manufacturing (31,045), followed by in-vitro diagnostic substances (4,939), biological product manufacturing (3,391), and pharmaceutical medicine manufacturing (2,564).

Since some of these workers produce medicine that is consumed by California consumers, we adjust total employment for the amount of manufacturing output that is exported from the state.[24] With this adjustment there are 36,906 pharmaceutical manufacturing workers engaged in producing medicines that are exported out of California. (Table 36) The economic impact results presented below are based on the distribution of employment across the 4 manufacturing sectors, with the adjustments for export employment described above. All impact results presented below are annual impacts.

Table 36: Overall Industry-Level Economic Impact of Pharmaceutical and Medicine Manufacturing Employment on California.

Impact Category (2010 Dollars)	Direct Effect	Multiplier	Total Economic Impact
Employment†	36,906	5.298	195,546
Output	$33,003,000,000	2.008	$66,270,000,000
Output Impact per Employee	–	–	$1,796,000
State and Local Tax Impact†	–	–	$2,601,825,000
Local Tax Impact per Employee	–	–	$70,500

[24] We adjust total employment by the ratio of California to national population (12%), assuming that Californians consume pharmaceuticals at the national rate.

Sources: Quarterly Census of Employment and Wages and IMPLAN (2010 dollars). † employment adjusted for export jobs. * The state and local tax impact is a comprehensive impact that is based on indirect business taxes (including sales and property taxes) as well as taxes collected from households, corporations, and employee compensation.

The employment multiplier of 5.298 indicates that, state-wide, each pharmaceutical manufacturing job supports about 4.3 other jobs in California, or the creation of one more manufacturing job is associated with about 5.3 more jobs in the state. We use the national weighted average ($870,700) for output per worker to determine the value of production for these workers. So, the direct value of the 36,906 manufacturing workers is approximately $33 billion (36,906 x $870,700). With an output multiplier of 2.008, the total economic impact of these workers on the state's economy is approximately $66.3 billion ($33 billion x 2.008). This is approximately 3.4% of California GPD and this impact can be attributed to about 0.1% of the state's employment. The impact of pharmaceutical workers is large because the value of output that is exported from the state is high. For example, the impact per worker is approximately $1.8 million. The economic activity associated with state-wide pharmaceutical manufacturing contributes about $2.6 billion in combined state and local taxes. On a per-worker basis the impact on state and local taxes in California is approximately $70,000 per worker.

Economic Impact of Biotechnology Research and Development Employment

Between 2002 and the second quarter of 2009, the average level of employment in biotechnology research and development in California is 20,598. Some of these employees develop pharmaceutical products that are ultimately consumed in the state. To identify those R&D workers involved in export activity, we adjust the total employment figure.[25] So, the impact for this sector is based on 18,126 R&D employees. (Table 37)

The impact results for the state total R&D employment are reported in the table below. The employment multiplier of 2.776 indicates that another R&D job created in the state is associated with a total of approximately 2.8 total jobs. We use the national average sales per R&D worker ($210,000) to calculate the dollar equivalent of the state's employment of these employees. So, the direct output value of these workers is about $3.8 billion (18,126 x $210,000). With an output multiplier of 2.379, the total economic impact for this sector is approximately $9 billion (2.376 x $3.8 billion). The impact per R&D worker is about $500,000. The economic activity associated with R&D employment creates approximately $454 million in state and local taxes. The tax impact per employee is about $25,000 in combined state and local taxes.

[25] As was the case with pharmaceutical manufacturing workers, the adjustment is based on California's population relative to the U.S. (12 percent).

Table 37: Overall Industry-Level Economic Impact of Biotechnology Research and Development Employment on California.

Impact Category (2010 Dollars)	Direct Effect	Multiplier	Total Economic Impact
Employment†	18,126	2.776	50,310
Output	$3,806,460,000	2.379	$9,054,828,000
Output Impact per Employee	–	–	$499,500
State and Local Tax Impact*	–	–	$453,909,000
Local Tax Impact per Employee	–	–	$25,000

Sources: Quarterly Census of Employment and Wages and IMPLAN (2010 dollars). † employment adjusted for export jobs. * The state and local tax impact is a comprehensive impact that is based on indirect business taxes (including sales and property taxes) as well as taxes collected from households, corporations, and employee compensation.

Combined Impact of Pharmaceutical and Medicine Manufacturing and Biotechnology Employment on the California Economy

The combined impact of pharmaceutical manufacturing and research jobs is approximately $75 billion. This is about 4 percent of California GDP. The combined employment impact is approximately 245,000 jobs. This is about one percent of the state total. These sectors contribute approximately $3 billion in state and local tax revenue.

Suggestions on how to Use the State-Level Impact Results

The total impacts described above are of use in educating the public, state-level economic development officials, and politicians about the importance of the pharmaceutical manufacturing and biotechnology R&D to the state's economy. The multipliers and per-worker impacts can be used to provide information regarding changes to the industry in the future. The multipliers are specific to the respective industry and to California and can be used to estimate impacts of changes in employment, or industry output. For example, if 100 new pharmaceutical manufacturing employees are to be hired in the state, the total employment impact will be approximately 540 jobs. State and local taxes would increase by approximately $7 million. Multipliers are also applicable to negative changes in output and employment. For example, if 100 R&D workers are laid off, industry output would decrease by approximately $50 million and state and local taxes would decrease by about $2.5 million.

Indirect, or Supplier Effects and Industry Cluster Analysis: Pharmaceutical Manufacturing

In this section we describe the supply relations between pharmaceutical manufacturers and between manufacturers and the biotech research and development industry. As mentioned above, the input-output features of IMPLAN provide the backward or supply linkages between industries. This indirect effect of the impact study identifies the suppliers to pharmaceutical manufactures and R&D firms. The results for the four subcategories of pharmaceutical manufacturers are presented in the table below. The results are based on the state-level ranking of suppliers. The rankings for the five counties vary from location to location, but the state-level examination reveals the general trend in supply relations. To identify the supply relationships, we stimulated each sector separately with a hypothetical $1 million increase in sales. For example, the results of this simulation indicate that each million dollar increase in sales is associated with a total indirect effect in medical and botanical manufacturing of roughly $620,000 (columns 1 and 2 in Table 38). The leading supplier to the medical and botanical manufacturing industry is the wholesale trade business that represents approximately 20 percent of the total indirect, or supplier effect. What is noteworthy of this sector, and of all the other manufacturing categories, is the supply relationship between pharmaceutical manufactures and between manufactures and the biotech research and development industry. For example, biological product manufacturing contributes 11.7 percent to the supply chain of medical and botanical manufacturing. Additionally, scientific research and development services (this category includes biotech R&D) contribute roughly 6.5 percent, pharmaceutical preparation manufacturing consists of 6.3 percent, and medical and botanical manufacturing relies on its own industry for 4.5 percent of to total supply effect. In sum, the $1 million increase in sales in medicinal and botanical manufacturing is associated with an indirect, or supplier impact on the pharmaceutical industry of approximately $179,000. This industry also spends approximately $5,300 on maintenance and repair construction. This represents about 0.8 percent of the supply expenditures for this sector of the pharmaceutical manufacturing sector.

Table 38: Top Ten Suppliers for Pharmaceutical and Medicine Manufacturing: Indirect Effects.

Medical and Botanical	Indirect Effect	Pharmceutical Preparation	Indirect Effect	In-vitro Diagnostic Substance	Indirect Effect	Biological Product	Indirect Effect
Total	$617,873	Total	$614,249	Total	$809,544	Total	$805,717
Wholesale trade businesses	$122,809	Pharmaceutical preparation manufacturing	$87,385	Pharmaceutical preparation manufacturing	$117,948	Wholesale trade businesses	$131,653
Biological product (except diagnostic) manufacturing	$72,089	Management of companies and enterprises	$81,658	Management of companies and enterprises	$111,455	Management of companies and enterprises	$105,465
Management of companies and enterprises	$66,317	Wholesale trade businesses	$78,401	Scientific research and development services	$65,759	Biological product (except diagnostic) manufacturing	$95,182
Scientific research and development services	$39,711	Scientific research and development services	$42,295	Wholesale trade businesses	$61,386	Pharmaceutical preparation manufacturing	$86,504
Pharmaceutical preparation manufacturing	$39,049	Petroleum refineries	$21,721	Biological product (except diagnostic) manufacturing	$38,530	Scientific research and development services	$61,622
Petroleum refineries	$38,734	Biological product (except diagnostic) manufacturing	$18,113	Lessors of nonfinancial intangible assets	$34,493	Management, scientific, and technical consulting services	$22,974
Medicinal and botanical manufacturing	$27,925	Medicinal and botanical manufacturing	$18,028	All other miscellaneous professional, scientific, and technical services	$27,776	Real estate establishments	$20,956
Real estate establishments	$13,483	Cable and other subscription programming	$17,082	Real estate establishments	$25,973	Telecommunications	$16,302
Telecommunications	$9,105	Management, scientific, and technical consulting services	$16,678	Management, scientific, and technical consulting services	$24,026	Cable and other subscription programming	$15,393
Cable and other subscription programming	$7,437	Other basic organic chemical manufacturing	$14,228	Telecommunications	$21,472	Petroleum refineries	$14,194

Source: IMPLAN. Based on a state-wide $1million sales increase for each sector.

A similar trend is present for pharmaceutical preparations manufacturing (columns 3 and 4 in Table 38). The results presented above indicate that the leading supplier to this industry is the industry itself, or pharmaceutical preparation manufacturing comprises 14.2 percent of the indirect effect for this manufacturing sector. Scientific research and development services consist of about 7 percent and biological product manufacturing and medicinal and botanical manufacturing each contribute 3 percent. In sum, the $1 million increase in sales in pharmaceutical preparation manufacturing is associated with an indirect, or supplier impact on the pharmaceutical industry of approximately $166,000. This industry also spends approximately $4,500 on maintenance and repair construction. This represents about 0.7 percent of the supply expenditures for this sector of the pharmaceutical manufacturing sector.

Pharmaceutical preparations manufacturing is also the leading supplier to in-vitro diagnostic manufacturing (columns 5 and 6), making up 14.5 percent of the indirect effect. Scientific research and development contributes 8.1 percent while biological product manufacturing is also a supplier with 4.8 percent. The million dollar increase in sales for in-vitro diagnostic substance manufacturing is associated with an increase in purchases within pharma manufacturing and biotech R&D of approximately $222,000. This industry also spends approximately $5,000 on maintenance and repair construction. This represents about 0.6 percent of the supply expenditures for this sector of the pharmaceutical manufacturing sector. A $1 million increase in sales of biological product manufacturing is associated with an industry supply increase of $243,000 (columns 7 and 8). This industry also relies on itself for 11.8 percent of its supply. Pharmaceutical preparations manufacturing contributes 10.8 percent and scientific R&D contributes 7.7 percent to total supply effect for this industry. The biological product manufacturing industry also spends approximately $6,300 on maintenance and repair construction. This represents about 0.7 percent of the supply expenditures for this sector of the pharmaceutical manufacturing sector. The supply relations described above have important implications for the development and growth of pharmaceutical clusters. For those readers who are unfamiliar with the concept of an industry cluster, we provide a brief description below and then illustrate how the data reported above can be used to explain the characteristics of the pharmaceutical manufacturing and biotech research and development clusters.

Michael Porter introduced the concept of an industry cluster in his 1990 book*, The Competitive Advantage of Nations* where a cluster is identified as a concentration of inter-connected companies and institutions in a region. It is helpful to use Porter's notion of the "Diamond of Competitive Advantage" to illustrate the components of a cluster and show how the cluster grows as firms interact. The four components of the diamond are: 1) demand by customers for innovative, cutting-edge products; 2) firms strategies and rivalries 3) supply relations with providers of specialized inputs such as machinery, components, or infrastructure and; 4) relations with supporting industries such as universities, trade associations, or vocational training providers that offer research information and technical support to firms in the cluster.

What drives the cluster is the demand for new, innovative products and the response by firms in the industry. Competition forces firms to innovate, develop new knowledge, skills, and business spin-offs. Because of the inter-connectedness in the cluster, the creation of new knowledge by one firm confers advantages to all firms in the industry and region, even if companies are competitors. As firms grow, so

do the other aspects of the cluster. Suppliers of specialized inputs and supporting industries develop stronger ties to the industries in the cluster. The concept of an industry cluster is a useful way to explain the relations between firms and suppliers in the pharmaceutical industry. This industry is driven by demands from the health care industry for innovative products; firms compete and develop new knowledge that is spread across the industry. The relations with supporting institutions and universities grow as does the relationship with suppliers such as the construction industry.

Our discussion of the supply relations among pharmaceutical manufacturers, described above, provides an opportunity to explore the specific supply characteristics of the manufacturing cluster. This examination provides insight into what is needed to "grow a cluster" in pharmaceutical manufacturing. For example, the data for the top ten suppliers to the manufacturing sector indicate that the wholesale trade business and the management of companies and enterprises are important suppliers to all four of the manufacturing sub-categories. To a lesser extent, the pharmaceutical manufacturing industry relies on real estate establishments, telecommunications (including cable and subscription programming), and petroleum refineries as suppliers. It is important that these industries are present for the growth of the pharmaceutical manufacturing cluster.

Each of the pharmaceutical manufacturing sectors relies on other aspects of this industry and industries related to scientific research and management. For example, medicinal and botanical manufacturing uses the output of its own industry and from the biological product and pharmaceutical preparation manufacturing industries as well. This sector also uses scientific research and development services. Pharmaceutical preparation manufacturing uses manufacturing output from its own industry and from biological product and medicinal and botanical manufacturing. This sector also uses the services of scientific research and development as well as other scientific services such as the management and technical consulting industry. In-vitro diagnostic substance manufacturing uses pharmaceutical preparation and biological product manufacturing industries as suppliers. Additionally, this sector uses the services of scientific research and development as well as other scientific and management consulting industries. Credit availability is also an important supply consideration for in-vitro diagnostic substance manufacturing. Like many of the other pharmaceutical manufacturers, biological product production relies on its own industry for supplies, as well as the pharmaceutical preparation sector. This sector also relies on biotech research and development and the services of other scientific and consulting firms. These results suggest that the pharmaceutical manufacturing industry cluster relies largely on itself as a supply source. This may explain why it is difficult to establish and grow this type a cluster as these supply relations must also be present and established.

Our interviews with pharmaceutical manufacturers reveal that while these inter-industry relations are important for the growth of the cluster, it is not vital that the various manufacturers be in close proximity to one another. The supply relations can be efficiently conducted over distance. Additionally, there do not appear to be labor market advantages related to the proximity of manufacturing employers. The location decision of pharmaceutical manufacturing firms is generally influenced by local incentives and tax breaks. There is some evidence that the proximity of a strategic partner is important when considering location. Also, small pilot manufacturing plants tend to locate near biotech R&D establishments during early stages when all parties involved are learning how to produce the

pharmaceutical product. However, in general, the manufacturing facilities are geographically dispersed. As described previously, only 37 percent of Californian pharmaceutical manufacturing employment is located in the five principle counties we examine.

Indirect, or Supplier Effects and Industry Cluster Analysis: Biotechnology Research and Development

The top ten suppliers to the biotechnology research and development industry are reported below in Table 39. These results indicate that the construction and building-related industries are important to the development of the biotech R&D cluster. For example, when biotech R&D experiences an increase in sales, real estate establishments, building services, maintenance and repair construction, and architectural and engineering services receive about 19 percent of the total indirect effect. This suggests that the building industry is an important supplier to the biotech R&D cluster. Other important suppliers are professional, scientific, technical services as well as legal and employment services. Telecommunications are also an important contributor to the cluster.

Table 39: Top Ten Suppliers for Biotechnology Research and Development: Indirect Effects.

Biotechnology Research and Development	Indirect Effect	Percent of Total Indirect Effect
Total	$505,259	100%
Real estate establishments	$37,178	7.40%
All other miscellaneous professional, scientific, and technical services	$35,293	7.00%
Management, scientific, and technical consulting services	$22,720	4.50%
Services to buildings and dwellings	$22,492	4.50%
Telecommunications	$19,589	3.90%
Maintenance and repair construction of nonresidential structures	$19,011	3.80%
Monetary authorities and depository credit intermediation activities	$18,959	3.80%
Architectural, engineering, and related services	$18,466	3.70%
Legal services	$16,519	3.30%
Employment services	$15,646	3.10%

Source: IMPLAN. Based on a state-wide $1million sales increase.

Providers of infrastructure are one of the important suppliers to a cluster. This is particularly the case with the biotech R &D cluster. Our interviews with representatives from bay area construction companies and locals for the Sheet Metal Workers, International Brotherhood of Electrical Workers (IBEW), and the United Association of Plumbers and Pipe Fitters (UA) illustrate the interconnectedness between the building trades and the pharmaceutical industry, particularly biotech research and development. Sheet metal work for R&D labs is similar to kitchen equipment work and involves the

installation of stainless steel tops, sinks, and counters. Electricians perform duties such as routing conduit in clean rooms and installing instrumentation and control panels. Pipe fitters do duct work and orbital welding. Many of the locals explained a "PLA-like" arrangement with the industry where many of the usual contractual arrangements are relaxed and flexibility provides a basis for consistent employment and uninterrupted work on projects.

In the pharma and biotech industries downtime due to faulty construction is devastating as production stops and costs rise. These consequential damages are a concern to all parties involved in building pharma infrastructure and this concern feeds back for a need for care and expertise in building. These efforts have resulted in a litigation rate in pharma-related construction that is below the average for the construction industry. The relation between the United Association of Plumbers and Pipefitters Local 467 and Genentech in San Mateo County illustrates the ties between the industry and the trade unions that have developed due to a concern over construction quality. This local does pipe fitting work in R&D labs and at pharmaceutical production facilities. Faulty pipe fitting in clean rooms or at production facilities is particularly devastating and costly. Consequently, weld failure rates must be below one percent. UA apprentice pipe fitters receive 6 months of rudimentary training in welding and an additional 6 months of training with the orbital welding equipment used in connecting pipes. The orbital welding performed at a pharma facility must meet high standards for cleanliness and requires the skills to set up the orbital welders for different pipe sizes and different programs. This is clean, high-tech work for these pipe fitters and the work is performed in a high-tech environment. UA local 467 has developed a unique relation with Genentech through on-going work at the facility in San Mateo County. The best workers are retained after the completion of a project with some pipe fitters spending 20 to 25 years working at the Genentech campus. In essence, UA local 467 and Genentech "grew up" together. When Genentech introduces a new process that requires unique pipe fitting, the UA local provides the training. The local tends to work directly with Genentech as contractors come and go. The local will also assist the company with the building permit process.

Our interviews with the building trades reveal their importance in the functioning of the biotech R&D cluster. Our interviews also reveal that it is important for R&D establishments to locate near one another for labor supply reasons. For example, biotech research firms in San Diego enjoy the benefit of a large supply of trained researchers who can more from one job to another without significant relocation costs. On the other hand, Amgen is relatively isolated in Ventura County and faces significant relocation costs when hiring additional R&D employees. It is important for research scientists to locate near a critical mass of other R&D workers. When a pharmaceutical product is not approved, research scientists are not moved to work on another product within the firm, but are typically released instead. Therefore, these workers face higher unemployment risks and reside in areas where they can move between employers easily. Consequently, there is an advantage to R&D firms to also locate in areas with access to R&D labor supply. This is not a concern for the pharmaceutical manufacturers. Once the product has been approved, it can be produced anywhere. Labor supply proximity is not an issue and location decisions for these firms are influenced by local incentives and tax breaks.

Small biotech R&D establishments locate close to the concentrated centers of the industry to take advantage of agglomerative effects such a proximity to scientist labor supply, construction expertise,

strategic partnerships, and venture capitalists. It is important to locate R& D facilities near the construction industry that specializes in this field to facilitate the FDA approval process. Since the financial crisis, it is more important for firms to locate near strategic partners than near venture capitalists. All of these factors outweigh property cost factors related to location.

Economic Impact of Building Pharmaceutical Infrastructure: Six Case Studies.

Previous analysis has focused on the economic impact of operating pharmaceutical and R&D facilities. In this section we describe the impact of building pharmaceutical infrastructure. We use recent examples of construction activity as case studies to illustrate topics of interest to the industry and to local economic development officials. These include:

- The impact on a local economy of building a manufacturing facility under a project labor agreement with a local hire requirement.
- The impact on the California economy of the construction of a large pharmaceutical manufacturing facility.
- The impact of building a small research and development facility on a local economy.
- The impact on the California economy of the construction of a small research and development facility.
- The impact associated with the employment of construction workers engaged in on-going maintenance and renovation work at an established manufacturing facility.
- The expected impact of the construction of a manufacturing facility on the state and county economy, if the facility had been built in California, instead of Ohio. This analysis also includes the potential impact and economic development consequences of operating this facility in a distressed, rural California county.

The Local Economic Impact of a Project Labor Agreement with Local Hire Provisions: An Illustration from the Construction of a Solano County Pharmaceutical Manufacturing Facility.

We use the second phase of the construction of the pharmaceutical manufacturing facility in Solano County to illustrate the economic impact of labor agreements that increase the employment of local construction workers. These agreements are associated with more local spending as construction workers dispose of their income in the area economy. This impact is measured by examining the induced effect associated with the disposal of income in the county.

The second phase of the construction project in Solano County was started in 2004 and completed in 2006. This is a separate building that initially utilized operating engineers and carpenters, and then finished with the mechanical trades. Pipefitters performed much of the work on the final stage. The project cost $900 million ($976 million, 2010 dollars) and employed 1,200 construction workers at the peak of construction. Average wage rates on this project ranged from $37 to $38 per hour ($45 to $50

with benefits). The project owner was time and quality sensitive and requested that the project be completed under a PLA. This agreement further stipulated that 90 percent of the work was to be completed by Solano County construction workers. Accordingly, 90 percent of the workers were Solano County residents with the remaining 10 percent coming from Alameda, Contra Costa, and Sacramento Counties.

To illustrate the economic benefit of PLA and local hire agreements on the Solano County economy, two impacts are estimated. (Table 40) The first is based on the actual use of 90 percent local union construction workers and the second impact is based on the use of union labor, but with 30 percent local workers. Thirty percent is the typical amount of local labor if the PLA did not include the local hire agreement. These impacts are reported in the table below.

Table 40: Economic Impact of the Construction of the Solano County Pharmaceutical Manufacturing Facility

Percent Local Construction Workers	Output Impact on Local Retail and Service Sectors	Employment Impact (Induced)	Local Sales Tax Impact
90 Percent Local Construction Workers	$101,067,000	752	$62,900
30 Percent Local Construction Workers	$30,309,000	226	$18,900

Source: IMPLAN, 2010 dollars. Impact results are based on a labor income analysis.

The results (Table 40) indicate that the impact on the county economy is substantially larger when the PLA also stipulates a local hire arrangement. The output, employment, and tax impacts associated with the disposal of construction worker income are approximately 3.3 times larger under the PLA-local hire agreement. For example, overall county economic activity is about $101 million when 90 percent of building is completed by Solano County construction workers. If 30 percent of the work is completed by resident union workers (with the remaining completed by out-of-county union workers), the impact on Solano is only $30 million. About 525 more local retail and service jobs are created by the spending of construction workers when a higher percent of construction is completed by county residents. Finally, when more income is spent in the county, more local tax revenue is generated. Our data indicate that when 90 percent of the work on this project was completed by resident construction workers, local sales taxes were higher by about $44,000. This is a conservative tax estimate as it does not include other taxes and fees that increase with local spending and economic activity.

The impact described above is an induced impact associated with the spending of construction labor income in the Solano County retail and service industries. The table below lists the specific industries that are affected by the spending of construction labor income. The data report the level of employment in the top 20 industries when 90 percent, versus 30 percent of the construction is completed by resident construction workers. The total number of Solano County retail and service

sector jobs when 90 percent of the work is completed by resident workers is 752, versus 226 when 30 percent of the work is completed by resident workers. County construction workers spend their income on local services and retail items including restaurants, health care, and various retail items. The data indicate that employment in these industries is higher when more local construction workers are used. For example, employment in the Solano County restaurant industry was higher by about 56 jobs when the project was built under the PLA-local hire agreement.

Table 41: Employment Impact by Industry: With 90 Percent Local Construction Workers and 30 Percent Local Construction Workers

Solano County Industry	90% Local Construction Workers	30% Local Construction Workers
Total	752.1	225.5
Food services and drinking places	79.9	24.0
Private hospitals	43.8	13.1
Real estate establishments	38.8	11.6
Offices of physicians, dentists, and other health practitioners	38.7	11.6
Retail Stores - General merchandise	37.7	11.3
Retail Stores - Food and beverage	32.8	9.8
Nursing and residential care facilities	28.5	8.6
Retail Stores - Clothing and clothing accessories	24.7	7.4
Retail Nonstores - Direct and electronic sales	23.3	7.0
Wholesale trade businesses	22.9	6.9
Private household operations	21.1	6.3
Retail Stores - Motor vehicle and parts	20.5	6.1
Retail Stores - Miscellaneous	14.4	4.3
Individual and family services	14.2	4.3
Medical and diagnostic labs and outpatient and other ambulatory care services	12.7	3.8
Grantmaking, giving, and social advocacy organizations	12.4	3.7
Retail Stores - Building material and garden supply	12.2	3.7
Automotive repair and maintenance, except car washes	11.4	3.4
Personal care services	11.4	3.4
Child day care services	11.2	3.4

Source: IMPLAN, labor income analysis

Suggestions on How to Use the Local Hire Impact Results

The results presented above indicate that the economic impact associated with the local spending of construction worker income is 3.3 times greater with the PLA-local hire arrangement compared to a more typical arrangement where 30 percent of the workers are local. It is important to keep in mind that the Solano County pharmaceutical manufacturing facility would be built with union labor, and union wage and benefit rates, regardless of the local hire agreement. So, there is no reason to expect a difference in labor costs to the project owner if the structure is built with or without the local hire agreement. But, this arrangement makes a significant difference to the county in which the project is built as the local hire arrangement funnels more spending, job creation and tax revenue into the region. Also, the local retail and service industries may not be aware on how they benefit from local hire agreements in construction.

The Economic Impact of Building Pharmaceutical Infrastructure on the California Economy: The Case of a Large Pharmaceutical Manufacturing Facility.

The second phase of the construction project in Solano County is used to illustrate the impact of building a large pharmaceutical manufacturing facility of the California economy. (Table 42) As described above this facility is the second phase that was started in Solano County in 2004 and completed in 2006. The project cost $900 million ($976 million, 2010 dollars) and employed 1,200 construction workers at the peak of construction.

The economic impact results reported below indicate that the employment of 1,200 construction workers during this project created and supported a total of 6,755 total jobs in the state. The employment multiplier (5.629) is large and indicates when a facility of this size is built; each job associated with the building of the project supports and creates a total of about 5.6 total jobs in California. The total economic activity associated with the construction of the facility is approximately $2 billion, or 1.7 million per construction worker. State and local tax revenue increased by approximately $21 million as a result of this construction project, or about $17,000 per construction job.

Table 42: Economic Impact of Building Phase Two of the Solano County Pharmaceutical Manufacturing Facility on the California Economy.

Impact Category (2010 Dollars)	Direct Effect	Multiplier	Total Economic Impact
Construction Employment	1,200	5.629	6,755
Value of Construction	$976,000,000	2.031	$1,982,120,000
Impact per Construction Employee	–	–	$1,652,000
State and Local Sales Tax Impact	–	–	$20,612,000
State and Local Sales Tax Impact per Construction Employee	–	–	$17,180

Sources: IMPLAN (2010 dollars).

The Economic Impact of Building Pharmaceutical Infrastructure on the San Mateo County and California Economies: The Case of a Small Biotechnology Research and Development Facility.

Impact on San Mateo County

A small biotechnology research and development facility was recently completed in San Mateo County. The total cost of this facility was approximately $40 million (2010 dollars). About 100 construction workers were involved in the building of the shell with another 350 involved with the build-out of the facility. All work was completed by San Mateo County construction workers. The impact results are reported below. (Table 43) The employment of 450 construction workers involved with this project was associated with the creation of a total of 516 jobs in San Mateo County. In dollar terms, the construction of the $40 million dollar facility was associated with an overall increase in county-level economic activity of approximately $52 million. With this heightened economic activity local sales taxes increased by about $48,000, or about $110 per construction job.

Table 43: Economic Impact of Building a Research and Development Facility on San Mateo County

Impact Category (2010 Dollars)	Direct Effect	Multiplier	Total Economic Impact
Construction Employment	450	1.147	516
Value of Construction	$40,000,000	1.297	$51,871,000
Impact per Construction Employee	–	–	$115,300
Local Sales Tax Impact	–	–	$48,300
Local Sales Tax Impact per Construction Employee	–	–	$110

Sources: IMPLAN (2010 dollars).

Impact of the California Economy

The impact of building this $40 million biotechnology research and development facility on the state economy is described below. (Table 44) The state-level impact results indicate that the 450 construction jobs directly involved in the project created and supported a total of 706 jobs in California. In dollar terms, the impact of building this facility is approximately $85 million and associated with an increase in state and local sales tax revenue of about $950,000. The tax impact per worker is approximately $2,000.

Table 44: Economic Impact of Building a Research and Development Facility in San Mateo County on the California Economy

Impact Category (2010 Dollars)	Direct Effect	Multiplier	Total Economic Impact
Construction Employment	450	1.569	706
Value of Construction	$40,000,000	2.135	$85,410,000
Impact per Construction Employee	–	–	$190,000
State and Local Sales Tax Impact	–	–	$954,000
State and Local Sales Tax Impact per Construction Employee	–	–	$2,120

Sources: IMPLAN (2010 dollars).

Impact of Construction Employment Involved with On-going Maintenance and Renovations of an Existing Pharmaceutical Manufacturing Facility.

Solano County Illustration

The first of the Solano County pharmaceutical manufacturing facility cost between $400 and $500 million (2002 dollars) and continues to employ between 50 and 90 construction workers annually. These workers conduct on-going maintenance and renovation work. The on-going employment impact is based on 70 annually employed construction workers. The results are reported in Table 45 below. The employment multiplier of 1.429 indicates that each on-going construction job creates a total of

1.429 total jobs in Solano County. Or, the 70 construction jobs create a total of 100 jobs in the county. The estimated value of construction work completed by these 70 workers is approximately $10.1 million. With an output multiplier of 1.415, the total economic impact of these construction workers in dollar terms is approximately $14.3 million. This economic activity is associated with an additional $122,000 in local taxes, or about $1,700 per worker.

Table 45: Impact of On-Going Employment of 70 Full-Time Construction Workers at the Solano County Pharmaceutical Manufacturing Facility.

Impact Category (2010 Dollars)	Direct Effect	Multiplier	Total Economic Impact
Construction Employment	70	1.429	100
Value of Construction	$10,112,000	1.415	$14,308,000
Impact per Construction Employee	–	–	$204,400
Local Tax Impact*	–	–	$121,600
Local Tax Impact per Construction Employee	–	–	$1,737

Sources: IMPLAN (2010 dollars). * The county-level tax impact is based on business and residential property taxes and that portion of sales taxes that remain in the county.

Impact on the California Economy

The impact described above is illustrative of Solano County. But, since counties differ in size, the impacts will also differ for various counties. So, it may be more useful to estimate the impact of those construction workers engaged in on-going maintenance and renovation of pharmaceutical manufacturing facilities at the state level. These results are presented in Table 46 below and indicate that, at the state level, 70 continuously employed construction workers are associated with the creation of 136 total jobs in California. The dollar equivalent of this level of employment is approximately $21.4 million. This level of economic activity generates about $1 million in state and local taxes. The multipliers and per worker impacts may be useful in estimating the impact of different levels of ongoing construction activity. For example, the employment multiplier indicates that the employment of one more continuously employed construction worker is associated with a total increase of about 2 jobs in

the state. The economic impact of these workers is approximately $300,000. The impact on state and local taxes is about $15,400 per worker.

Table 46: Impact of On-Going Employment of 70 Full-Time Construction Workers at a Pharmaceutical Manufacturing Facility on the California Economy.

Impact Category (2010 Dollars)	Direct Effect	Multiplier	Total Economic Impact
Construction Employment	70	1.943	136
Value of Construction	$10,112,000	2.115	$21,384,000
Impact per Construction Employee	–	–	$305,500
State and Local Tax Impact*	–	–	$1,078,000
Local Tax Impact per Construction Employee	–	–	$15,400

Sources: IMPLAN (2010 dollars). * The state and local tax impact is a comprehensive impact that is based on indirect business taxes (including sales and property taxes) as well as taxes collected from households, corporations, and employee compensation.

The Potential Economic Impact of Building and Operating a Pharmaceutical Manufacturing Facility in California (Instead of Ohio)

In 2005 San Diego-based Amylin Pharmaceuticals announced plans to establish a biomedical manufacturing facility in West Chester, Ohio. Other states (California, Kentucky, Massachusetts, and North Carolina) competed for this project.[26] The location decision was influenced by incentives and tax relief offered by the state of Ohio and Butler County. Alkermes, Inc., Amylin's technology partner, is also located near West Chester. The strategic benefits of locating near their partner also influenced the location decision. Amylin's initial development plans called for $70 million in renovations of an existing facility in Ohio that would initially employ 50 pharmaceutical manufacturing workers per year. By 2007 the plans expanded to $410 million in construction expenditures with employment rising to 500

[26] See "Amylin Completes W. Chester Purchase," *Business Courier of Cincinnati*, December 29, 2005; http://www.bizjournals.com/cincinnati/stories/2005/12/26/daily19.html

workers. Between 2005 and 2007, the state of Ohio and Butler County offered Amylin $117 million in incentives to locate and expand operations in Ohio.[27]

In this section we estimate the economic impact of Amylin's expansion plans hypothetically *if* they had occurred in California. Since there was interest in having the facility located in an economically distressed area, in our hypothetical, we estimate the impact of Amylin's expansion plans *if* the firm had located in Imperial County. The impact is based on the final plans for 500 pharmaceutical manufacturing workers and $410 million (or, $432 million in 2010 dollars) in renovations and new construction. The construction impact is a one-time impact. The impact of the manufacturing operation can be thought of as a yearly impact.

Potential Economic Impact of Amylin Pharmaceutical Construction Expenditures on the California Economy.

The 2010 equivalent of Amylin's planned construction expenditures in 2007 is approximately $432 million. Data from the 2007 Economic Census of Construction indicates that construction workers engaged in this type of building activity have an output per worker of about $353,000. Or, $432 million in pharmaceutical manufacturing building activity would require about 1,223 construction workers. (Table 47) With an employment multiplier of 3.217, the direct employment associated with the building of pharmaceutical facilities would have been associated with a total increase of 3,935 more jobs in California had Amylin decided to locate in this state and spend the same of construction. The corresponding total dollar impact of this building activity would have been approximately $916 million and generated about $9.5 million in state and local sales taxes. The total economic impact per construction worker would have been approximately $750,000 and about $8,000 with respect to the per worker sales tax impact.

[27] See "Study: Ohio Overpaid for West Chester Amylin Deal," Business Courier of Cincinnati, January 20, 2010; http://cincinnati.bizjournals.com/cincinnati/stories/2010/02/01/story15.html

Table 47: Potential Economic Impact of Amylin's Decision to Locate in California: Impact of $432 Million in Construction Activity.

Impact Category (2010 Dollars)	Direct Effect	Multiplier	Total Economic Impact
Employment	1,223	3.217	3,935
Output ($)	$432,140,000	2.120	$916,021,000
Output Impact per Employee	–	–	$749,000
State and Local Sales Tax Impact	–	–	$9,526,000
State and Local Sales Tax Impact per Employee	–	–	$7,790

Sources: Quarterly Census of Employment and Wages and IMPLAN (2010 dollars)

Potential Economic Impact of Amylin Pharmaceutical Construction Expenditures on the Imperial County Economy.

If Amylin had located in Imperial County, the building impact would have been much smaller. This is a small county with a population of about 164,000 in 2008. Additionally, data from the BLS indicate that nonresidential construction employment was as high as 125 workers (in 2008). Therefore, much of the economic impact associated with the construction of Amylin facilities would have leaked out of Imperial County economy as there are insufficient suppliers for this scale of building activity and much of the work would have been completed by traveling construction workers. The total number of construction workers needed to complete the $432 million project is 1,223. We estimate that 98 of these jobs would be filled by Imperial County construction workers and that this project would place heavy demands on the local labor supply. (Table 48) Since the county is small, and leakages are high, the employment multiplier is about 1.4, or the 98 local construction jobs support another 38 local jobs for a total employment impact of 136. If Amylin had located the facility in Imperial County and spent $432 million on local construction, only a fraction would be spend in the county. Using the regional purchase coefficient for IMPLAN we estimate the local construction spending to be $34,571,000 for this project. The total impact on the county would be about $39 million. The building activity would contribute approximately $12,000 to county sales taxes. The economic impact per construction worker would be about $400,000 and the tax impact per worker is about $130.

Table 48: Potential Economic Impact of Amylin's Decision to Locate in Imperial County: Impact of $432 Million in Construction Activity.

Impact Category (2010 Dollars)	Direct Effect	Multiplier	Total Economic Impact
Employment	98	1.388	136
Output ($)	$34,571,000	1.126	$38,943,000
Output Impact per Employee	–	–	$397,000
Local Sales Tax Impact	–	–	$12,800
Local Tax Impact per Employee	–	–	$130

Sources: Quarterly Census of Employment and Wages and IMPLAN (2010 dollars)

Potential Economic Impact of Amylin Pharmaceutical Manufacturing on the California Economy.

If Amylin had located in California and followed through with plans to employ 500 manufacturing workers, the total impact on employment in the state would be about 2,500 jobs. (Table 49) Or, each manufacturing job would create a total of 4.896 jobs, according to the employment multiplier for this sector. The corresponding dollar value of output for these 500 manufacturing workers is about $435 million, or $870,700 per worker. The total economic impact in dollar terms would be approximately $850 million, or $1.7 million per worker. Had Amylin located in California, state and local taxes would have increased by about $31 million or by $63,000 for each manufacturing worker.

Table 49: Potential Economic Impact of Amylin's Decision to Locate in California: Impact of 500 Pharmaceutical Manufacturing Jobs.

Impact Category (2010 Dollars)	Direct Effect	Multiplier	Total Economic Impact
Employment	500	4.896	2,448
Output ($)	$435,350,000	1.947	$847,604,000
Output Impact per Employee	–	–	$1,695,000
State and Local Tax Impact	–	–	$31,450,000
State and Local Tax Impact per Employee	–	–	$62,900

Sources: Quarterly Census of Employment and Wages and IMPLAN (2010 dollars). * The state and local tax impact is a comprehensive impact that is based on indirect business taxes (including sales and property taxes) as well as taxes collected from households, corporations, and employee compensation.

Potential Economic Impact of Amylin Pharmaceutical Manufacturing on the Imperial County Economy.

The impact of Amylin manufacturing employment on the Imperial County economy, if the firm had decided to locate in this county, is based on the assumption that the 500 manufacturing jobs would have been filled by employees who moved to the county. (Table 50) The impacts and multipliers reported below are low because much of the induced spending would leak from the county economy as employees are unable to buy all they need from the Imperial County service and retail sector. The impacts and multipliers are also small because indirect (supply) purchases would be made in other counties. The pharmaceutical manufacturing industry relies on itself and biotechnology research and

development for supplies. The economic impacts of pharmaceutical manufacturers for the other counties that are described above are large, in part, because of the indirect effect, or supply purchases within the county if a sector of the pharma manufacturing industry is stimulated. But, this would not be the case if Amylin had located in Imperial County. For example, data from the BLS indicate that there is presently one other pharmaceutical company in Imperial County. So, much of the indirect, or supply purchases would leak out of the county had Amylin located in Imperial County. There is not much of a pharma cluster in Imperial County. Better economic development would assess the pre-existing clusters in the county and focus on expanding these.

In spite of the potential for leakages, the impact of an Amylin manufacturing facility on the county economy would have been large, relative to the overall county economy. For example, the 500 manufacturing workers would have produced approximately $435 million in product for a total impact of about $480 million. This would have been approximately 10 percent of Imperial County GPD. The 500 workers would have supported another 351 county jobs for a total of 851. This is about one percent of the county's total employment. The Amylin facility would have contributed about $1.6 million in local taxes, or about $3,200 per worker.

Table 50: Potential Economic Impact of Amylin's Decision to Locate in Imperial County: Impact of 500 Pharmaceutical Manufacturing Jobs.

Impact Category (2010 Dollars)	Direct Effect	Multiplier	Total Economic Impact
Employment	500	1.702	851
Output ($)	$435,350,000	1.104	$480,449,000
Output Impact per Employee	–	–	$961,000
Local Tax Impact	–	–	$1,615,000
Local Tax Impact per Employee	–	–	$3,200

Sources: Quarterly Census of Employment and Wages and IMPLAN (2010 dollars). * The county-level tax impact is based on business and residential property taxes and that portion of sales taxes that remain in the county.

Conclusions

The pharmaceutical, biopharmaceutical and biotech R&D industries in California provide very good jobs concentrated in local communities thereby seeking and helping to establish labor markets densely populated with scientific, educated and skilled labor. The manufacturing arm of these industries is more free to roam compared to the managerial and scientific research arm of these industries. But even manufacturing shows a clustering nationally and locally suggesting needs for closeness tied to issues of research, venture capital availability, cultural amenities and reliable labor markets. This clustering of these interrelated industries often in proximity with other high tech industries has symbiotically generated a construction industry dominated by union general contractors and fed by union apprenticeship training programs which has both grown up with this new industry but also has adapted to its needs. Similar to specialized suppliers, these specialized construction companies help the industry deliver its products safely and in a timely fashion where purity of product and efficient delivery of new discoveries are of the essence.

Local communities benefit tremendously from the good jobs and relatively steady business of this industry and those who build it. We have shown for a selected number of counties precisely how much the local economy is stimulated, how much tax revenues are increased and how many new jobs both inside and outside the industry are created by building and operating pharmaceutical, biopharmaceutical and biotech research, development and manufacturing facilities. For readers wishing to review these results, we refer them to the executive summary. For readers interested in specific counties, we refer them to the sections on Alameda, San Diego, San Mateo, Solano and Ventura counties in Part 2 of this report. For readers wishing to review the big picture of this report, we refer them to the Overview at the very beginning.