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**The Geographic Concentration and Export
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Identifying the Concentration and Export Orientation of Biopharmaceutical Industries in Massachusetts

In accord with export base theory, the economic impact of an industry on a state or local economy is highly dependent on whether it is an export-based industry selling its goods or products outside of the state or a local industry serving to residents of the state.¹ To identify the export base orientation of an industry, we need to estimate how concentrated biopharmaceutical industries are in Massachusetts compared to the nation as a whole. Do biopharmaceutical industries in Massachusetts employ a greater share of the state's workforce than the nation does? Alternatively, is employment in biopharmaceutical industries in Massachusetts "basic" or export based? To answer these key questions, we have used the location quotient (LQ) technique for our analysis. The LQ technique in urban economics is widely used in economic geography and locational analysis. The values of a location quotient represent the ratio of an industry's share of local employment to the industry's share of national employment². From the location quotient analysis, we will be able to identify the comparative degree of specialization in Massachusetts' biopharmaceutical industries and to determine whether the biopharmaceutical related industries in Massachusetts has a greater share of employment in the state's economy than they do in the U.S. economy.

Table 1 displays our estimates of the values of the location quotients for three biopharmaceutical Massachusetts' industries and all three biopharmaceutical industries combined during 2001 and 2005. The share of employment in all biopharmaceutical industries combined in Massachusetts was higher than the national share in both years. The shares in two of

¹ For a review of the core features of export base theory, see: Arthur O' Sullivan, Urban Economics, Third Edition, Richard D. Irwin, Boston, 1996.

² See: Isserman, Andrew M (1977), The Location Quotient Approach for Estimating Regional Economic Impacts, Journal of American Institute of Planners, pp. 33-41.

The basic formula for the location quotient (LQ) is the following:

$LQ = (\text{State's employment in industry } i \text{ in year } t / \text{Total state's employment in year } t) / (\text{U.S. employment in industry } i \text{ in year } t / \text{Total U.S. employment in year } t)$.

There are only three categories of values for a location quotient:

(i) $LQ < 1$ (indicates that Massachusetts employment in industry i was less than expected for the given industry nationwide. The employment in this industry is not sufficient to meet Massachusetts' demand for goods and services produced from this industry).

(ii) $LQ = 1$ (indicates that Massachusetts employment in industry i was exactly the same as that expected for a given industry nationwide. The employment in this industry matches Massachusetts' demand for goods and services produced by the industry).

(iii) $LQ > 1$ (indicates that Massachusetts employment in industry i is greater than that expected for a given industry. The surplus employment in the industry will produce goods and services that are exported out of Massachusetts to other states or to other nations).

the biopharmaceutical industries, except medical instrument and supplies manufacturing, were rising over this time period. The share of pharmaceutical and medicine manufacturing industry employment in Massachusetts was 8.2% higher than the national share. The relatively low value of the location quotient for pharmaceutical and medicine manufacturing industries in Massachusetts is somewhat puzzling given the significant worldwide importance of this industry in Massachusetts. Employment in medical instruments and supplies manufacturing in Massachusetts was nearly 59% higher than the national share in 2005 although this share has declined from an 84% higher ratio in 2001. Employment in medical instrument and supplies manufacturing industries in Massachusetts has declined modestly in recent years owing mostly to cyclical economic factors. Despite the declining employment in this sector nationwide, experts are optimistic that this sector has substantial growth potential and will continue to exist as an important industry in Massachusetts similar to the other two biopharmaceutical industries.³ Given the sharp deterioration in employment in the state’s manufacturing sector over the 2000-2005 period, medical instrument device and supplies manufacturing sector has experienced only modest declines in employment in Massachusetts.

Table 1:
Location Quotients (LQ) for Biopharmaceutical Industries in Massachusetts, 2001 and 2005

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

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

³ (i). See: Mark Holmer, “Lifeblood for Manufacturing: Medical Device Industry Promises Stable Growth in State’s Declining Manufacturing Base”, Boston Business Journal, April 30, 2004.

(ii). See: Alan Clayton-Mathews and Rebecca Loveland, Medical Devices: Supporting the Massachusetts Economy, University of Massachusetts Donahue Institute, Report Prepared for the Massachusetts Medical Device Industry Council, May 2004.

(iii). See: Michael H. Best, MassBenchmarks (2006), “Massachusetts Medical Devices: Leveraging the Region’s Capabilities”, Vol. 8, issue 1, pp. 14-25.

Massachusetts is one of the most dominant states in research and development in the physical, engineering and life sciences service industry. Massachusetts has a comparative advantage in this particular sector fueled by a large number of excellent universities with research labs as well as private/public research centers accompanied by a huge inflow of both private and public funds in this sector. The public grants funding flow has been stable despite declining private venture capital investment flows, particularly during and after the 2001 recession.⁴ The estimated location quotient of 2.773 for the research and development in physical, engineering and life sciences service industry indicates that the share of employment in this sector in Massachusetts was nearly three times higher than the national share. The value of the location quotient in this sector in Massachusetts increased from 2.417 in 2001 to 2.775 in 2005, a sizable increase.

Overall, the Commonwealth employs a relatively high share of its workforce in biopharmaceutical industries. The state has a comparative advantage in this sector as the state is endowed with key factors- venture capital, a highly skilled labor force, and a supportive infrastructure. In 2005, biopharmaceutical industry employment in Massachusetts accounted for 2 percent of all private sector wage and salary employment whereas the sector's share of national employment was only 1 percent for the entire U.S. The share of employment in biopharmaceutical industries in Massachusetts was two times higher than the share nationwide. The location quotient for all biopharmaceutical industries in Massachusetts rose from 1.883 in 2001 to 2.004 in 2005.

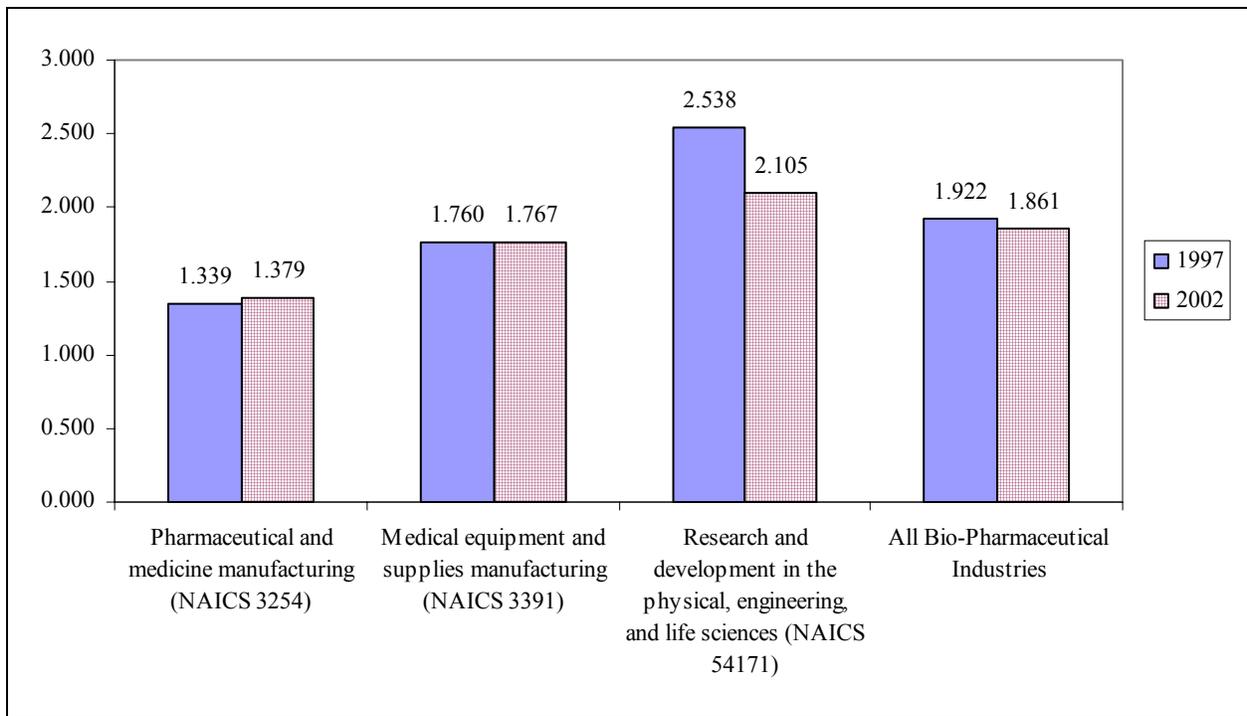
Employment data from alternative sources reveal similar trends in the values of the location quotient for Massachusetts' biopharmaceutical industries. The U.S. Census Bureau conducts an Economic Census of industry every five years. The information on individual industries, including employment, number of establishments, revenue, and the annual payroll of

⁴ During the 1998-2002 period, venture capital investment fund flows in Massachusetts was \$28.08 billion and ranked second only to California. For evidence, see: Milford B. Green, "Industrial Geographer", Venture Capital Investment in United States, 1998-2002, Vol. 2, Issue 1, pp. 2-30, 2004, University of Ontario, London, Canada. Between 2000 and 2005, Massachusetts obtained \$11.5 billion in research grants from the National Institutes of Health (NIH), the second highest amount only after California. For evidence, see: NIH awards trend, <http://grants.nih.gov/grants/award/awardtr.htm>.

In 2005, Massachusetts raised \$2.35 billion in venture capital investment, ranking second highest among the states. For evidence, see: "2005 CED North Carolina Venture Report", Council for Entrepreneur Development (http://www.cednc.org/resources/reports_and_surveys/vc_report/2005.pdf)

industries is considered extremely reliable. The location quotients for biopharmaceutical industries in Massachusetts were 1.922 and 1.861 in 1997 and 2002, respectively. (Chart 1). In contrast to the smaller location quotient for pharmaceutical and medicine manufacturing industry from the QCEW survey, the location quotient coefficient for this industry from the Economic Censuses was higher. The share of employment in pharmaceutical and medicine manufacturing industries in Massachusetts was 34 to 39 percent higher than the national share in the same industry in both 1997 and 2002.

Chart 1:
Location Quotients for Biopharmaceutical Industries Based on
Economic Censuses of Industry Data, 1997 and 2002



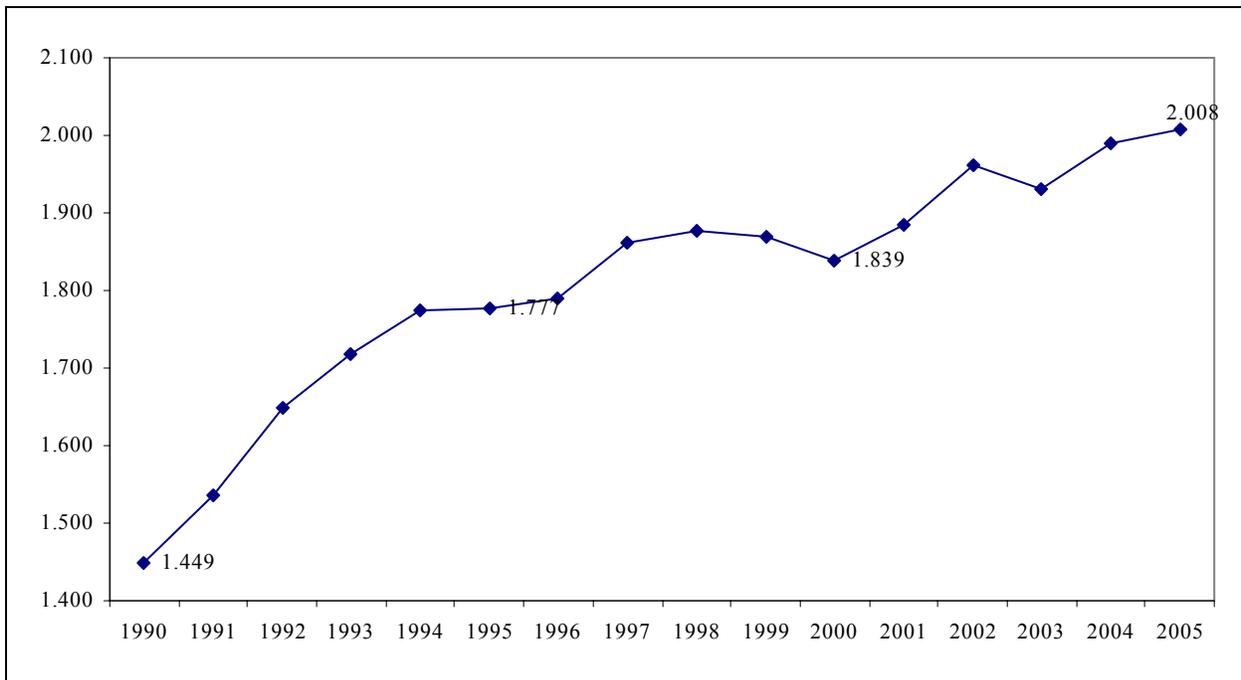
Source: 1997 and 2002 Economic Censuses, U.S. Census Bureau, tabulation by authors.

Were the location quotients for biopharmaceutical related industries in Massachusetts stable over time? To answer this question, we analyzed biopharmaceutical industry wage and salary employment data for the U.S. and Massachusetts for the period 1990 to 2005.⁵ The values of the location quotient for the biopharmaceutical industries in Massachusetts exhibit a rising

⁵ Since making a transition to the North American Industrial Classification System (NAICS), the U.S. Bureau of Labor Statistics in recent years has reconstructed NAICS based data from the SIC basis in the Quarterly Census of Employment and Wages (QCEW) program. The NAICS based data for the QCEW program for national, state and sub state areas available from the U.S. Bureau of Labor web site.

trend over time. The location quotient ratio for the biopharmaceutical industry in Massachusetts increased from 1.449 in 1990 to 1.777 in 1995, to 1.839 in 2000 and slightly over 2.00 in 2005. (Chart 2). Overall, trends in the location quotient of the Massachusetts’ biopharmaceutical industries over the past 15 years clearly reveals that jobs in these industries have become increasingly export-oriented over time, capable of generating important multiplier effects on the economy as a whole via purchases from suppliers and the induced spending by workers, managers, and owners of these companies.

Chart 2:
Trends in the Location Quotient for Biopharmaceutical Industries in Massachusetts, 1990-2005



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

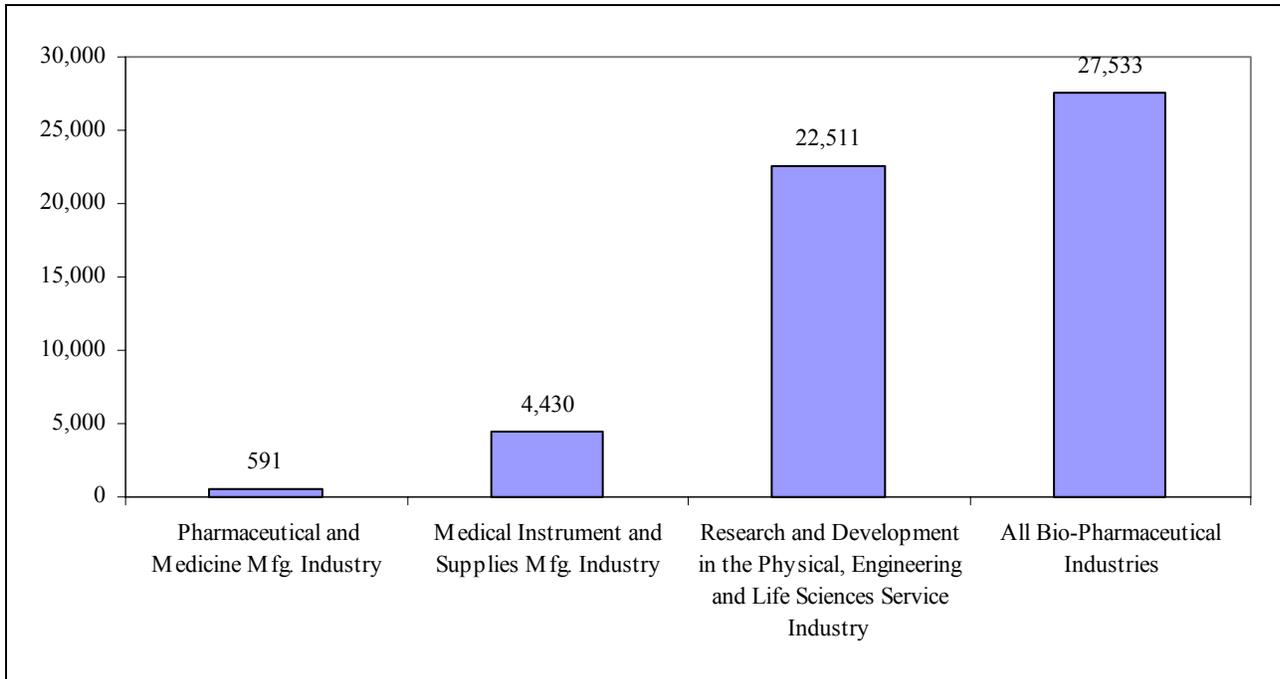
For all biopharmaceutical industries combined in Massachusetts, the value of the Location Quotient was consistently greater than 1. When the Location Quotient is greater than 1, we can estimate the number of jobs that were “export” based in biopharmaceutical industries in Massachusetts.⁶ The number of biopharmaceutical industry jobs in Massachusetts over and

⁶ To estimate the number of jobs that were basic or “export” base, we used the following formula:
Basic Sector Employment = ((Massachusetts employment in industry i / U.S. employment in industry i) – (Total Massachusetts employment / Total U.S. employment)) * U.S. employment in industry i.

above the expected number of jobs in the same industry in the state based on national ratios are considered to be basic or “export” jobs. These export jobs in biopharmaceutical industries produce goods and services for sale to other states or other countries. In 2005, of the 55,000 biopharmaceutical industry jobs in Massachusetts, we estimated that 27,553 or more than 50% were export-oriented jobs. (Chart 3). Among the three biopharmaceutical industries, the highest number of export jobs in 2005 were in research and development in the physical, engineering and life science services industry (22,511) followed by medical instrument and supplies manufacturing (4,430) and pharmaceutical and medicine manufacturing industry (591). The number of 591 basic jobs in pharmaceutical and medicine manufacturing in Massachusetts is likely to be very conservative given the imports of different brands and products and the underestimation of export jobs. We anticipate that higher estimates of basic jobs in pharmaceutical and medicine manufacturing in Massachusetts would be produced by direct surveys of these firms on their sales outside the state. The estimates of basic employment in pharmaceutical medicine manufacturing industry in Massachusetts from the Economic Censuses of 1997 and 2002 data yielded a higher number of export jobs in this industry. In 2002, we estimated from the Economic Census’ employment data that there were 2,506 basic jobs in the pharmaceutical and medicine-manufacturing industry in Massachusetts.

These estimates are likely to be conservative given brand differences in products produced, i.e., the industry consists of a heterogeneous set of firms producing these products. We may import some fraction of our demand from other states and export our goods to other states and countries.

Chart 3:
Basic or “Export” Wage and Salary Employment in Biopharmaceutical
Industries in Massachusetts, 2005

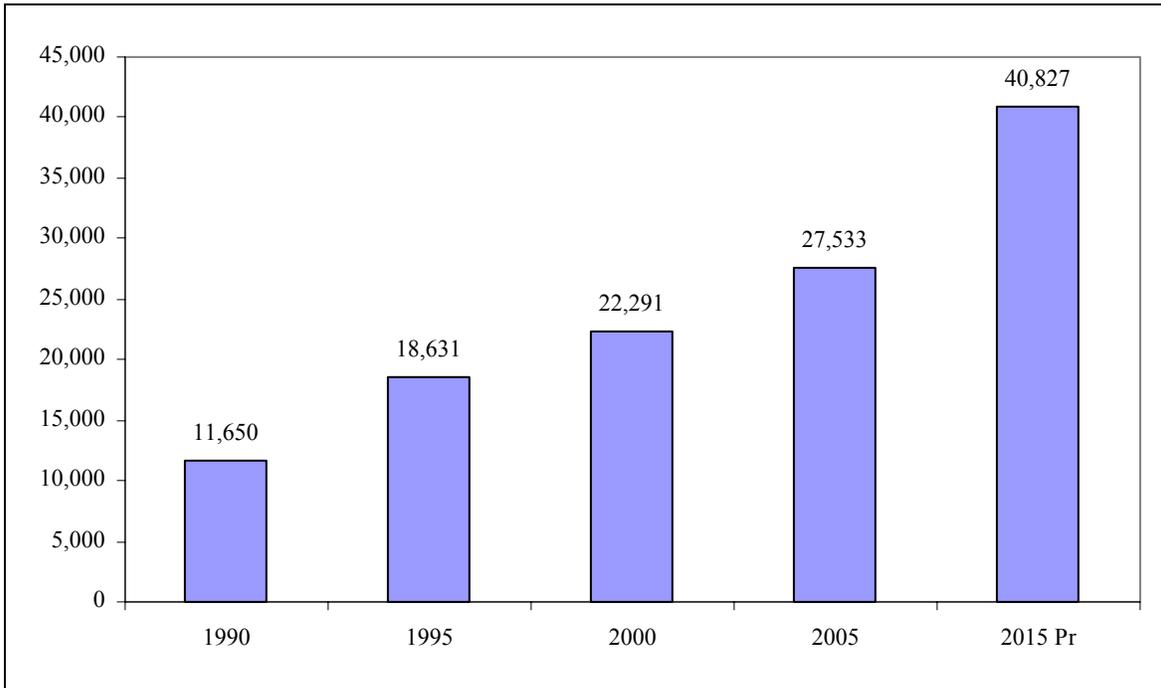


Source: NAICS based Quarterly Census of Employment and Wages (QCEW), U.S. Bureau of Labor Statistics, tabulations by authors.

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

Development will be analyzed by CLMS staff to identify projected growth in these key sectors of the state's economy over the coming decade.

Chart 4:
Trends in Basic or "Export" Wage and Salary Employment in
Biopharmaceutical Industry in Massachusetts, 1990-2005 and Projected 2015



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