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Medical Devices: A Stronghold of the Commonwealth's Economy

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ILLUSTRATION: NAOMI SHEA

Medical Devices

A Stronghold of the Commonwealth's Economy

ALAN CLAYTON-MATTHEWS

We benefit from medical devices throughout our lives: Prenatal development is monitored by ultrasound devices, sports injuries are diagnosed with magnetic resonance imaging and fixed with arthroscopic tools, and heart blockages are cleared with angioplasties and drug-coated stents. Devices include the simple and mundane—eyeglasses and thermometers—and stretch to the boundaries of technology—laser scalpels, needles embedded with microprocessors, MRI machines, and artificial hearts. All are products of the medical device industry. Massachusetts is one of the nation's leading states in medical device development and production.

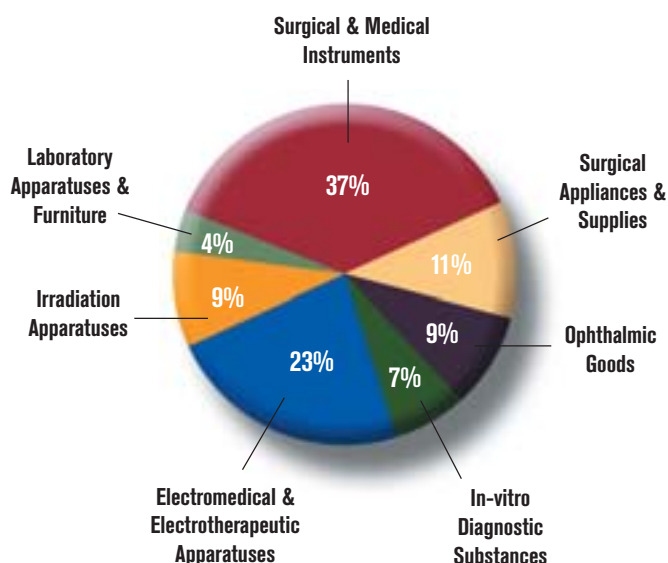
Medical devices have drastically reduced the invasiveness of surgical procedures, shortened recovery times, and lowered medical costs. This trend is continuing at a rapid pace, aided by advances in electronics and biotechnology. To aid diabetics, for example, internal pumps under development will monitor and deliver insulin; they are the closest thing yet to an artificial pancreas. Medical devices and biotechnology developments are becoming increasingly complementary over time, as devices of increasing sophistication and miniaturization are used to deliver new pharmaceutical and biotechnological products. In the future, “nano” may be used to deliver biological agents directly to cancer cells.

The field of medical devices is the larger part of a medical science sector that supports the health services sector. According to statistics from the 1997 Economic Census,¹ the medical science sector in Massachusetts was composed of three industry groups:

- the medical device industry, which consisted of 264 manufacturing establishments with 20,756 employees, a payroll of \$989 million, and shipments of \$4.0 billion;
- pharmaceuticals, which consisted of 57 manufacturing establishments with 5,612 employees, a payroll of \$270 million, and shipments of \$1.8 billion; and
- biotechnology, which consisted of 282 research establishments with 9,311 employees, a payroll of \$589 million, and shipments of \$1.5 billion.

Altogether, the Commonwealth’s medical science sector consisted of 603 establishments with 35,679 workers, a payroll of over \$1.8 billion, and shipments of \$7.3 billion. This sector is therefore larger than several key high-technology sectors, including computers and office equipment, and electronic components, which had employment levels of 25,600 and 31,000, respectively.

Medical Devices Employment in Massachusetts, 1997



Source: U.S. Bureau of the Census, 1997 Economic Census

Massachusetts Medical Devices in a National Context

Using four measures of economic size and impact from the 1997 Economic Census—value of shipments, employment, payroll, and value added (labor plus overhead)—expressed in both absolute size and per capita terms, Minnesota and Massachusetts lead the nation in the production of medical devices. Though Massachusetts does not rank first on any of the eight criteria, it ranks high on all.

In terms of population and overall economic activity, California, Illinois, New York, and Florida are far larger than either Massachusetts or Minnesota, so their higher rankings on measures of absolute size do not indicate a higher concentration of medical device manufacturing. To rank states in terms of concentration of medical device activity, per capita comparisons are appropriate.

One way to combine these ranking criteria into a single comparison measure is to assign a rank score to each and form states’ total scores as the sum of their rank scores on each category.² Using this simple scheme, Minnesota and Massachusetts rank first and second, respectively, on the four per capita measures and tie for third on the four absolute size criteria.

Rankings of Top Five Medical Device States by Production Characteristic

Absolute Size					Per Capita			
Value of Shipments	Employment	Payroll	Value Added	RANK	Value of Shipments	Employment	Payroll	Value Added
CA	CA	CA	CA	1	MN	MN	MN	MN
IL	IL	IL	IL	2	CT	UT	MA	CT
MA	NY	MA	MN	3	MA	MA	UT	MA
MN	MN	MN	MA	4	UT	CT	IL	UT
FL	MA	NY	FL	5	NE	IL	CT	NE

Sources: U.S. Bureau of the Census, 1997 Economic Census

Combining all eight criteria, Massachusetts ranks second behind Minnesota and ahead of California, Illinois, Connecticut, and Utah. The thrust of these rankings is confirmed by conversations with industry executives in the Commonwealth. Minnesota and Massachusetts have similar agglomeration economies, with a favorable mix of higher education, as well as medical and high-tech industries.

Why be concerned about how Massachusetts ranks in measures of medical device production relative to other states? The one-word answer is “exports.” Over half the output of the Commonwealth’s medical device industry is exported to other states or countries.³ Because revenues from exports are ultimately received by Massachusetts workers and suppliers of capital to the state’s medical device companies, industries that export support the state economy’s health and growth. Given the agglomeration economies that are favorable to production of medical devices—that is, the state’s concentration in higher education, teaching hospitals, precision production, and electronics—Massachusetts would be expected to rank high on measures of relative production volume, and it does.

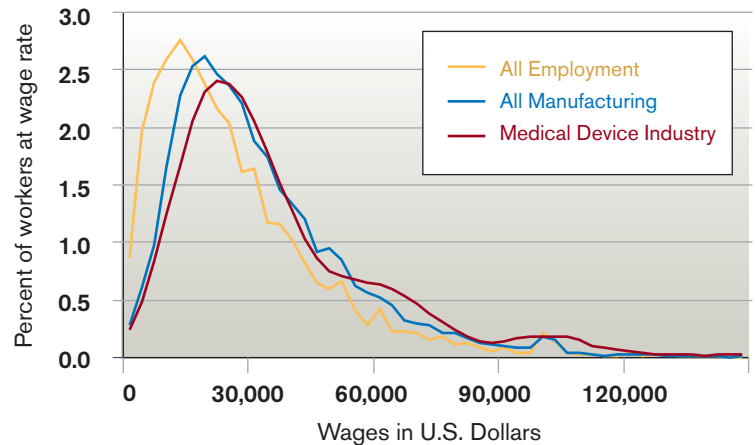
Basic Characteristics of the Massachusetts and U.S. Medical Device Industry

Number and size of establishments. According to the 1997 Economic Census, there were 264 manufacturing establishments in the state’s medical device industry. These companies employed 20,800 workers, or 3.39 of every thousand residents. Nationally, there were 335,800 employees in 1997, or 1.26 per thousand residents. The industry is thus 2.7 times as concentrated in Massachusetts as in the nation overall. The value of shipments from the state’s manufacturing facilities totaled \$4.0 billion, with a payroll in 1997 of \$1.0 billion.

Aggregate sales are dominated by a handful of large companies. In a 2000 *Boston Business Journal* survey of the largest 25 medical device employers in Massachusetts, 1999 sales ranged from \$2.8 billion for Boston Scientific Corporation, the largest company, to \$2.5 million for UroMed Corporation, the 24th-ranked company in terms of sales.

As of 1998, there were just over two dozen Massachusetts-headquartered, publicly held medical companies, with \$3.2 billion in sales. Though the vast majority of companies are privately held and small by comparison (approximately half these manufacturing establishments were small, employing fewer than 20 employees), they are critically important to the vitality and technological advancement of this industry. One indicator is the scale of venture capital funding, which is targeted to small start-ups. Over the four quarters ending in the third quarter of 2000, venture capital funding received by the state’s medical device firms totaled \$314 million.⁴ To illustrate its magnitude, this invest-

U.S. Annual Wage Distribution for All Employment, All Manufacturing, and Medical Device Industry



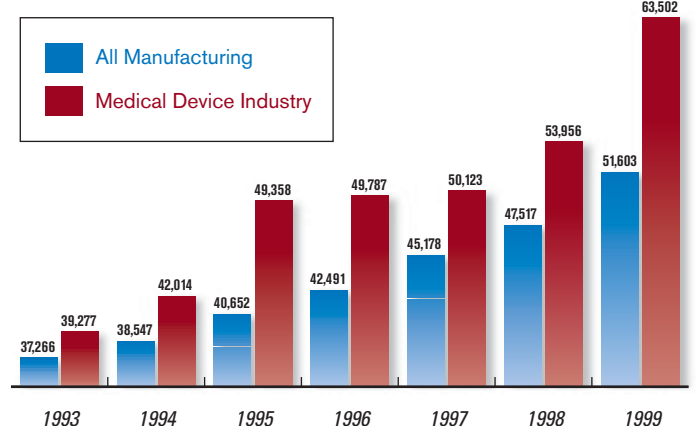
Source: U.S. Bureau of the Census, Current Population Survey 1994-1998

ment is roughly equal to the total research and development spending of the 26 Massachusetts-headquartered, publicly held medical device companies in 1997 and is nearly twice the amount spent in 1997 on capital expenditures for all medical device manufacturing establishments in the state.

Industrial composition. In Massachusetts, surgical and medical instruments is the largest industry in the medical device sector, with 37 percent of medical device employment. The next largest, with 23 percent of employment, is electromedical and electrotherapeutic apparatuses. In contrast, these two industries comprise 31 percent and 16 percent of national medical device employment, respectively. The relative concentration of these two industries in Massachusetts reflects the state’s comparative specialization in precision specialty production and electronics.

The distribution of employment in Massachusetts among the other medical device industries is 11 percent in surgical appliances and supplies, 9 percent in irradiation

Massachusetts Annual Wages in Medical Devices and Manufacturing



Source: Massachusetts Division of Employment and Training, ES-202

apparatuses, 9 percent in ophthalmic goods, 7 percent in in-vitro diagnostic substances, and 4 percent in laboratory apparatuses and furniture. Relative to the nation as a whole, Massachusetts has a higher proportion of its employment in irradiation apparatuses and a lower proportion in surgical appliances and supplies and in-vitro diagnostic substances.

Employment wages, salaries, and benefits. Not surprisingly, wages and salaries in medical devices are higher than in manufacturing and in the economy as a whole. Median annual wages of medical device workers were \$30,000 during 1994–1998, according to the CPS, versus \$28,000 in manufacturing and \$21,243 for all workers.⁵

Even though manufacturing workers on the whole have a lower level of education than all workers, they are generally paid better, which is true at every level of educational attainment. For college-educated medical device workers, this premium is even greater. A medical device worker with an associate's degree earned an average annual salary of \$41,145 in 1994–1998, versus \$36,916 in all manufacturing and \$30,470 in all jobs. A medical device worker with a bachelor's degree earned, on average, \$66,292 per year versus \$54,012 in all manufacturing and \$44,307 in all jobs; a medical device worker with a professional or graduate degree earned an average of \$85,101 per year versus \$77,477 in all manufacturing and \$70,704 in all jobs. These premiums probably reflect the value of specific job training for those with a high school education or less and higher market valuations for degrees related to medical device research and development for those with a college education. One in 20 medical device workers earned more than \$100,000 annually in the 1994–1998 period.

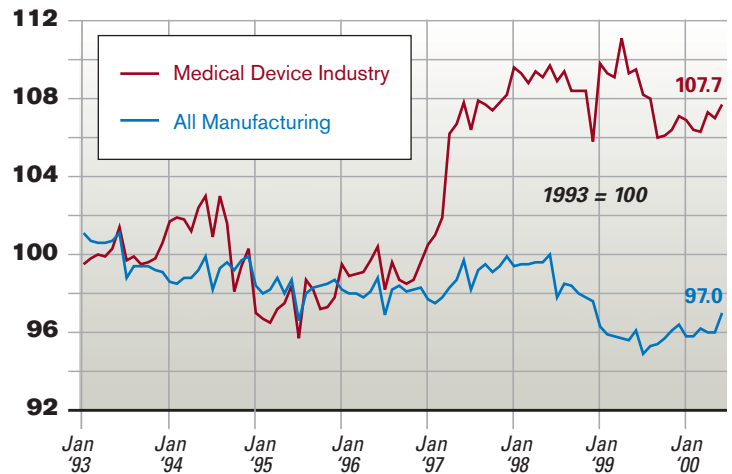
Current and Future Trends

The Commonwealth's medical device industry is expanding rapidly. Employment, wages, productivity, and foreign exports have grown faster than the state's manufacturing sector as a whole, and medical device wages and foreign exports have been growing faster in Massachusetts than in the nation.

Employment. Since 1993, medical device employment in Massachusetts has been up and down, but with an upward trend.⁶ In 1993 and 1994, there were about 16,000 jobs in the medical device industry. During the national and regional slowdown in 1995, employment declined to 15,500. In 1997, it rose sharply and has since been in the 17,000 to 17,500 range. The strength of the industry is apparent when compared with overall trends in Massachusetts manufacturing employment. In 1997, aggregate manufacturing employment rose, but it didn't keep up with medical instruments.

Between January 1997 and June 1998, the date of the most recent peak in statewide manufacturing employment, total manufacturing jobs expanded by 2.4 percent, whereas

Massachusetts Employment Indices



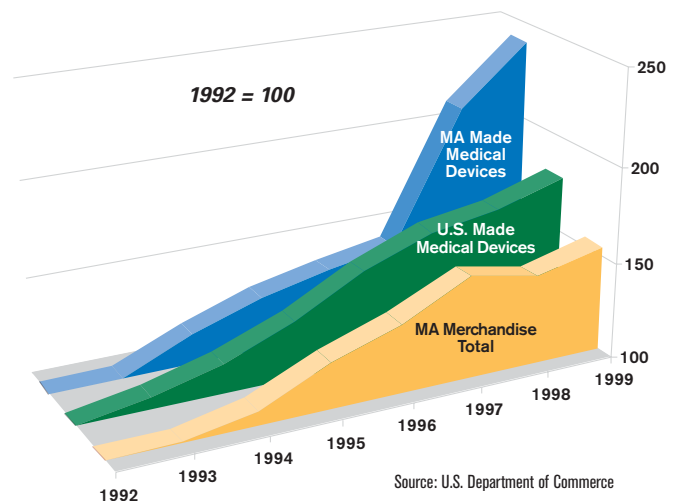
Source: Massachusetts Division of Employment and Training, ES-202

medical device jobs increased 9.1 percent. Then the effects of the Asian financial crisis were felt. Statewide manufacturing employment fell sharply through June 1999 and has remained roughly level since then. In June 2000, overall manufacturing employment was 2.9 percent below its June 1998 peak. The fall in medical device employment, however, was less severe. As of June 2000, employment was only 1.8 percent lower than in June 1998.

Medical device employment trends in Massachusetts and in the United States were similar from 1997 to 1999. Annual average employment grew by 2.6 percent in Massachusetts and by 3.0 percent in the nation as a whole.

Exports. In Massachusetts, the growth in medical device exports to foreign countries has been rapid. Europe has been the chief destination of exports, with demand driven by high incomes relative to most of the rest of the world, but growth in East Asia is accelerating from a much smaller per capita base. As incomes rise in East Asia in the long run, the market should expand dramatically.

Exports to Foreign Countries Indices of Growth



Source: U.S. Department of Commerce

Venture capital. By financing the development of new technologies in start-up firms, venture capital funding plays a crucial role in the growth of the medical device industry. In the four-quarter period ending in September 2000, Massachusetts firms received a total of \$314 million in venture capital financing.⁷

The medical device sector competes with other technology-related sectors for venture capital funding, principally information technology (IT) and biotechnology. The total supply of venture capital funds depends in part on investors' perceptions of the likelihood of successful "liquidity events," such as initial public offerings (IPOs) or acquisitions in which investors recoup their initial outlay plus a substantial profit.

Nationally, the medical device industry received 2.3 percent of all venture capital funding in the four-quarter period ending in September 2000. The share of all venture capital funds going to medical device companies is roughly equivalent to that received by biotechnology firms, but well below that received by firms in the IT sector. The relative unattractiveness of medical device companies compared with IT is largely due to the longer time to a liquidity event, especially an IPO outcome; FDA approval to market a device, and Health Care and Financing Administration (HCFA) reimbursement approval needed to make the device profitable are time-consuming processes. The medical device industry compares favorably with biotechnology on this score, especially if a device can be registered with the FDA as a 510(k) device, which can usually be brought to market quickly, without the need for clinical trials.

Massachusetts receives roughly 10 percent of the total supply of venture capital funds for medical devices in the United States, though the amount can vary markedly in the short run. For the four-quarter period ending in September 2000, the state received 19.5 percent of all U.S. venture capital funding for medical devices. That figure is inflated by the remarkably successful first quarter of 2000, when Massachusetts medical device companies received \$163.3 million, nearly half of the U.S. total. In the next two quarters, Massachusetts companies received \$30.9 million and \$46.2 million, representing 9.2 percent and 8.7 percent of the U.S. total.

In the amount of venture capital funding it receives, how does Massachusetts fare relative to other areas? In terms of the share of national venture capital financing, the state does well. Its share of national venture capital funding for medical devices (roughly 10 percent) exceeds what would

The competition for venture capital funds is, in part, affected by the size and risk of the expected return. By their nature, venture capital investments are risky. The expectation is that many—if not most—ventures will fail to be profitable, but those that are will compensate. Relative to biotechnology, medical devices are perceived to be less risky, but successes are perceived to be less profitable.

The risk advantage derives from the small probability, in pharmaceuticals, of discovering a safe and effective drug relative to the probability, in medical devices, of developing a safe and effective instrument. On the other hand, the payoff for a successful drug is enormous relative to the payoff for a successful device, because once the drug or device is approved for marketing, the marginal costs of producing a drug are typically very small relative to those of producing a medical device.

be expected, based on medical device industry measures, such as the share of national shipments, value added, or employment of 6 to 7 percent. On the other hand, venture capital funding is concentrated in a handful of regions, including Silicon Valley, New England, San Diego, the Midwest, and the Southeast. Though New England and Massachusetts typically rank second or third, Massachusetts falls far behind Silicon Valley in the share of funds it receives.

The Role of Hospitals and Universities

Teaching hospitals and universities play an arguably more important role in the growth of the medical device sector than venture capital

does.⁸ More research is done in these institutions than in private industry, often resulting in the licensing of technology to medical device firms and occasionally in the formation of start-up companies or joint ventures with existing companies. Massachusetts hospitals and universities license and form ventures with companies around the world, but roughly 30 percent to 40 percent of the deals are with in-state partners.

Massachusetts public policy should focus on providing quality public education, lowering the cost of living, promoting Massachusetts as a place to do business, and developing an information-sharing liaison with the industry.

Though aggregate figures for the effect on the medical device industry are not available, the order of magnitude can be inferred from a couple of examples. The University of Massachusetts receives approximately \$200 million in research money annually, more than half of which goes to the UMass Medical Center. The university's Office of Commercial Ventures and Intellectual Property had license revenues of \$12.4 million in FY 2001. Such revenues have been rising at double-digit rates annually since the office was started in 1995. Roughly three-quarters of these revenues are medical related, and more than 10 percent are due directly to medical devices.

Universities attribute the rapid growth in the licensing of sponsored research to the Bayh-Dole Act, passed in the 1980s. This legislation allows universities to own the intellectual property created by faculty and research personnel. Other countries are beginning to emulate this model, an indication of the policy's success in increasing the volume of university-sponsored research.

In another example, Massachusetts General Hospital conducts \$250 million in research annually, with a significant portion related to medical device research in lasers, imaging devices, and other radiology applications. Much of this research is performed in the hospital's Center for Minimally Invasive Technologies. Medical device-related licensing revenues are running at about \$2 million per year. The role of such research in other teaching hospitals is similar, though the scale is less than at Mass General or Brigham and Women's. These two rank first and second, respectively, in the volume of research performed by Massachusetts hospitals.

Conclusion

Massachusetts medical devices form the largest part of the state's vibrant medical science sector, which also includes pharmaceuticals and biotechnology. Massachusetts is one of the leading states in the production of medical devices, providing good jobs that employ high-paid scientists, engineers, and production workers. Through its economic links with electronics, metal and plastics manufacturers, hospitals, and financial institutions, the medical device sector comprises an important part of the state's high-technology economic base.

The long-term outlook for the sector is one of continued growth, supported by growing worldwide demand for health services, and the state's comparative advantage in the development of new technologies. In order to ensure the future success of the medical device sector—and the state's economy as a whole—Massachusetts public policy should focus on providing quality public education, lowering the cost of living (especially housing costs), promoting Massachusetts as a place to do business, and developing an information-sharing liaison with the industry. ▮

1 Department of Commerce, 2000

2 For each criterion, first place was assigned five points; second four points; and so on through one point for fifth place.

3 According to the Regional Economic Models Inc.'s Massachusetts economic accounts for 1998, exports of the medical device industry (SICs 384 and 385) were estimated to be 1,441 million (\$92) and output was estimated to be 2,784 million (\$92), for an export-to-output ratio of .5176. Here, exports refer to sales to the rest of the United States and the world.

4 PriceWaterhouseCoopers, 2000

5 Annual wages are calculated as follows: For each sample individual, the CPS reports earnings in the prior year from the primary employer (i.e., the employer for whom the individual worked the longest in the prior year), as well as weeks worked last year and number of employers in the prior year. (If the person worked for two or more employers concurrently, only one employer is counted.) For purposes of calculating annual wages, the sample was restricted to those individuals who worked for a single employer in the prior year. Annual earnings were calculated as earnings received from the primary employer divided by weeks worked times 52.

6 The sources of information for this section are the state and national data from the "covered" payroll employment series, ES-202 (Division of Employment and Training, 1993–2001, and the U.S. Bureau of Labor Statistics, 2001). The ES-202 provides a time series of employment and wages from 1993 to 1999 for Massachusetts and from 1997 to 1999 for the United States as a whole for the medical device sector, defined as SICs 384 and 385.

7 The data on venture capital in this section are from quarterly surveys on venture capital investments (PriceWaterhouseCoopers, 2000).

8 The sources of information for this section are interviews with executives from medical device companies or related businesses.

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