Innovation Indicators

Report to the Council for Labor and Economic Growth

August 2007

**Michigan Department of Labor & Economic Growth,
Bureau of Labor Market Information and Strategic Initiatives**

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Introduction

This is the first annual report on innovation indicators produced for the Michigan Council for Labor and Economic Growth. The purpose of this report is to present an overview of Michigan's strengths and weaknesses on a series of measures relating to innovation in the economy. For purposes of this report, innovation is defined as follows:

> **Innovation is the conversion of knowledge and ideas into a benefit, which may be for commercial use or the public good; the benefit may be new or improved products, processes or services. Innovation is a process of continuously generating and applying new ideas[1].**

The research team conducted an extensive search of literature and studies to identify a broad set of measures for consideration as indicators of innovation. The five indicators selected met these criteria established by the team:

- measure the capacity for technological innovation and the composition of the state workforce;
- published on a regular basis, at least annually, for all 50 states; and
- produced by a reliable source with a consistent methodology.

The innovation indicators selected for this report are:
- Education level of the workforce
- Percentage of scientists and engineers in the workforce
- Number of patents issued
- Industry investment in research and development
- Venture capital investment

Highlights

While a complete understanding of Michigan's innovative capacity may not be within the scope of a report that examines only five variables, broad conclusions can be made with a certain amount of confidence from such an analysis. In general, Michigan compares favorably to the U.S. average on most of these measures, yet there is potential to further elevate the state's innovative capacity and standing to a level among the very best in the nation[2]. Consider this:

- The education level of Michigan's workforce is better than the U.S. average in terms of high school graduates and those with at least some college or an associate's degree, but slightly lags the nation in terms of those with a 4-year degree or higher. And, while the state may only be slightly behind the U.S. in this regard, there is much room for improvement before it matches those states that are the "best in class" in terms of workers with bachelor's degrees or higher.

- On the surface, Michigan fares well when compared to other states with regard to the ratio of scientists and engineers to all jobs, placing ninth overall. However, further analysis showed that the extremely high proportion of engineers (due to the auto sector) in the state was the main reason for this high overall ranking. Michigan's position drops to 37th when looking at the ratio of scientists alone. Growth of these jobs as a primary focus would be one way to improve the state's overall innovative capacity.

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[1] This definition draws upon work by SRI International in "Benchmarks for the Next Michigan", produced for the Michigan Economic Development Corporation; and a common definition cited on numerous websites.

[2] For context, Michigan has the eighth largest population and the ninth largest economy among U.S. states, based on 2006 population estimates from the U.S. Census Bureau, and 2006 estimates of gross domestic product by state, from the U.S. Bureau of Economic Analysis.

- The state's patent picture is not as straightforward as it may seem. On the one hand, Michigan ranks 12th overall in the nation in terms of patents per capita. However, this standardized measure was only slightly above the U.S. average in 2006, and significantly below the numbers posted by the top states. The numbers of patents overall have increased slightly over the past five and 10 years, but this growth has mostly lagged the nation.

- Michigan has historically ranked among the top states in industrial research and development spending, although the pace of annual growth for Michigan lagged the national average in 2004. Motor vehicle manufacturing dominates industrial R&D spending in Michigan, fueled by the substantial Big Three automakers' investment here, and the presence of more than 330 motor vehicle-related R&D facilities. Nationally, federal funds contribute about 10 percent of total industrial R&D spending; the federal share is just one percent of industrial R&D in Michigan.

- Venture capital investment in the U.S. is highly concentrated in a handful of states; Michigan accounted for less than one-half of one percent of the U.S. total in 2006. Michigan's 21st century jobs fund initiatives are increasing the venture capital funds available for investment in Michigan companies, and spurring more funds to locate offices here. In Michigan and the U.S., life sciences and IT-related industries capture the majority of venture capital investment.

This report is organized in five sections. Each section provides a brief explanation of an indicator and its importance in the context of innovation, the major findings of our analysis, including comparisons to the U.S., other states and regions as appropriate, and time series comparisons where the data allow.

Workforce Education

The education level of a labor force is an important indicator of economic innovation and general economic health, as lower unemployment rates typically correlate with higher levels of education. In order to "adapt and innovate to contend with global—not just national—competitors", the state must ensure that its residents are highly educated by global standards[3]. However, while studies tend to focus on the education level of the population, an indicator focusing on the education level of the *workforce* is arguably more important in determining potential innovation and ingenuity in the state, since this indicator would represent people that are actively taking measures to work or potentially innovate.

Chart 1: Distribution of workforce by highest level of education attained (2005)

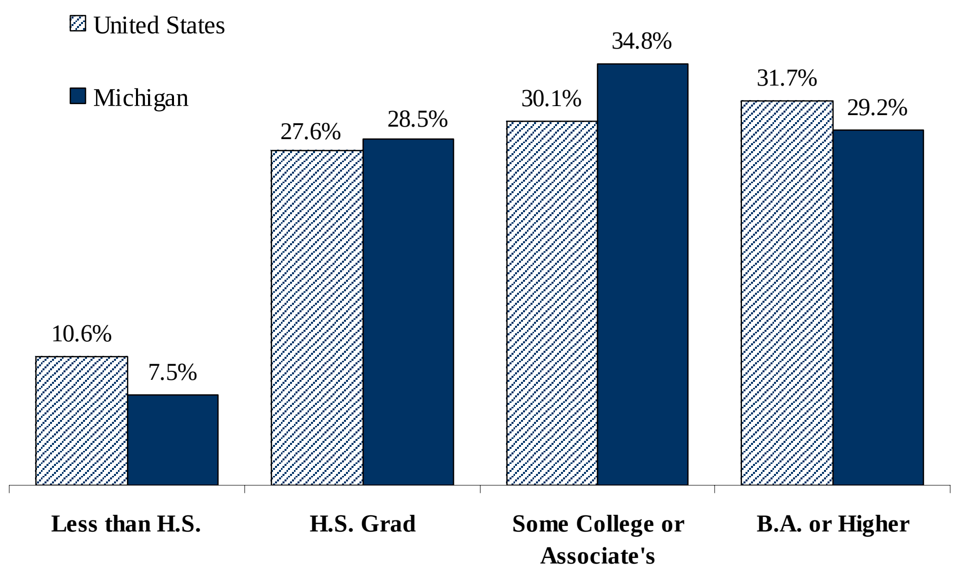

Chart 1 represents the share of the total labor force, aged 25 years or older for each educational classification for Michigan versus the U.S. total[4]. The most obvious difference is in the "Some College" category, in which the state displays a notably larger proportion of workforce than the U.S. average[5]. This could potentially be the result of the success of Michigan's community college system as well as the cultural perception that high-paying but low-education jobs are available—which has likely provided a disincentive to further education beyond a certificate or high school diploma[6]. This factor also may be part of the reason that the state trails the nation in terms of workers in the highest-educated group, those with a bachelor's degree or higher. Comparable time-series data are not available for any *long-term* trend analysis; however, it can be noted that these comparisons mirrored the previous year figures[7].

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[3] *Final Report of the Lt. Governor's Commission on Higher Education and Economic Growth*, December 2004, p. 1
[4] Data are from the U.S. Census Bureau's American Community Survey for 2005; This is the most recent data available as of June 2007
[5] This may appear to differ from the Lt. Governor's report in that their findings showed Michigan lagged the U.S. in the "Associate's or higher degree" category. However, these data are not comparable, as the chart above displays 2005 data instead of 2000, and references labor force 25 and older, not population. In addition, the labor force indicator will include those that have not yet completed any degree in the "Some College or Associate's" category.
[6] Just 27 percent of parents surveyed across the state in 2005 believe that higher education is necessary for their children's success in the future economy, according to *Your Child* from the University of Michigan Health System.
[7] Long-term trends are not available due to the fact that the American Community Survey is a relatively new census program, and that early survey samples were not adequate for direct year comparisons. Also, categories for education levels were not consistent, further complicating time comparisons.

The number of universities in the state relative to its population provides additional insight on potential innovative capacity[8]. Table 1 compares the number of colleges and universities granting bachelor's degrees or higher per capita among the five Great Lakes regional states and the U.S. Michigan is among the lowest in the region with only 4.5 colleges per one million residents. This was 26 percent less than Indiana, which led the region, and was 22 percent below the U.S. average.

Table 1: Number of colleges and universities per capita

State	4-Year Colleges	Population	Colleges per Million People
Indiana	37	6,093,372	6.1
Ohio	67	11,155,606	6.0
Illinois	72	12,440,357	5.8
Michigan	44	9,865,583	4.5
Wisconsin	23	5,375,751	4.3
U.S.	**1,606**	**288,378,137**	**5.6**

As a general conclusion, it would seem that Michigan is *at best* average in terms of the share of people in its workforce with a bachelor's degree or higher, but is above average with regards to those with at least some college or an associate's degree. However, the outlook of the current U.S. and global economy is such that innovation will be crucial to not only 1) economic success, but also 2) mere economic survival, at least in maintaining the current standard of living. Since postsecondary education "fosters discovery of new ideas that create new goods, services and whole industries"[9], measures taken to improve the education level of the state's workforce will play a critical role in achieving both of those goals. While Michigan does not substantially lack college graduates compared to the U.S. average, it is far from the best in class, leaving much room for improvement in terms of educated workers and innovative capacity.

In spite of this, the fact that the state has a lower proportion of its labor force that are high school dropouts and a higher share of those with at least some college or an associate's degree when compared to the U.S. average provides a bright spot for the state's educational potential, thus too for its innovation outlook. It is apparent from these statistics that many existing workers are potentially college-degree ready, meaning they have finished high school and would be able to enroll in a bachelor's degree program or have already completed postsecondary coursework towards that end.

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[8] It is recognized that enrollment size of colleges could potentially change this outcome, but the mere presence of 4-year institutions contribute greatly to innovative capacity, as many of these have the potential to draw researchers and research and development dollars to an area, sometimes even in spite of the enrollment capacity of the institution.

[9] *Final Report of the Lt. Governor's Commission on Higher Education and Economic Growth*, December 2004, p. 6

Scientists and Engineers

The relative share of scientists and engineers working in an economy is relevant to the development of new technologies and innovations as well as the advancement of existing ones. Such occupations should continue to grow in importance as the economy continues to be ever-more defined by technology-driven changes.

Chart 2: Number of scientists and engineers per 10,000 jobs (2005)

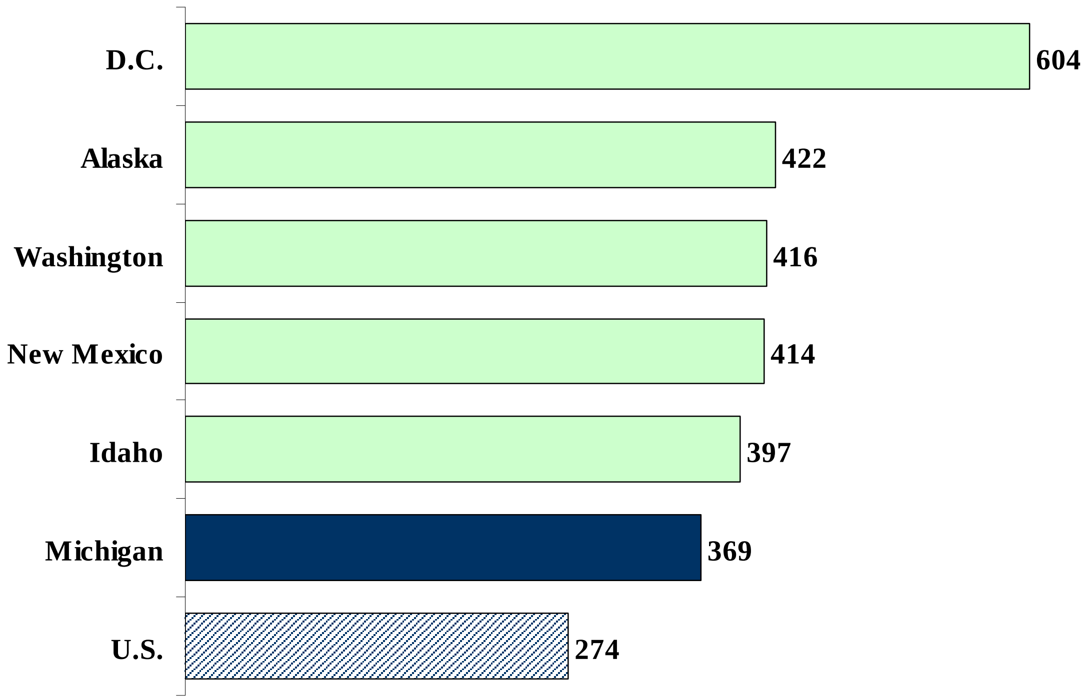

Chart 2 illustrates how Michigan's share of scientific and engineering occupations stacks up to the U.S. and the top five states[10]. These data are displayed as "number of scientific and engineering occupations per 10,000 jobs" in order to place the percentage shares into a more relevant context. Out of 50 states and the District of Columbia, Michigan ranked ninth overall, as scientists and engineers accounted for 3.69 percent of all jobs in the state. In the total number of scientists and engineers, the state broke the top five with nearly 160,000 science and engineering jobs, but was less than half the total of the national leader (California, 470,000).

In terms of a broader geographic comparison, Michigan was well ahead of all regional states and accounted for almost one-third of all of the scientists and engineers in the five-state Great Lakes region. Furthermore, Michigan's relative share of 369 science and engineering occupations per 10,000 total jobs was 26 percent higher than the U.S. average.

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[10] Data were collected from the *Bureau of Labor Statistics, Occupational Employment Statistics* program 2005 and substantial value-added analysis was done to create figures and rankings noted in the chart, tables and text.

The major reason for the state's apparent success in these types of jobs comes from the auto-manufacturing sector, which has a higher than average share of engineers than most industries. So, while Michigan is strong in terms of total science and engineering jobs, its disproportionate share of engineers relative to scientists has the potential to make direct comparisons between states somewhat misleading. This is evidenced by the fact that the state has an engineer-to-scientist ratio of four to one, which was the highest in the nation and more than twice the U.S. average.

Table 2: Ranking of engineering job shares

Rank	State	Engineering Occupations	Engineers per 10,000 Jobs
1	**Michigan**	**128,760**	**297**
2	Washington	69,960	264
3	New Mexico	19,670	258
4	Colorado	52,890	246
5	Idaho	14,120	236

Table 3: Ranking of scientific job shares

Rank	State	Scientific Occupations	Scientists per 10,000 Jobs
1	District of Columbia	24,430	400
2	Alaska	6,460	215
3	Montana	7,610	184
4	Wyoming	4,210	167
5	Idaho	9,600	161
37	**Michigan**	**31,040**	**72**

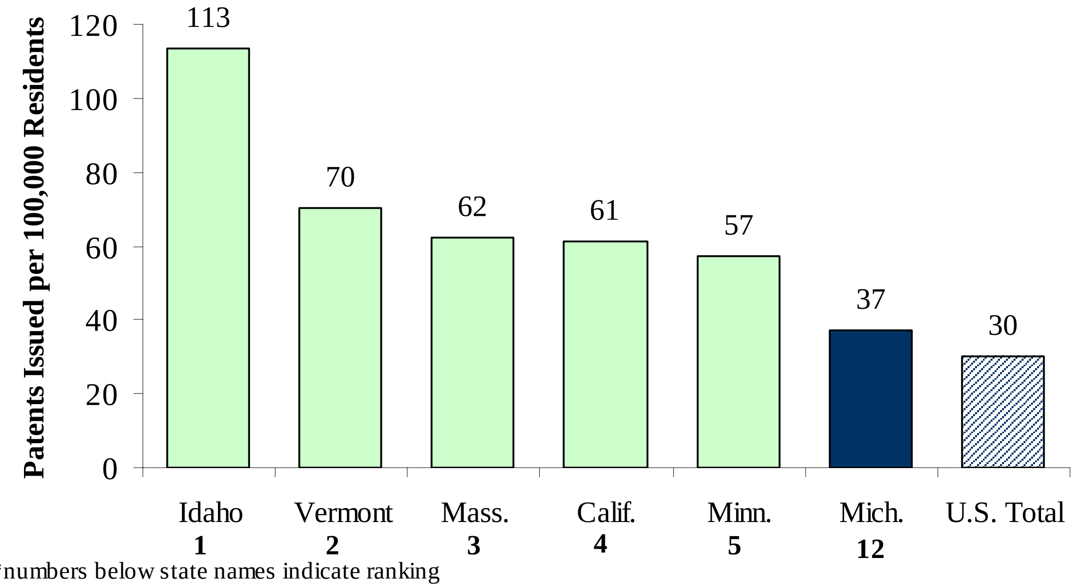
Tables 2 and 3 illustrate this issue in further detail. Michigan ranks first in the U.S. in its share of engineers, but is in the bottom 25^{th} percentile in terms of its relative share of scientists. Based on these observations, it is apparent that the state has been both a producer of, and an attractor for engineering talent—specifically those engineers involved in the design of motor vehicles and production processes associated with auto-manufacturing—but shows room for improvement when looking at scientific occupations. The one bright spot in this regard would be that it does employ a large number of scientists (31,000) in spite of its somewhat low percent share. Even then, however, it only has 20 percent of the scientists that California employs.

This is important because there are fundamental differences between how scientists and engineers each contribute to the innovative capacity of an economy. Scientists are generally more inclined to study natural and physical sciences to gain a better understanding of their particular field and contribute to its knowledge base. Their research can further engineers' understanding of natural and physical processes so that they are better equipped to effectively and efficiently create and apply innovative solutions for practical problems in society, business, etc. It would seem advantageous for a state to be not only well-equipped to apply knowledge and concepts to practical situations (where Michigan ranks high) but to also encourage contributive capacity to the natural and physical knowledge based upon which engineering solutions can be built.

Patents

Patents are widely considered a rough measure of the innovativeness of an economy[11]. They provide a raw indication of the number of new goods or services that have been created within a specific locality. As stated in the New Economy Index, the "capacity of firms to develop such new products will determine their competitive advantage and ability to pay higher wages"[12]. For fairness to smaller states, the relative number of patents (per population) will be examined here.

Chart 3: Patents per capita for Michigan, U.S. and top five states (2006)



Michigan ranks fairly high—12th overall—in the number of patents issued per capita, as seen in Chart 3[13]. However, to keep this in perspective, the state only does somewhat better when compared to the U.S. overall, and is significantly lower than all of those in the top five. The state's relative ranking has mostly stagnated over the past six years as well; it was ranked 11th overall in 2000.

Another potential factor affecting the conclusions drawn from this chart is the utilization of patents in the locality from which they originated. Michigan's overall patent picture may be affected by its relative ability or inability to utilize patents for commercial use when compared to other states. Future research and analysis may shed light on how to best measure this accurately. However, it is safe to assume that Michigan is likely not among the very best performers in innovation when looking at patent data, and is probably more accurately classified as average or slightly above on the national scale.

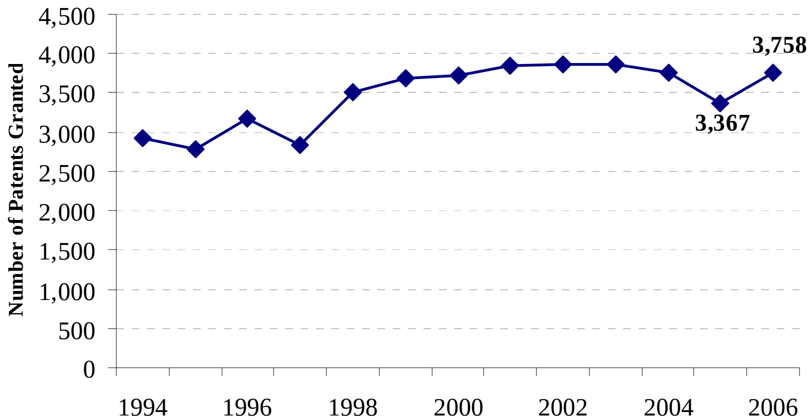
[11] While patents are often considered an output measure of innovation, meaning that the more patents issued, the more innovative the economy, it should be noted that there is an argument that such data should be viewed as an input measure to innovation. The argument is grounded in the fact that it is not the number of patents issued that matters, but how effectively those patents are utilized to create a finished product or service. Still, states with high relative numbers of patents also tend to score well in other innovative measures, and for our sake we will consider patent data as a raw (if only rough) measure of a state's innovative performance.

[12] *The 2002 New Economy Index*, available at http://www.neweconomyindex.org/states/2002/05_innovation_04.html

[13] Patent issuance data are from the U.S. Patent and Trademark Office.

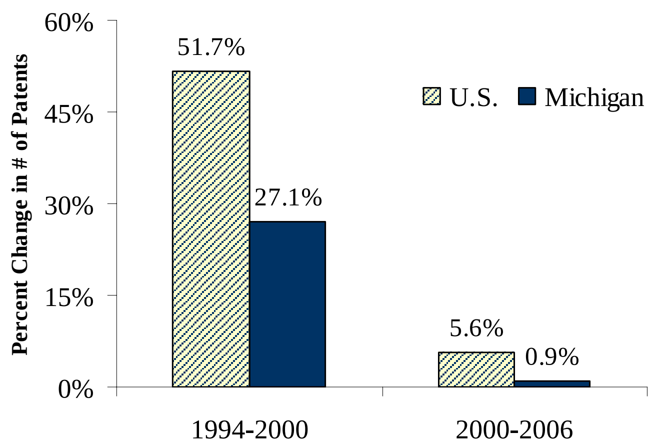
Chart 4 provides a recent historical view of the trends in innovation as measured by the annual level of patents in Michigan. Although experiencing a few ups and downs in the 1990s, patents inched upward but mostly leveled off in the 21st century, with the exception of a dip seen in 2005. Between 2004 and 2005, patents declined by 10.4 percent in the state, but this was largely the trend observed nationwide as well, with the U.S. reporting a drop of 11.4 percent in the same period. However, the U.S. and Michigan rebounded in 2006, even though the nation saw an increase of more than 20 percent in that time versus the statewide gain of 11.6 percent[14].

Chart 4: Patents issued over time in Michigan



The chart below displays patent growth rates for two time periods: the mid to latter part of the 1990s and early to mid 2000s. Looking at patents in this light reaffirms the conclusion that Michigan may not perform as well in patent production as an initial look at the data might lead one to believe. While positive growth was recorded in both of these time periods, Michigan clearly lagged the U.S. overall in terms of increasing its innovative contributions as measured by patent data. Between 1994 and 2000, the state's patents increased at a rate roughly half the U.S. overall, and from 2000-2006, the nation saw a growth rate more than six times the state's rate. Between 1994 and 2006 overall, Michigan's patents increased by an average of only 2.5 percent per year. The U.S. grew by 4.6 percent per year.

Chart 5: Patent growth rates since 1994



[14] While the state overall did not match the national performance average in terms of patent growth, the University of Michigan and Michigan State University were both in the top six percent of all universities nationwide in number of patents issued in 2005. This fact is offered as a footnote because the amount of these patents (only slightly more than 100 combined for the two schools)**,** are such a small share of overall number of patents in the state.

Industrial Research and Development

Industry investment in research and development measures capital invested in product or process development. This investment is vital in bringing new ideas to the marketplace, which is the essence of innovation.

Table 4: Top 10 states in industrial R&D (2004)

Rank	Area	Funds for industrial R&D (millions of dollars)	Gross Domestic Product by State (millions of current dollars)	R&D dollars per $10,000 GDP
N/A	US	$208,301	$11,633,572	$179
1	California	$46,614	$1,515,453	$308
2	**Michigan**	**$15,170**	**$363,380**	**$417**
3	Massachusetts	$11,819	$309,483	$382
4	New Jersey	$10,993	$409,156	$269
5	Texas	$10,992	$904,412	$122
6	Washington	$8,840	$252,384	$350
7	New York	$8,793	$908,308	$97
8	Illinois	$8,554	$534,364	$160
9	Pennsylvania	$8,005	$464,467	$172
10	Connecticut	$7,177	$183,873	$390

Industrial research and development in the U.S. totaled $208 billion in 2004, up four percent from 2003[15]. Michigan industrial R&D in 2004 fell slightly below its 2003 level, decreasing by 0.3 percent.

Industrial R&D spending is concentrated geographically, with the top 10 states accounting for two-thirds of the U.S. total in 2004. California led the nation in total industrial R&D spending; Michigan ranks second, with more than $15 billion in 2004. Adjusting the data for size provides some perspective on the R&D intensity of states' economies. As Table 4 shows, Michigan led the nation in industrial R&D spending per gross domestic product by state[16] (GDP), followed by Connecticut, Massachusetts, Washington and California.

The dominance of the auto industry in Michigan is evident in the high concentration of funds in manufacturing, which captured 93 percent of Michigan's R&D spending in 2004 (see chart 6). The U.S. overall showed more balance between manufacturing and non-manufacturing industries, with 71 percent in manufacturing. Motor vehicles, trailers, and parts (NAICS 3361-3363) accounted for 72 percent of Michigan's industrial R&D spending; chemical manufacturing, which includes pharmaceuticals and medicines, comprised 11 percent.

Michigan dominates auto related R&D spending in North America, accounting for more R&D than all other U.S. states, Canada[17], and Mexico[18] combined. In the U.S. alone, Michigan captured 70 percent of auto-related R&D in 2004. The Michigan Economic Development Corporation has identified more than 330 companies with automotive research and development facilities in Michigan, including nine of the world's 10 largest original equipment manufacturers[19].

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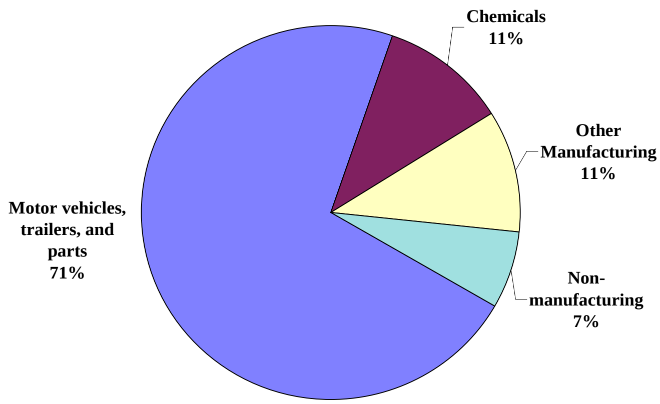
[15] Data regarding research and development spending in the U.S. are produced by the Survey of Industrial Research and Development, and published by the National Science Foundation (NSF); 2004 is the most recent year for which data were available at the time of publication.
[16] Gross Domestic Product (GDP) by state data are from the U.S. Dept. of Commerce, Bureau of Economic Analysis.
[17] Statistics Canada, catalogue no. 88-202-XIE. Table 3, Total intramural R&D expenditures by Industry.
[18] Battelle.org, Global R&D Report, September 2005. While the Battelle analysis does not estimate spending for specific industries, even assuming all 2004 industrial R&D estimated for Mexico was auto-related the statement is true.
[19] "Michigan Automotive Research and Development Facilities Directory", Third edition. Michigan Economic Development Corporation.

Chart 6: Distribution by industry of Michigan's industrial R&D spending (2004)

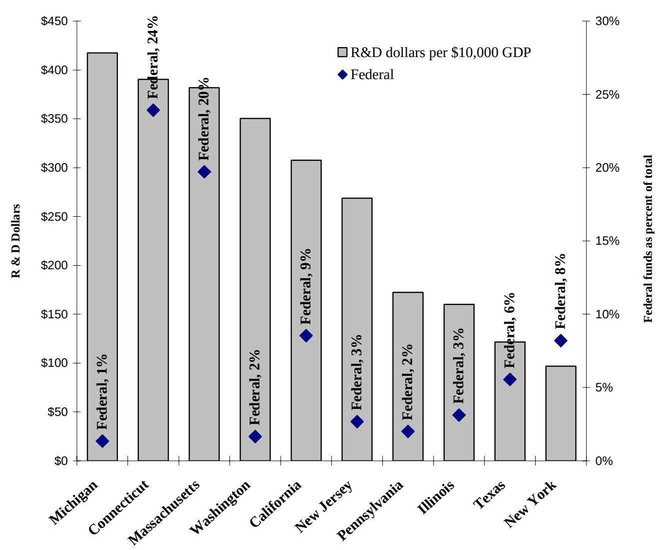


In R&D among non-manufacturing industries in Michigan, professional, scientific and engineering services (NAICS 54) captured the largest share, at three percent of the state's total; information (NAICS 51) followed, at 2.6 percent.

In 2004, federal funds accounted for $20.3 billion, or nearly 10 percent of total U.S. industrial R&D. Six states each had more than $1 billion in federal spending for industrial R&D in 2004[20]. Those six states – California, Connecticut, Florida, Maryland, Massachusetts and Virginia – accounted for nearly half of Department of Defense (DOD) obligations for industrial R&D, and two-thirds of the Department of Health and Human Services (HHS) obligations for industrial R&D that year. Michigan received .4 percent of DOD's industrial R&D obligations in 2004, and one percent of HHS[21].

Federal funds account for a smaller percent of Michigan's total industrial R&D spending than any other of the top 10 states. Federal funds added just $204 million to Michigan's total industrial R&D in 2004 (chart 7). Thus, Michigan's R&D intensity is more dependent on its companies and other sources and less dependent on support from the federal government than any other state in the top 10.

Chart 7: Federal contribution to states' industrial R&D intensity



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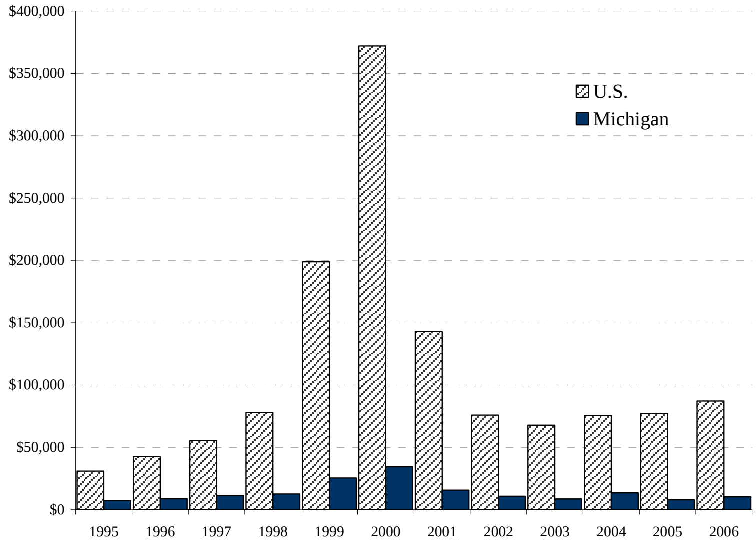
[20] Source: National Science Foundation, Federal Funds for Research and Development, Fiscal years 2004-2006: Table 90, Federal obligations for research and development, by state and other locations, selected agency, and performer: FY 2004. Note that geographic distribution of DOD obligations are reported based on the location of the prime contractor.

[21] In total 2004 R&D obligations to all performers, not just industry, Michigan accounts for .6 percent of DOD and nearly 2 percent of HHS.

Venture Capital

Venture capital is a key driver of innovation because it enables investment in young firms. It fosters growth by filling the financing gap for new businesses that lack the credit history expected by commercial lenders. Venture capital often takes an active role in management, adding value through expertise in managing and growing young ventures.

Chart 8: Venture capital dollars invested per 1,000 population (2006)



Nationally, $26 billion was invested by venture capitalists in 2006, the highest level since 2001[22]. The dominant trend in recent history is the surge in investment coincident with the rise of the 'dot-coms'. U.S. venture capital investment peaked at $105 billion in 2000. Michigan venture capital investment mirrored the national trend, peaking in 2000 at $342 million, and totaling $103 million in 2006.

Thirteen venture capital firms are located in Michigan[23]. This presence is important, because proximity is a consideration for venture capital firms in evaluating potential investments. At present, these Michigan firms have an estimated $60 million available for investment[24]. Several additional firms, while headquartered in other states, maintain offices in Michigan and source deals here as part of their investment strategy. Boosting venture capital investment is one of the strategies of Michigan's 21st Century Jobs Fund, which to date has direct investments of $55 million in venture capital funds. These funds in turn will be invested in Michigan companies.

Life sciences and information-related industries dominate venture capital investment, both nationally and in Michigan[25]. In 2006, life sciences captured 51 percent of venture capital investment in Michigan, and 28 percent in the U.S. Information-related industries accounted for 33 percent of Michigan, and 37 percent of U.S. investment.

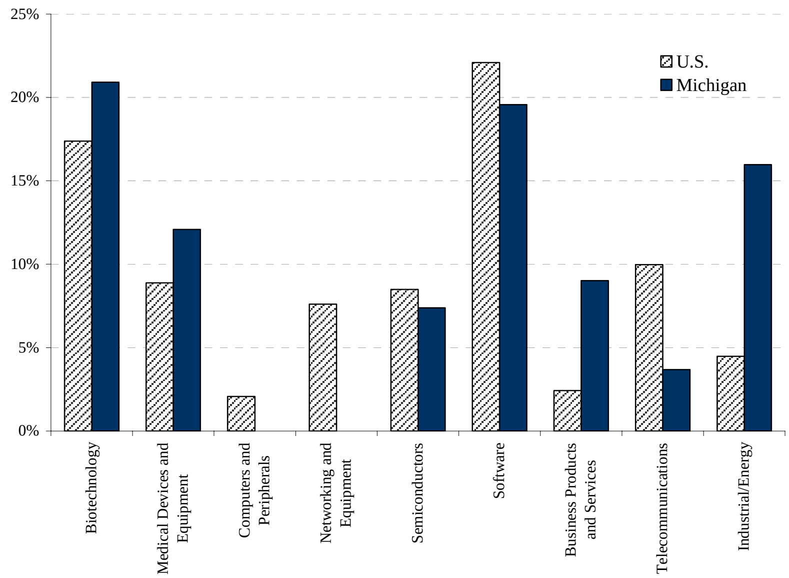
Because venture capital investment annually is placed in a limited number of deals – just 15 in Michigan in 2006 -- it is helpful to examine investment over a longer time period. Chart 9 shows Michigan and

[22] PricewaterhouseCoopers Moneytree™ Report is the source for data on venture capital investment in the U.S.
[23] Because venture capital firms tend to organize as limited liability partnerships, Michigan's single business tax has been cited as a factor that may have discouraged venture capital firms from locating in Michigan.
[24] According to the Michigan Venture Capital Association, these firms currently have an estimated $72 million available for investment; based on their investment strategies, 84 percent will be allocated to Michigan firms.
[25] Analysis based on data from the PricewaterhouseCoopers Moneytree™ Report. For purposes of this report, life sciences includes biotechnology and medical devices; information-related includes computers and peripherals, IT services, networking and equipment, semiconductors, and software.

U.S. venture capital investment by industry–during the period 2002-2006. During this period, life sciences captured one-third of all venture capital invested in Michigan.

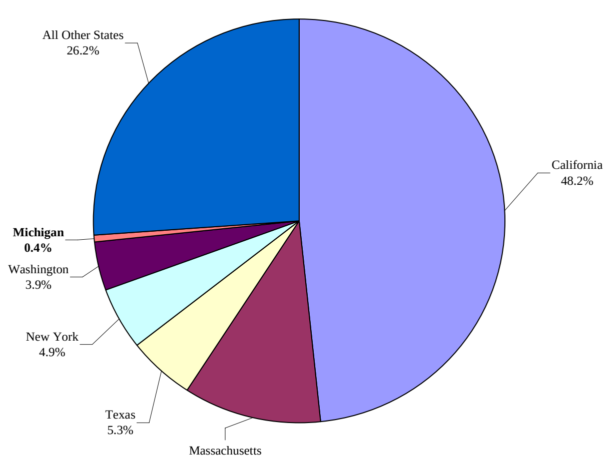
Investment in information related industries totaled 44 percent of venture capital nationally, compared to 37 percent in Michigan[26]. Industrial and energy companies captured 16 percent of Michigan's venture capital investment, a share four times greater than the percent this sector captured nationally.

Chart 9: Distribution of U.S. and Michigan Venture Capital Investments by Industry 2002-2006



Venture capital investment in the U.S. tends to be highly concentrated geographically, with the top 10 states representing 86 percent of 2006 investments. Chart 10 shows the distribution by state of 2006 total U.S. venture capital investment[27]. California alone commands nearly half of U.S. venture capital investment, a share that has grown from 40 percent a decade ago. While Michigan's venture capital investment has grown in absolute terms, its share of U.S. investment declined from 1995-2000; it has stabilized since. Michigan's 2006 percent of total US venture capital investment is 0.4 percent, equal to the state's average over the last five years.

Chart 10: Geographic distribution of U.S. 2006 venture capital dollars invested



[26] Investment in software development was strong nationally and in the state; networking and equipment, and computers and peripherals accounted for 10% of investment nationally, but were negligible in Michigan.
[27] Analysis based on data from PricewaterhouseCoopers Moneytree™ Report.