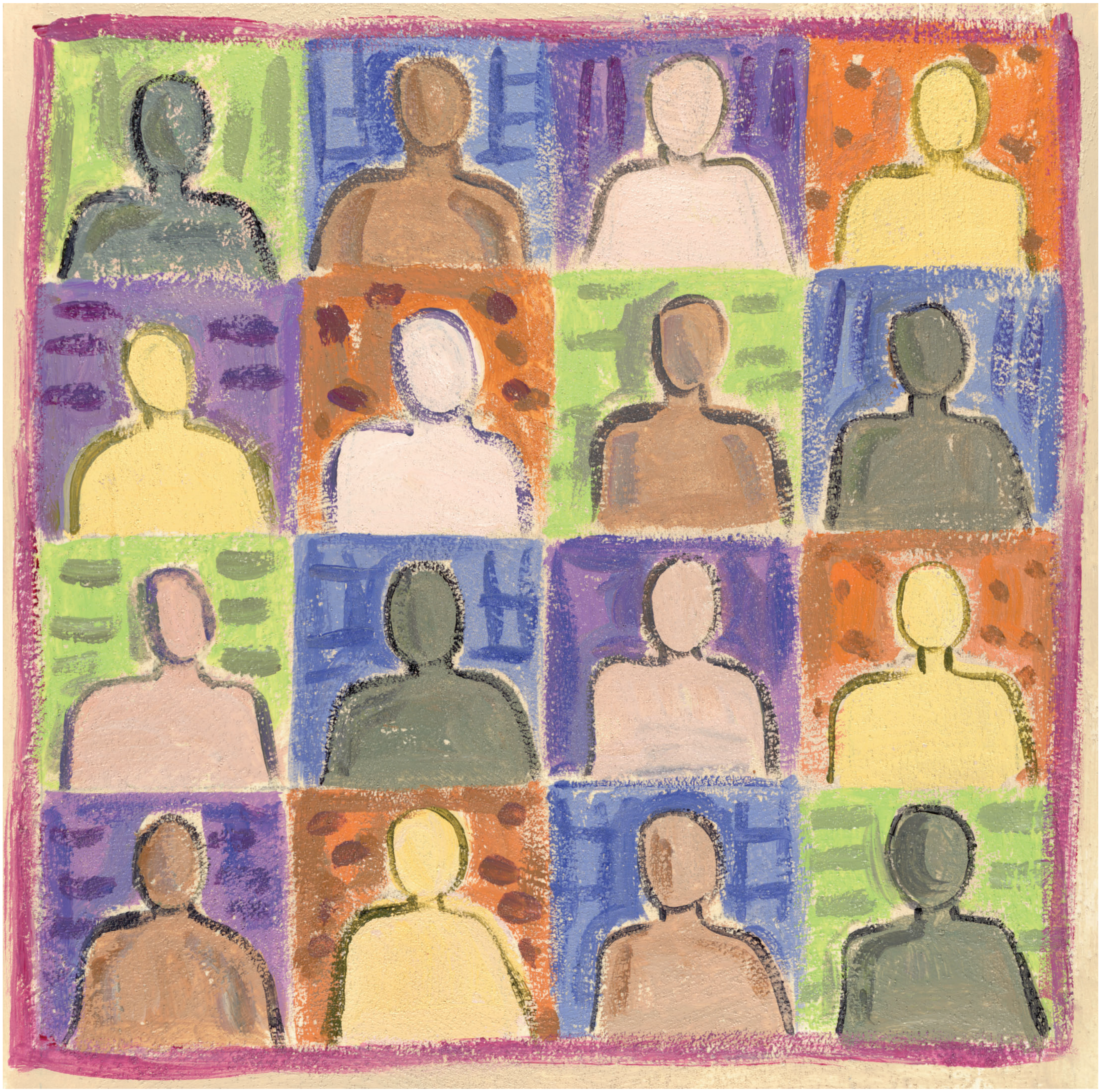


Economic Effects of Intellectual Property-Intensive Manufacturing in the United States

by Robert J. Shapiro and Nam D. Pham
with foreword by Alan S. Blinder

July 2007

Table of Contents

FOREWORD

While we live in the Information Age, tangible items like bricks and mortar, stores and offices, factories and mines, drill presses and lathes cannot be ignored. Physical capital remains vital to our nation's (or any nation's) GDP, productivity, wages and employment. The policy emphasis on more capital spending, in the U.S. and elsewhere, is not misplaced. Nonetheless, in a real sense, it is ideas that rule the world. So the U.S. and other governments interested in promoting growth should pay at least equal attention to policies that foster technology and innovation.

Perhaps surprisingly, this has always been so — or at least for as long as we have data. From the earliest studies of what is called "growth accounting" by Robert Solow and Edward Denison in the 1950s, right up to the latest studies, economists have consistently found that what is called "the residual" contributes more to economic growth than either growth of labor input or growth of the capital stock — sometimes more than both of them combined. Because "the residual" is the part of growth that *cannot* be accounted for by increasing inputs of labor and capital, it is not a stretch to identify it with technology, which is exactly what generations of economists have done.

As Robert Shapiro and Nam Pham remind us in this fascinating study, an increasing share of the market valuation of the top U.S. companies is now apparently based on "intangibles" ("ideas," if you will), rather than on companies' stockpiles of physical assets. They reckon that this share of value rose from about 25 percent in 1984 to about 64 percent in 2005 — a huge increase in just two decades. It is true that market valuations of ideas can sometimes run amok, as the late 1990s illustrated dramatically. But, irrational exuberance aside, there is genuine, lasting value in ideas — at least for society. For example, while almost all of the dot.coms of 1999 have disappeared into the sands of history, the economic value of the Internet is huge and growing.

One reason why ideas are slippery things to *value* is that they are slippery things to *measure*. Mere counting certainly will not do, even if we had some way to count ideas — for, plainly, there is an immense difference in value between a good idea and a useless one. So economists look for proxy measures, of which expenditures on research and development (R&D) is probably the leading candidate. Although the process is inherently risky and random, more intense searching for ideas (as measured by R&D spending) will probably turn up more good ones. And an impressive amount of economic research, dating back decades, supports this hypothesis. Shapiro and Pham follow in this rich tradition. This body of research, by the way, also shows that R&D expenditures have, on average, offered high rates of return.

While the federal government spends enormous sums on R&D, that impressive expenditure is dwarfed by private sector R&D spending — on which Shapiro and Pham concentrate, focusing on the manufacturing sector. Which industries do the spending? All of them — but far from equally. Shapiro and Pham neatly divide major U.S. manufacturing industries into high-R&D and low-R&D sectors according to how much they spend on R&D per employee. The division is surprisingly clean and sharp. If we ignore the ever-present (but uninterpretable) "miscellaneous" category, the *highest* spender among the low-R&D industries (electrical equipment) spent an average of about $5,600 per employee on R&D over the years 2000-2004. By contrast, the *lowest* spender among the high-R&D industries (basic chemicals) spent about twice as much. According to Shapiro and Pham, the five biggest-spending industries, in order, were (with spending per employee in parentheses):

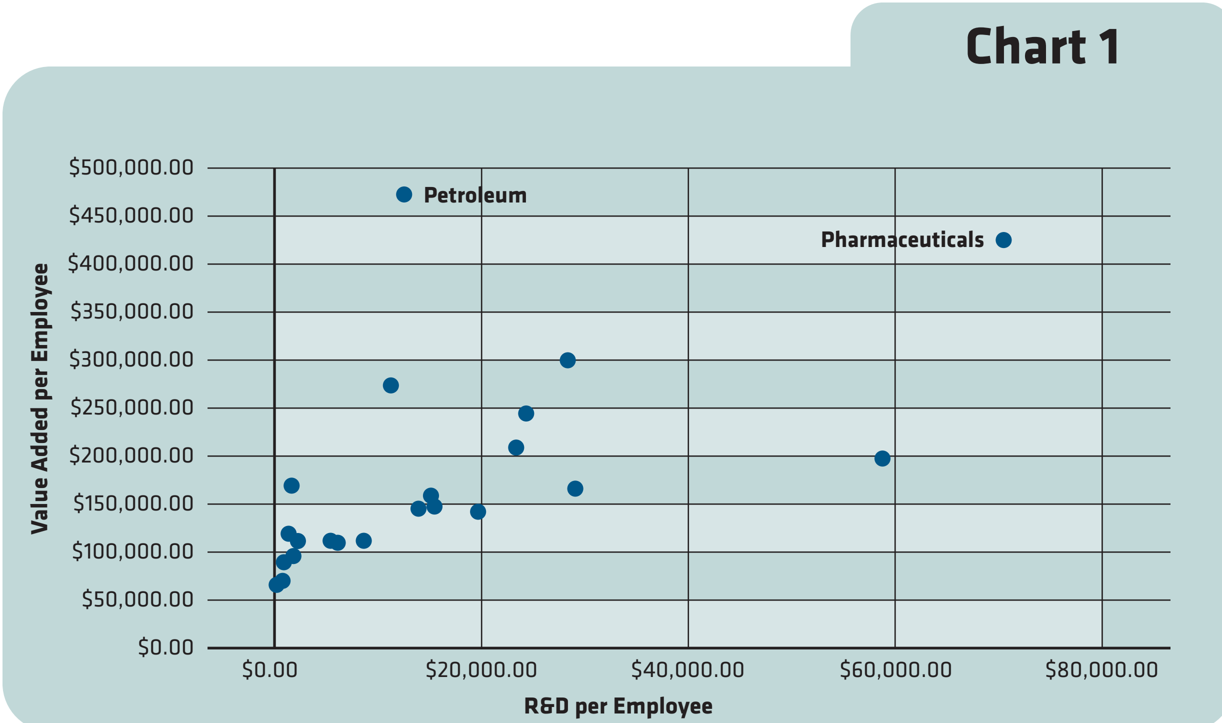
Pharmaceuticals	**($70,055)**
Communications Equipment	**($57,551)**
Semiconductors	**($30,257)**
Computers and peripherals	**($24,458)**
Resins and synthetic fibers	**($24,272)**

Note that the rankings drop off significantly after second place.

Shapiro and Pham show that the high-R&D industries stand out in other respects, too. They had higher value added per worker; they paid higher wages; and they lost jobs at a slower pace. (The manufacturing sector as a whole lost 16 percent of its employment over the 2000-2004 period; among its specific industries, jobs increased only in pharmaceuticals.)

The sharpest correlation of all is with value added per employee, which is a rough measure of *productivity*. To a remarkable degree, America's most productive manufacturing industries are the ones that invest the most in R&D. How strong is that relationship? The picture on the next page should be worth a thousand words. It plots R&D per employee horizontally and value added per employee vertically; and the positive

R&D per Employee and Value Added per Employee Relationship



correlation is visible to the naked eye. Two industries stand out from the others with extremely high value added per employee: petroleum and pharmaceuticals. The story with petroleum is simple: The high price of oil enabled the industry to produce huge value added with little R&D. If we remove this one outlier, the "correlation coefficient" rises to a high value of +0.79; and the relationship looks roughly linear.

Shapiro and Pham conclude that U.S. policymakers should foster the *creation* of more intellectual property (IP) and work harder to *protect* the IP that American companies already have. However, with or without IP protection, good ideas will be copied, modified, improved upon and invented around. Today's fresh new invention is destined to become tomorrow's stale old idea. If America is to remain the leader of the economic pack, we must keep on innovating in the future — just as we have done in the past. Shapiro and Pham are right that the incentive to create IP depends, in part, on our ability to protect it. But it also depends on other things, such as entrepreneurship, a sensible tax system, a steady flow of scientific and engineering talent, vibrant capital markets and government support for basic science. Together, these and other ingredients comprise the raw materials for faster economic growth, higher productivity and higher wages.

Alan S. Blinder
Princeton University

May 2007

EXECUTIVE SUMMARY

The creation and adoption of new ideas — in a word, innovation — is a very powerful factor that helps to determine progress of modern economies. Economists trace 30 percent to 40 percent of all U.S. gains in productivity and growth over the course of the 20th century to economic innovation in its various forms. Today, some two-thirds of the value of America's large businesses can be traced to the intangible assets that embody ideas, especially the intellectual property (IP) of patents and trademarks. Promoting and protecting new intellectual property should be a high priority for U.S. policymakers.

Here, we explore some of the ways that the generation of intellectual property in U.S. manufacturing benefits workers and companies. American manufacturing divides fairly clearly into industries that invest heavily in the research and development that generates new intellectual property, and others that do not. The most IP-intensive industries, on a per-employee basis, are pharmaceuticals, communications equipment and semiconductors — especially as compared to industries such as textiles and apparel, food and beverages, or wood products. By several important measures, IP-intensive areas of manufacturing produce relatively much larger benefits, with the most IP-intensive industry, pharmaceuticals and biopharmaceuticals, generating the greatest such benefits.

Today, some two-thirds of the value of America's large businesses can be traced to the intangible assets that embody ideas, especially the intellectual property (IP) of patents and trademarks.

- From 2000 to 2004, IP-intensive manufacturing produced much more value per employee than non-IP-intensive manufacturing — some $181,000 per worker, per year, compared to less than $106,000 — and in the most IP-intensive industry, pharmaceuticals, an average worker produced more than $425,000 in value every year.

- From 2000 to 2004, IP-intensive manufacturing paid much higher wages, on average, than non-IP intensive manufacturing — nearly $51,000 per worker compared to just over $35,000 — and in the most IP-intensive industry, an average worker earned almost $66,000 a year.

- Manufacturing employment contracted sharply from 2000 to 2004, with both IP-intensive and non-IP intensive industries shrinking their workforce, on average, by 15 percent to 16 percent. The one manufacturing area that expanded its workforce was the most IP-intensive: Jobs in pharmaceutical companies increased by more than 8 percent over this period.

- Even as manufacturing jobs contracted overall, science and engineering jobs grew — by about 17 percent in IP-intensive industries, compared to 13 percent in non-IP-intensive manufacturing. Again, science and engineering jobs grew much faster in highly-IP-intensive areas — up nearly 86 percent in pharmaceuticals and 88 percent in computer manufacturing.

These findings reflect the growing role that intellectual property plays in American growth and productivity. Moreover, IP-intensive industries in both manufacturing and services provide much of America's current comparative advantages in the global economy. Government policy must recognize that protecting and promoting the creation and adoption of new products, processes and business methods is critical to the country's future prosperity and growth.

I. Introduction

In the last generation, the "idea-based" economy has moved from metaphor to reality in the United States. In 1984, the book value of the top 150 public companies — what their physical assets would bring on the open market — equaled about 75 percent of their stock market value.[1] American businesses were worth roughly what their land, equipment and buildings could be sold for. In 2005, the book value of America's 150 largest public firms equaled 36 percent of their stock market capitalization: Some two-thirds of the value of large U.S. companies now lies in their intangible assets — mainly their intellectual property (IP), or patents and trademarks, as well as databases, brands, organizational techniques, and their employees' knowledge, experience and relationships.[2]

Here, we explore some of the concrete economic benefits of generating this intellectual property. Using National Science Foundation data on industry investments in the research and development (R&D) activities that produce intellectual property across U.S. manufacturing, we found that these investments have a range of positive economic effects. Focusing the analysis on manufacturing subsectors and industries that undertook some R&D over the years 2000 to 2004, we found that those which are relatively more IP-intensive produce greater value added per employee, pay higher average wages and have stronger records in job creation than those that are less IP-intensive. The data further show that the most highly IP-intensive subsectors and industries produce the greatest value added gains and the highest wages. Some of these effects also are evident across state economies. Although state-by-state data on R&D investments are less reliable than the industry-level data, states with higher IP-producing R&D per employee pay higher average wages and, to a lesser degree, produce higher value added per employee.

- Our analysis identified five subsectors and nine industries under them that are IP-intensive, compared to 11 other subsectors. We also identified 15 states with relatively IP-intensive manufacturing, compared to 36 others.[3] Over the years 2000 to 2004:

- IP-intensive industries produced about 72 percent more value added, per employee ($181,417) than non-IP-intensive industries ($105,703).

- The average employee in IP-intensive industries earned about 44 percent more ($50,998) than the average employee in non-IP-intensive industries ($35,359).

- All U.S. manufacturing lost about 3 million jobs, with IP-intensive industries shedding jobs at modestly lower rates than non-IP-intensive areas. Setting aside one IP-intensive sector — computer/electronics, which shifted thousands of jobs offshore in this period — non-IP-intensive areas shed jobs two-thirds faster than IP-intensive industries.

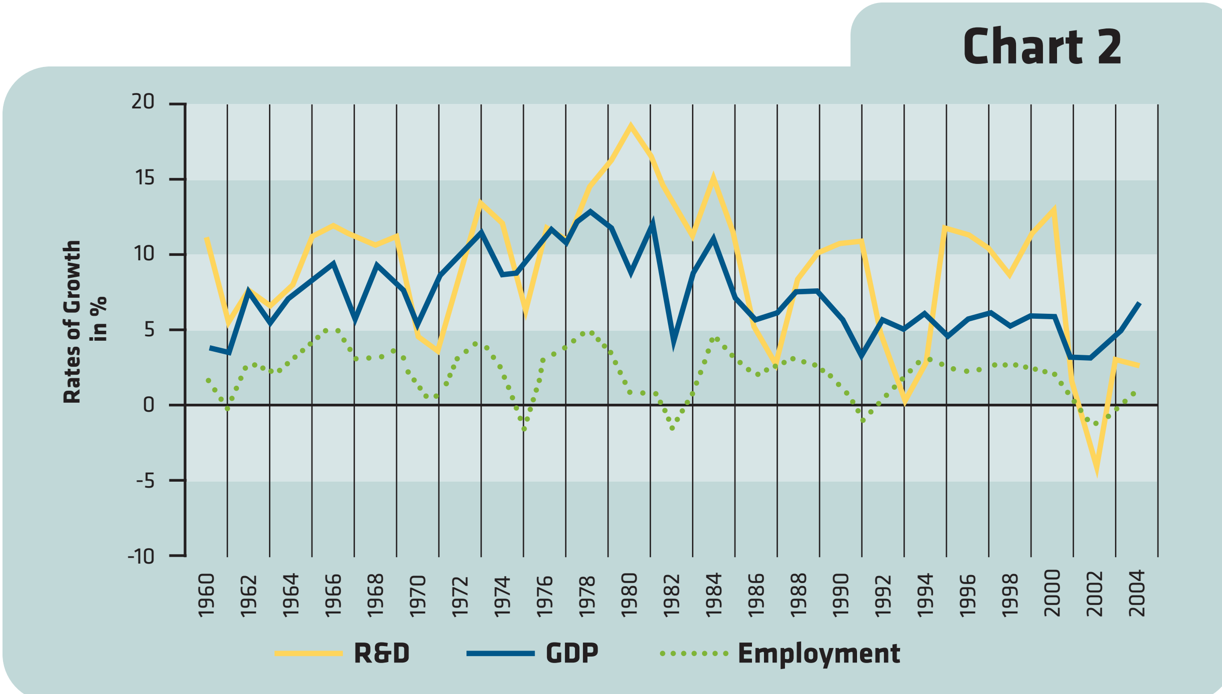
- IP-intensive industries also created new science and engineering jobs at a 28 percent higher rate than non-IP-intensive areas. Excluding computers/electronics, IP-intensive industries created those jobs at a rate nearly 140 percent higher than non-IP-intensive areas.

...we found that those that are relatively more IP-intensive produce greater value added per employee, pay higher average wages, and have stronger records in job creation than those that are less IP-intensive.

- The most IP-intensive manufacturing industry is pharmaceuticals, which invested $70,055 a year per employee in R&D over the 2000-2004
    - Pharmaceutical firms generated an average $425,529 in value added per employee compared to $130,218 for all manufacturing;
    - Pharmaceutical firms paid average wages of $65,702 compared to $40,358 for all manufacturing;

1 McKinsey Global Institute.
2 The research was supported by World Growth. The analysis and conclusions are solely those of the authors.
3 Includes District of Columbia.

Rates of Growth of R&D, Nominal GDP and Employment, 1960-2004[4]



- Pharmaceutical firms expanded their workforce by 8.3 percent, compared to job losses of 16.1 percent for all manufacturing.

- An average manufacturing worker in IP-intensive states earned $44,760, or nearly $7,000 a year, and 18.2 percent more than the average employee in non-IP-intensive states, at $37,865.

- IP-intensive states produced about $3,000 more value added per manufacturing employee ($131,404) than non-IP-intensive states ($128,447).

These results support numerous analyses pointing to the large role that idea-based industries play in American growth and prosperity.

These results support numerous analyses pointing to the large role that idea-based industries play in American growth and prosperity. One hallmark study found that two of the economy's most IP-intensive industries, computer hardware and software, were responsible for 35 percent of the country's real economic growth in the latter 1990s, when they accounted for just 8 percent of GDP.[5] Other studies trace one-half to three-fourths of recent U.S. productivity gains to the same industries.[6] Researchers also have found that the pharmaceutical and biotechnology industry, by many measures the economy's most IP-intensive area, expands GDP by at least $27 billion annually, on a permanent basis, for every one-time R&D investment of $15 billion.[7] These effects may help explain why movements in overall GDP and employment generally track movements in R&D spending by private firms, as shown in the figure above.

4 Chart 2, Industrial R&D Performance in the United States, By Source of Funds: 1953-2004, National Science Foundation, http://www.nsf.gov/statistics/nsf07314/content.cfm?pub_id=2488&id=2.

5 Stephen Oliner and Daniel Sichel, "The Resurgence of Growth in the Late 1990s: Is Information Technology the Story?" Federal Reserve Board, May 2000; Congressional Budget Office, *The Budget and Economic Outlook, Fiscal Years 2001-2010,* Appendix A; *The Economic Report of the President,* February 2000, Table 2-3; Dale Jorgenson and Kevin Stiroh, "Raising the Speed Limit: U.S. Economic Growth in the Information Age," May 2000; Karl Whelan, "Computers, Obsolescence and Productivity," Table 4, February 2000.

6 Frank Lichtenberg, "Pharmaceutical Innovation, Mortality Reduction, and Economic Growth," National Bureau of Economic Research, Working Paper No. 6569, May 1999.

7 "The Emerging Digital Economy II," Economics and Statistics Administration, U.S. Department of Commerce, June 1999.

Why IP can have significant economic effects is clear when we trace the impact of particular R&D spending. A biopharmaceutical firm or a company that develops microprocessors commits R&D funding over a period of years and develops a new, FDA-approved treatment for HIV or a faster graphical processor. IP protections enable the developers to recoup their large R&D investments — the typical, new biopharmaceutical costs about $1.2 billion to develop[8] — and earn healthy rates of return, increasing their operating funds and profits. More operating capital supports additional R&D or market-expanding activities, creating new, highly paid jobs to support those activities. The higher profits are distributed to shareholders, increasing their incomes. Their higher incomes lead to either higher consumption, which creates jobs to produce the additional goods and services they purchase; or higher savings, which increases business investment and creates jobs to produce the goods and services purchased in investment activities.

The creation of valuable, new IP has other significant, direct economic benefits. For example, a new microprocessor may increase the efficiency and productivity of countless firms and workers that adopt it, raising company profits, workers' wages, and triggering the second-level income and job benefits already noted. Similarly, new biomedical treatment may raise the efficiency of health-care companies, with all those effects, and save or extend the lives of people who then continue to be productive.

Measuring an Industry's Use and Creation of Intellectual Property

Determining how manufacturing companies and industries that create intellectual property affect jobs and growth in the larger economy involves, first, measuring the activities involved in producing IP. This issue is usually approached as part of analyses measuring the impact of innovation. Virtually all such studies measuring intellectual property start with spending for research and development, because research has shown that R&D correlates closely with rates of successful invention or innovation.[9] Researchers have further found that increases in R&D produce more than proportional increases in inventive output.[10] Moreover, R&D has proved to be a more accurate and useful proxy than patent filings or patent awards for both the creation of valuable IP and innovation generally.[11] Since R&D correlates with successful innovation, it is unsurprising that a long line of studies also have found that R&D spending by firms is closely associated with rising profits and market value.[12]

Since R&D correlates with successful innovation, it is unsurprising that a long line of studies also have found that R&D spending by firms is closely associated with rising profits and market value.[12]

We follow these lines of research here and measure the IP intensity of sectors, subsector and industries by the ratio of their R&D spending to their number of employees, and measure the IP intensity of states by the ratio of R&D spending by companies to their number of employees. In addition to calculating the IP intensity of each manufacturing subsector and industry that conducts any R&D, we categorize each as either IP-intensive or non-IP-intensive, based on whether their IP intensity is greater or less than average for all R&D manufacturing subsectors and industries. We then compare the economic performance of each of these manufacturing subsectors and industries, in terms of their value added, job creation and wages. We find that IP-intensive manufacturing subsectors and industries perform generally much better on all of these measures than their non-IP-intensive counterparts.

While the federal government spends considerable

8 Grabowski testimony.
9 Rogers, M., "The Definition and Measurement of Innovation," Melbourne Institute Working Paper, 1998.
10 Mansfield, E., "Industrial Research and Development Expenditures: Determinants, Prospects, and Relation to Size of Firm and Inventive Output," Journal of Political Economy, August 1964.
11 Hall, B.H., "Innovation and Market Value," Working Paper, 1998. Revised in 2000 and published in R. Barrell, G. Mason, and M. O'Mahony, eds., Productivity, Innovation and Economic Performance. New York: Cambridge University Press, 2000.
12 Rogers, 1998, op cit; . Greenhalgh, Christine & Rogers, Mark, "The Value of Innovation: The Interaction of Competition, R&D and IP," Research Policy, Elsevier, May 2006; Pakes, A., "On Patents, R&D, and the Stock Market Rate of Return," Journal of Political Economy, April 1985; Greenhalgh, C. and Longland, M., "Intellectual Property in UK Firms: Creating Intangible Assets and Distributing the BBenefits via Wages and Jobs," Oxford Bulletin of Economics and Statistics, 2001.

amounts on R&D, private enterprises accounted for more than 90 percent of all R&D expenditures in recent years, including $188 billion of a national total of $208 billion in 2004.[13] We also focused this research on those industries that report some R&D spending, as reported by the National Science Foundation, and examined those with relatively high IP intensity, compared to those with relatively low IP intensity. The analysis covers the years 2000 to 2004, because in 1999 the Commerce Department and National Science Foundation shifted from the SIC industry-classification system to the current NAICS classification system. The data on R&D spending, employment, scientific and engineering employment, value added and payrolls, by subsector and industry, are in Table A of the Appendix.

IP Intensity of U.S. Manufacturing Subsectors and Industries: R&D per Employee, 2000-2004

Table 1

	R&D *(millions)*	Employment	R&D per Employee	IP Intensity
All Manufacturing	**$113,443**	**14,954,000**	**$7,634**	–
IP Intensive	**$94,064**	**4,692,000**	**$20,039**	●
Petroleum, coal	$1,273	103,000	$12,373	●
Chemicals	$24,128	849,000	$28,580	●
Basic chemicals	$1,980	176,000	$11,249	●
Resin, synthetic rubber, fibers	$2,494	102,000	$24,272	●
Pharmaceuticals	$16,902	239,000	$70,055	●
Computers and electronics	$39,173	1,349,000	$29,281	●
Computers, peripherals	$3,922	168,000	$24,458	●
Communications equipment	$12,353	210,000	$57,551	●
Semiconductors	$13,800	478,000	$30,257	●
Navigational, measuring equipment	$8,389	427,000	$19,623	●
Transportation equipment	$23,501	1,687,000	$14,012	●
Motor vehicles, trailers	$16,416	1,071,000	$15,333	●
Aerospace products	$6,151	406,000	$15,621	●
Miscellaneous	$5,989	704,000	$8,552	●
Non-IP Intensive	**$19,378**	**10,257,000**	**$1,889**	
Food, beverages, tobacco	$2,140	1,635,000	$1,309	
Textiles, apparel, leather	$329	901,000	$392	
Wood	$142	549,000	$259	
Paper, printing	$2,640	1,241,000	$2,133	
Plastics, rubber	$1,807	963,000	$1,880	
Nonmetallic minerals	$699	493,000	$1,405	
Primary metals	$552	521,000	$1,079	
Fabricated metals	$1,444	1,633,000	$884	
Machinery	$6,388	1,218,000	$5,284	
Electrical equipment	$2,934	513,000	$5,629	
Furniture	$303	590,000	$517	

● = High

13 Federal funds for industrial R&D performance in the United States, by industry and company size: 1999-2003, National Science Foundation; www.nsf.gov/statistics/nsf07314/content.cfm?pub_id=2488&id=2.

II. Impact of Intellectual Property on Economic Performance in Manufacturing

The National Science Foundation reports that 16 manufacturing subsectors record some R&D spending, including nine industries under three manufacturing subssectors. Based on R&D spending per employee, five of these subsectors are IP intensive: petroleum and coal; chemicals, including three industries (basic chemicals, pharmaceuticals and biopharmaceuticals, and resin, synthetic rubber and fibers); computers and electronics, with four industries (computers and peripherals, communications equipment, semiconductors, and navigational and measuring equipment); transportation equipment, with two industries (motor vehicles and trailers, and aerospace products); and the miscellaneous subsector. These five subsectors, with 4,692,000 employees, or 31 percent of the manufacturing workforce, account for $94.064 billion in R&D spending, or 83 percent of all manufacturing R&D. The most IP-intensive industry by far is pharmaceuticals and biopharmaceuticals, with R&D spending of $70,055 per employee — nearly 10 times the $7,634 average for all manufacturing — followed by communications equipment at $57,551 per employee. R&D spending in the five IP-intensive subsectors and their industries averaged $20,039 per employee, or nearly three times the average for all manufacturing.

By contrast, 11 manufacturing subsectors had below-average R&D spending per employee and are considered non-IP intensive: food, beverages and tobacco; textiles, apparel and leather; wood; paper and printing;

Table 2

IP Intensity and Economic Growth: R&D and Value Added per Employee, Annual Average, 2000-2004[14]

	IP Intensity	R&D per Employee	Value Added per Employee	Value Added Performance
All Manufacturing	–	**$7,634**	**$130,218**	–
IP Intensive	●	**$20,039**	**$181,417**	●
Petroleum, coal	●	$12,373	$471,585	●
Chemicals	●	$28,580	$302,336	●
Basic chemicals	●	$11,249	$273,116	●
Resin, synthetic rubber, fibers	●	$24,272	$243,303	●
Pharmaceuticals	●	$70,055	$425,529	●
Computers and electronics	●	$29,281	$168,180	●
Computers, peripherals	●	$24,458	$209,775	●
Communications equipment	●	$57,551	$197,317	●
Semiconductors	●	$30,257	$170,214	●
Navigational, measuring	●	$19,623	$143,610	●
Transportation equipment	●	$14,012	$145,797	●
Motor vehicles, trailers	●	$15,333	$148,949	●
Aerospace products	●	$15,621	$158,026	●
Miscellaneous	●	$8,552	$110,565	
Non IP Intensive		**$1,889**	**$105,703**	
Food, beverages, tobacco		$1,309	$168,930	●
Textiles, apparel, leather		$392	$64,712	
Wood		$259	$67,627	
Paper, printing		$2,133	$108,456	
Plastics, rubber		$1,880	$95,081	
Nonmetallic minerals		$1,405	$113,256	
Primary metals		$1,079	$117,505	
Fabricated metals		$884	$87,190	
Machinery		$5,284	$110,085	
Electrical equipment		$5,629	$108,348	
Furniture		$517	$71,530	

● = High

14 Table 12, Company and Other Non-federal Funds for R&D, National Science Foundation, http://www.nsf.gov/statistics/nsf07314/content.cfm?pub_id=2488&id=2; and County Business Pattern, U.S. Census Bureau, http://censtats.census.gov/cgi-bin/cbpnaic/cbpsel.pl.

The close associations are clear when it comes to wages: The average wage in IP-intensive manufacturing subsectors and industries is substantially greater than the average for all manufacturing ...

plastics and rubber; nonmetallic minerals; primary metals; fabricated metals; machinery; electrical equipment; and furniture. These 11 subsectors employ 10,527,000 workers, or nearly 69 percent of the U.S. manufacturing workforce, and spend a total of $19.378 billion on R&D, or just 17.1 percent of all manufacturing R&D. The average R&D per employee among these subsectors comes to $1,889, or 9.4 percent of the $20,039 per employee R&D investments in IP-intensive areas.

IP Intensity and Value Added per Employee

The data also clearly show a close association between the IP intensity of these subsectors and industries, and the average contribution per worker to the American economy. To measure those contributions, we analyzed the value added per employee by subsector and industry. All together, the 16 subsectors had an average annual value added of $130,218 per employee over the period 2000 to 2004. On average, each employee in an IP-intensive subsector added $181,417 in economic value to the economy each year, or about 40 percent more than the average for all manufacturing employees. The top three IP-intensive sectors, in value added per employee, were petroleum and coal ($471,585 each per year), pharmaceuticals and biopharmaceuticals ($425,529) and overall chemicals ($302,336). The average employee in these three, very high IP-intensive areas added between 2.3 and 3.6 times as much value to the economy as the average manufacturing worker. Four of the five IP-intensive sectors and all nine industries under those subsectors also had above-average annual value added per employee; well above the average for all manufacturing. (The exception was miscellaneous manufacturing. *(Table 2)*

The correlation between IP intensity and value added per employee is also clear among non-IP-intensive subsectors. On average, each employee in a non-IP-intensive subsector added $105,703 in economic value to the economy each year, or 41 percent less than the average employee in an IP-intensive subsector. Ten of the 11 non-IP-intensive subsectors also produced below-average value added per employee. Their contributions ranged from $64,712 per employee in textiles, apparel and leather, and $67,627 in wood, to $168,930 value added per employee in food, beverages and tobacco, the only non-IP-intensive subsector that performed above average in value added.

We also found some striking associations between the growth in R&D in subsectors and industries — closely related to how much their IP intensity increased or declined — and gains or declines in their value added. From 2000 to 2004, R&D in the pharmaceutical and biopharmaceutical industries grew from $12.8 billion to $32.5 billion, an increase of almost 150 percent, or about nine times the 16.5 percent R&D growth for all manufacturing. Over the same period, the pharmaceutical industry's value added increased by more than 45 percent, compared to 3.4 percent for all manufacturing. By contrast, R&D expenditures in the communications equipment industry, with the second highest IP intensity over this period, declined almost 50 percent from more than $16 billion in 2000 to about $8 billion in 2004. Over this same period, the industry's total value added also declined by almost 50 percent.

IP Intensity and Wages per Employee

The close associations are clear when it comes to wages: The average wage in IP-intensive manufacturing subsectors and industries is substantially greater than the average for all manufacturing, while workers in non-IP intensive subsectors earn substantially lower than the average for all manufacturing.

Table 3 shows that over the years 2000 to 2004, the average wage in U.S. manufacturing was $40,358. Every IP-intensive subsector and industry reported higher wages, except one (miscellaneous manufacturing). The average for IP-intensive subsectors was $50,998, or 26 percent above all manufacturing. The IP-intensive sectors with the highest average wages were pharmaceuticals and biopharmaceuticals workers ($65,702), petroleum and coal workers ($64,947), and communications equipment workers ($64,062), all about 60 percent higher than the average wage for all manufacturing workers. Conversely, all non-IP-

15 www.bls.gov/data.

intensive subsectors except one (primary metals) paid average wages lower than overall manufacturing. The average workers in non-IP-intensive manufacturing earned $35,359 a year in this period, or nearly one-third less than the average for IP-intensive subsectors.

IP Intensity and Employment

Recent years have seen large and historically anomalous losses in U.S. jobs in manufacturing. The 2001 downturn lasted nine months, from February to November, and produced the smallest GDP decline of any postwar recession, one-half of one percent. By historical standards, such a GDP decline should have produced about 500,000 job losses. In fact, data from the Bureau of Labor Statistics show that U.S. private employment fell very sharply and kept on contracting for nearly three years after the recession ended, losing more than 3.4 million private-sector jobs from February 2001 to its trough in July and August of 2003.[15] Moreover, the private sector took 52 months to get back to its February 2001 job levels, compared to 18 months in previous postwar recessions.

Most of these losses hit manufacturing. Manufacturing companies employed about 15 percent of all private-sector workers when the 2001 recession began; yet, some 2.6 million of the 3.4 million job losses from early 2001 to mid-2003, or more than three-quarters of the total, came from manufacturing. Moreover, overall private-sector employment has recovered — *albeit* anemically by historical standards — but manufacturing jobs have continued to contract. In January 2000, the first month of this study, 17.3 million Americans held jobs in U.S. manufacturing

Table 3

IP Intensity and Wages: R&D and Wages per Employee, Annual Average, 2000-2004[16]

	IP Intensity	R&D per Employee	Average Wage	Wage Performance
All Manufacturing	–	**$7,634**	**$40,358**	
IP Intensive	●	**$20,039**	**$50,998**	●
Petroleum, coal	●	$12,373	$64,947	●
Chemicals	●	$28,580	$55,588	●
Basic chemicals	●	$11,249	$60,561	●
Resin, synthetic rubber, fibers	●	$24,272	$53,945	●
Pharmaceuticals	●	$70,055	$65,702	●
Computers and electronics	●	$29,281	$56,410	●
Computers, peripherals	●	$24,458	$59,832	●
Communications equipment	●	$57,551	$64,062	●
Semiconductors	●	$30,257	$50,924	●
Navigational, measuring equipment	●	$19,623	$59,839	●
Transportation equipment	●	$14,012	$49,389	●
Motor vehicles, trailers	●	$15,333	$47,436	●
Aerospace products	●	$15,621	$59,761	●
Miscellaneous	●	$8,552	$37,588	
Non IP-Intensive		**$1,889**	**$35,359**	
Food, beverage, tobacco		$1,309	$32,117	
Textiles, apparel, leather		$392	$25,521	
Wood		$259	$29,663	
Paper, printing		$2,133	$38,951	
Plastics, rubber		$1,880	$34,168	
Nonmetallic minerals		$1,405	$38,075	
Primary metals		$1,079	$43,606	●
Fabricated metals		$884	$36,566	
Machinery		$5,284	$43,231	
Electrical equipment		$5,629	$37,941	
Furniture		$517	$29,238	

● = High

16 Table 12, Company and Other Non-federal Funds for R&D, National Science Foundation, http://www.nsf.gov/statistics/nsf07314/content.cfm?pub_id=2488&id=2; and County Business Pattern, U.S. Census Bureau, http://censtats.census.gov/cgi-bin/cbpnaic/cbpsel.pl.

Employment and Employment Changes, Manufacturing, 2000-2004[17]

Table 4

	IP Intensity	Employment 2000	Change 2000-2004	Job Growth 2000-2004
All Manufacturing		**16,473,994**	**-2,652,018**	**-16.1%**
IP Intensive	●	**5,156,988**	**-792,572**	**-15.4%**
Excluding Computers	●	**3,599,901**	**-343,824**	**-9.6%**
Petroleum, coal	●	109,223	-5,296	-4.8%
Chemicals	●	885,848	-62,828	-7.1%
Basic chemicals	●	191,979	-26,770	-13.9%
Resin, synthetic rubber, fibers	●	113,573	-19,626	-17.3%
Pharmaceuticals	●	227,461	18,836	8.3%
Transportation equipment	●	1,872,630	-246,888	-13.2%
Motor vehicles, trailers	●	1,198,065	-148,321	-12.4%
Aerospace products	●	446,243	-73,600	-16.5%
Miscellaneous	●	732,200	-28,812	-3.9%
Computers and electronics	●	1,557,087	-448,748	-28.8%
Computers, peripherals	●	193,897	-68,038	-35.1%
Communications equipment	●	256,501	-105,308	-41.1%
Semiconductors	●	571,377	-197,648	-34.6%
Navigational, measuring equipment	●	461,516	-60,183	-13.0%
Non-IP Intensive		**11,317,066**	**-1,859,446**	**-16.4%**
Primary metals		601,627	-150,485	-25.0%
Fabricated metals		1,790,817	-276,222	-15.4%
Machinery		1,377,950	-290,006	-21.0%
Electrical equipment		589,406	-150,342	-25.5%
Furniture		640,444	-85,076	-13.3%
Food, beverages, tobacco		1,637,484	-520	0.0%
Textiles, apparel, leather		1,134,057	-414,805	-36.6%
Wood		597,684	-62,885	-10.5%
Paper, printing		1,367,332	-229,133	-16.8%
Plastics, rubber		1,056,507	-148,407	-14.0%
Nonmetallic minerals		523,698	-51,565	-9.8%

● = High

companies; and in February 2001, the number was still 17 million. By July 2003, when overall U.S. private-sector employment hit its low point in this business cycle, just 14.4 million Americans still held manufacturing jobs; and by December 2004, the last month covered in this study, manufacturing jobs had declined a little more to 14.3 million. The latest data, for February 2007, show that while overall private-sector employment has recovered somewhat to 115.2 million, manufacturing jobs have edged down further to 14.1 million.

While overall employment fell sharply in U.S. manufacturing over this period, the number of IP-producing jobs — full-time equivalent research and development scientists and engineers (S&E) — rose by 101,000 jobs in all manufacturing.

While IP-intensive industries have been far from immune from these very strong trends, they also performed better than non-IP-intensive sectors in this area from 2000 to 2004. IP-intensive manufacturing sectors employed 5.2 million workers in 2000 and lost some 793,000 jobs over the period, a decline of 15.4 percent, compared to non-IP-intensive sectors which employed 11.3 million people in 2000 and lost 1.9 million jobs, or a 16.4 percent decline.

17 Table 12, Company and Other Non-federal Funds for R&D, National Science Foundation, http://www.nsf.gov/statistics/nsf07314/content.cfm?pub_id=2488&id=2; and County Business Pattern, U.S. Census Bureau, http://censtats.census.gov/cgi-bin/cbpnaic/cbpsel.pl.

Table 5

Scientists and Engineers, Employment and Employment Changes, Manufacturing, 2000-2004[18]

	IP Intensity	S&E Employment 2000	Changes 2000-2004	Job Growth 2000-2004
All Manufacturing		**617,000**	**101,200**	**16.4%**
IP Intensive	●	**472,000**	**80,900**	**17.2%**
Excluding Computers	●	**211,000**	**67,900**	**32.0%**
Petroleum, coal	●	3,000	1,000	33.3%
Chemicals	●	83,000	37,000	42.9%
Basic chemicals	●	13,000	-2,400	-18.5%
Resin, synthetic rubber, fibers	●	10,000	- 600	-6.0%
Pharmaceuticals	●	43,000	36,900	85.8%
Transportation equipment	●	109,000	25,100	23.0%
Motor vehicles, trailers	●	76,000	13,000	17.1%
Aerospace products	●	25,000	12,900	51.6%
Miscellaneous	●	17,000	4,800	28.2%
Computers and electronics	●	261,000	13,000	4.7%
Computers, peripherals	●	24,000	21,000	87.9%
Communications equipment	●	92,000	- 42,100	- 45.8%
Semiconductors	●	65,000	32,400	49.8%
Navigational, measuring equipment	●	78,000	-3,400	-4.4%
Non-IP Intensive		**145,000**	**20,300**	**13.4%**
Primary metals		5,000	-100	-2.0%
Fabricated metals		11,000	4,700	42.7%
Machinery		54,000	8,600	15.9%
Electrical equipment		24,000	-4,600	-19.2%
Furniture		3,000	-100	-3.3%
Food, beverages, tobacco		10,000	6,400	64.0%
Textiles, apparel, leather		2,000	3,800	190.0%
Wood		2,000	-1,000	-50.0%
Paper, printing		13,000	3,000	15.4%
Plastics, rubber		13,000	1,100	8.5%
Nonmetallic minerals		8,000	-1,500	-18.8%

● = High

There were important variations across sectors. Jobs in pharmaceutical and biopharmaceutical manufacturing, the most IP-intensive industry, actually rose by almost 19,000, or nearly 9 percent. On the other hand, one subsector, computers and electronics, accounted for nearly 60 percent of all job losses in IP-intensive manufacturing. Excluding that subsector, the 11 non-IP-intensive subsectors lost jobs at a 67 percent greater rate than the other four IP-intensive manufacturing subsectors.

IP Intensity and Jobs in Science and Engineering

While overall employment fell sharply in U.S. manufacturing over this period, the number of IP-producing jobs — full-time equivalent research and development scientists and engineers (S&E) — rose by 101,000 jobs in all manufacturing. Some 80 percent of the gains were in the IP-intensive subsectors and industries. Moreover, these R&D jobs grew 28 percent faster in IP-intensive industries (17.2 percent) than in non-IP-intensive manufacturing (13.4 percent). Once again, within IP-intensive manufacturing, computers and electronics lagged significantly, with gains of less than 5 percent. Excluding that subsector, science and engineering jobs in the other four IP-intensive subsectors grew 32 percent, or more than twice the rate of non-IP-intensive manufacturing. Moreover, in pharmaceuticals, jobs in science and engineering increased nearly 86 percent.

18 Table 12, Company and Other Non-federal Funds for R&D, Table 41, Full-time Equivalent Scientists and Engineers by Industry, National Science Foundation, http://www.nsf.gov/statistics/nsf07314/content.cfm?pub_id=2488&id=2; and County Business Pattern, U.S. Census Bureau, http://censtats.census.gov/cgi-bin/cbpnaic/cbpsel.pl.

Average R&D and Average Wages, per Manufacturing Employee, by State, 2000-2004[19]

Table 6

	IP Intensity	R&D per Employee	Wage per Employee	Wage Performance
All Manufacturing		**$9,683**	**$40,268**	
IP Intensive	●	**$17,219**	**$44,760**	●
Arizona	●	$11,012	$42,630	●
California	●	$18,573	$45,434	●
Colorado	●	$16,829	$42,308	●
Connecticut	●	$23,766	$49,095	●
Delaware	●	$23,934	$42,902	●
District of Columbia	●	$23,114	$37,316	
Idaho	●	$9,896	$37,383	
Illinois	●	$9,828	$41,135	●
Maryland	●	$16,704	$44,808	●
Massachusetts	●	$24,057	$49,686	●
Michigan	●	$20,127	$46,532	●
Minnesota	●	$11,832	$41,632	●
New Hampshire	●	$12,751	$41,763	●
New Jersey	●	$23,399	$47,907	●
Oregon	●	$13,039	$40,997	●
Non-IP Intensive		**$5,701**	**$37,865**	
Alabama		$1,899	$33,932	
Alaska		$300	$35,305	
Arkansas		$779	$29,704	
Florida		$5,205	$36,755	
Georgia		$2,525	$34,416	
Hawaii		NA	$31,743	
Indiana		$6,735	$40,877	●
Iowa		$3,505	$36,559	
Kansas		$8,846	$38,242	
Kentucky		$1,740	$38,078	
Louisiana		$1,264	$42,942	●
Maine		NA	$37,309	
Mississippi		$2,872	$29,338	
Missouri		$4,038	$35,617	
Montana		$1,581	$33,160	
Nebraska		$1,128	$32,721	
Nevada		$4,377	$38,546	
New Mexico		$6,437	$35,390	
New York		$8,056	$40,643	●
North Carolina		$3,843	$33,151	
North Dakota		NA	$32,042	
Ohio		$5,519	$41,296	●
Oklahoma		$1,885	$35,231	
Pennsylvania		$7,637	$39,261	
Rhode Island		NA	$36,984	
South Carolina		$2,672	$36,337	
South Dakota		$893	$30,835	
Tennessee		$2,280	$35,959	
Texas		$8,326	$40,803	●
Utah		$4,249	$36,494	
Vermont		$1,902	$39,904	
Virginia		$8,131	$37,923	
Washington		$8,258	$45,325	●
West Virginia		$2,608	$37,557	
Wisconsin		$4,492	$38,871	
Wyoming		NA	$37,889	

● = High

19 State manufacturing R&D data from 2003 and 2004, and include R&D spending by the federal government as well as private firms. Table 35, Funds for R&D by State, National Science Foundation, http://www.nsf.gov/statistics/nsf07314/content.cfm?pub_id=2488&id=2; and County Business Pattern, U.S. Census Bureau, http://censtats.census.gov/cgi-bin/cbpnaic/cbpsel.pl.

III. Impact of Intellectual Property-Based Manufacturing on State Economies

Intellectual property-based companies and industries are distributed across the country in ways that can affect the overall economic performance of manufacturing in the states. As in our preceding analysis of subsectors and industries, we measure the IP intensity of each state economy based on its R&D investments by manufacturing concerns, per manufacturing employee, over the years 2000 to 2004.[20]

The data show a clear correlation between the IP intensity of a state's manufacturing and the wages earned by manufacturing workers in that state.

We found 15 states (including the District of Columbia) that are relatively IP intensive, with R&D spending per manufacturing employee averaging $17,219, compared to the national average of $9,683 and three times the $5,701 average for the 36 non-IP-intensive states. The five states with the most IP-intensive manufacturing sectors are Massachusetts ($24,057 R&D investment per manufacturing employee, nearly three times the national average and four times the average for non-IP-intensive states); Delaware ($23,934); Connecticut ($23,766); New Jersey ($23,399); and the District of Columbia ($23,114). (The underlying data on average annual R&D spending, value added, wage payrolls and employment in manufacturing, by state, for 2000-2004, is provided in the Appendix, Table B.)

State economies are more economically diverse and subject to much greater variation in the forces affecting their performance than subsectors and industries. Therefore, the links between IP intensity and the wages, value added and employment in manufacturing, by states, are less direct and less strong than those found for subsectors and industries. The strongest relationship appears in wages: Manufacturing workers in state with relatively IP-intensive manufacturing sectors earn significantly higher wages, on average, than their counterparts in states with non-IP-intensive manufacturing. In addition, manufacturing companies in states that are relatively IP intensive produce significantly higher value added, per manufacturing employee, than less IP-intensive states. However, we can find no link between the IP intensity of the manufacturing sector, by state, and job creation rates by states.

IP Intensity and Manufacturing Wages per Employee, by State

The data show a clear correlation between the IP intensity of a state's manufacturing and the wages earned by manufacturing workers in that state *(Table 6)*. Eighteen states and the District of Columbia have above-average manufacturing wages, including 13 of the 15 IP-intensive states, as compared to six of 36 non-IP-intensive states. The annual wage earned by manufacturing workers in IP-intensive states averaged $44,760, or $6,895 more and 18.2 percent greater than the average of $37,865 in non-IP-intensive states. The four states with the most IP-intensive manufacturing sectors — Massachusetts, Delaware, Connecticut and New Jersey — reported average annual manufacturing wages of $47,398, or $9,533 more and 25.2 percent greater than the average in non-IP-intensive states.

IP Intensity and Value Added per Employee in Manufacturing, by State

The data also show some general correlation between the IP intensity of a state's manufacturing sector and the value added it produces *(Table 7)*. Sixteen states and the District of Columbia produced above-average value added in manufacturing, including seven of the 15 IP-intensive states as compared to 10 of 36 non-IP-intensive states. The value added produced by manufacturing companies in IP-intensive states averaged $131,404, or $2,957 more and 2.3 percent greater than the average of $128,447 average in non-IP-intensive states. The four states with the most IP-intensive manufacturing sectors — Massachusetts, Delaware, Connecticut and New Jersey — reported average value added of $140,125, or $11,678 more and 9.1 percent greater than the average for non-IP-intensive states.

State economies are more economically diverse and subject to much greater variation in the forces affecting their performance than subsectors and industries.

20 2003 and 2004 R&D data by state are used.

Average R&D and Value Added, per Manufacturing Employee, by State, 2000-2004[21]

Table 7

	IP Intensity	R&E per Employee	Value Added per Employee	Value Added Performance
All Manufacturing		**$9,683**	**$129,479**	
IP Intensive	●	**$17,219**	**$131,404**	●
Arizona	●	$11,012	$153,781	●
California	●	$18,573	$133,222	●
Colorado	●	$16,829	$118,889	
Connecticut	●	$23,766	$127,903	
Delaware	●	$23,934	$157,601	●
District of Columbia	●	$23,114	$61,594	
Idaho	●	$9,896	$138,649	●
Illinois	●	$9,828	$128,699	
Maryland	●	$16,704	$124,085	
Massachusetts	●	$24,057	$132,296	●
Michigan	●	$20,127	$128,793	
Minnesota	●	$11,832	$117,726	
New Hampshire	●	$12,751	$104,896	
New Jersey	●	$23,399	$142,700	●
Oregon	●	$13,039	$143,035	●
Non-IP Intensive		**$5,701**	**$128,447**	
Alabama		$1,899	$101,919	
Alaska		$300	$129,130	
Arkansas		$779	$102,346	
Florida		$5,205	$108,249	
Georgia		$2,525	$125,702	
Hawaii		NA	$85,324	
Indiana		$6,735	$136,800	●
Iowa		$3,505	$141,096	●
Kansas		$8,846	$115,262	
Kentucky		$1,740	$125,445	
Louisiana		$1,264	$201,904	●
Maine		NA	$110,573	
Mississippi		$2,872	$89,944	
Missouri		$4,038	$131,257	●
Montana		$1,581	$101,658	
Nebraska		$1,128	$114,712	
Nevada		$4,377	$115,144	
New Mexico		$6,437	$245,608	●
New York		$8,056	$125,841	
North Carolina		$3,843	$140,976	●
North Dakota		NA	$112,205	
Ohio		$5,519	$127,539	
Oklahoma		$1,885	$116,991	
Pennsylvania		$7,637	$126,514	
Rhode Island		NA	$97,001	
South Carolina		$2,672	$119,637	
South Dakota		$893	$109,003	
Tennessee		$2,280	$119,507	
Texas		$8,326	$147,417	●
Utah		$4,249	$112,159	
Vermont		$1,902	$116,681	
Virginia		$8,131	$155,432	●
Washington		$8,258	$134,155	●
West Virginia		$2,608	$115,530	
Wisconsin		$4,492	$121,793	
Wyoming		NA	$156,492	●

● = High

21 State manufacturing R&D data from 2003 and 2004, and include R&D spending by the federal government as well as private firms. Table 35, Funds for R&D by State, National Science Foundation, http://www.nsf.gov/statistics/nsf07314/content.cfm?pub_id=2488&id=2; and County Business Pattern, U.S. Census Bureau, http://censtats.census.gov/cgi-bin/cbpnaic/cbpsel.pl.

IV. Conclusion

The United States is the world's most innovative large economy, and a handful of industries create much of the intellectual property that drives the majority of that economic innovation. Moreover, the development and application of the innovations that embody such new intellectual property are the most powerful forces driving gains in productivity and incomes. As we establish in this analysis, the economy's most IP-intensive manufacturing industries also produce disproportionate economic benefits. They produce much more value added per employee than other areas of manufacturing; their employees, on average, earn much higher incomes than other manufacturing workers; and their job-creation records are better than other manufacturing industries. IP-intensive industries also contribute to the economic performance of states. Like IP-intensive industries, state economies that are relatively IP intensive create more value added per employee than other states, and the average manufacturing worker in IP-intensive states earns considerably more than his or her counterpart in non-IP-intensive states.

Given these powerful economic effects, U.S. policymakers should accord much greater priority to protecting intellectual property. For example, they should create a new, cabinet-level White House position to oversee how all federal activities — in trade, in legal issues addressed by the Patent and Trademark Office and the Justice Department, in the budget, and in economic regulation — may affect IP and its protections. One place to begin would be increased federal support for the basic research on which much private-sector R&D depends, especially in health-care areas.

IP-intensive industries also are part of America's current comparative advantages in world trade. Innovative U.S. companies increasingly look to world markets to recover the high costs of developing most new products and processes, because as the pace of innovation accelerates, innovators have fewer years to recover those costs. As a result, protecting the IP rights of American citizens and companies in foreign markets should receive much higher priority in U.S. trade policy and negotiations. For example, the current administration has generally failed to pursue intellectual-property cases at the World Trade Organization — filing only three WTO cases in the last six years against countries for their tolerating widespread violations of the IP rights of Americans, compared to 15 cases filed by the preceding administration in its last four years.

The administration also should accord as much priority to foreign violations of IP rights in the patent area as it has recently to foreign violations of copyrights.

The administration also should accord as much priority to foreign violations of IP rights in the patent area as it has recently to foreign violations of copyrights. Commerce Secretary Carlos M. Gutierrez has criticized China and India for software piracy and copyright infringements in entertainment and branded products but publicly ignored widespread violations of patent rights in the same countries. The administration also failed to protest a recent move by the Thai government to unilaterally abrogate the patents of U.S. pharmaceutical and biopharmaceutical companies, much as it ignored similar actions by Brazil in 2005. Respect by foreign governments for the IP rights of American citizens and companies should have high priority in U.S. trade negotiations, and the administration should consider withholding access to the General System of Preferences for countries that tolerate widespread violations of those rights.

The administration and Congress should finally recognize the central role in America's economic life played by those who generate valuable, new intellectual property. Across U.S. economic, budgetary, trade and regulatory policies, they should take serious and systematic steps to protect and promote its future creation and dissemination.

APPENDIX

Average Annual R&D, Value Added, Payroll, Employment, and Scientists and Engineers (S&E), by Manufacturing Subsector and Industry, 2000-2004[22]

Table A

	R&D *(millions)*	Value Added *(millions)*	Payroll *(millions)*	Employees	S&E
All Manufacturing	**$113,443**	**$1,936,338**	**$602,179**	**14,954,000**	**641,000**
Food, beverages, tobacco	2,140	276,170	52,504	1,635,000	11,000
Textiles, apparel, leather	329	57,678	22,788	901,000	3,000
Wood	142	37,033	16,270	549,000	2,000
Paper, printing	2,640	134,230	48,265	1,241,000	14,000
Petroleum, coal	1,273	48,593	6,688	103,000	4,000
Chemicals	24,128	256,004	47,157	849,000	92,00
Basic chemicals	1,980	47,868	10,682	176,000	10,000
Resin, synthetic rubber, fibers	2,494	24,761	5,521	102,000	11,000
Pharmaceuticals	16,902	102,224	15,767	239,000	54,000
Plastics, rubber	1,807	91,152	32,815	963,000	12,000
Nonmetallic minerals	699	55,593	18,729	493,000	7,000
Primary metals	552	60,206	22,632	521,000	5,000
Fabricated metals	1,444	141,765	59,618	1,633,000	13,000
Machinery	6,388	133,390	52,531	1,218,000	57,000
Computers and electronics	39,173	224,853	75,904	1,349,000	250,000
Computers, peripherals	3,922	34,878	10,052	168,000	23,000
Communications equipment	12,353	41,760	13,456	210,000	71,000
Semiconductors	13,800	79,413	24,340	478,000	79,000
Navigational, measuring equip.	8,389	61,104	25,524	427,000	74,000
Electrical equipment, appliances	2,934	55,247	19,398	513,000	22,000
Transportation equipment	23,501	244,408	83,188	1,687,000	122,000
Motor vehicles, trailers	16,416	158,536	50,749	1,071,000	81,000
Aerospace products	6,151	63,999	24,241	406,000	31,000
Furniture	303	42,088	17,244	590,000	3,000
Miscellaneous	5,989	77,718	26,451	704,000	22,000

22 Company and Other Non-federal Funds for R&D, Employment in R&D Performing Companies, Full-time Equivalent Scientists and Engineers by Industry, National Science Foundation, http://www.nsf.gov/statistics/nsf07314/content.cfm?pub_id=2488&id=2; and County Business Pattern, U.S. Census Bureau, http://censtats.census.gov/cgi-bin/cbpnaic/cbpsel.pl.

APPENDIX

Table B

Average Annual R&D, Value Added, Payroll and Employment, Manufacturing Sector, by State, 2000-2004[23]

	R&D (millions)	Value Added (millions)	Payroll (millions)	Employment
All Manufacturing	**$129,092**	**$1,936,263**	**$602,179**	**14,954,405**
IP Intensive	**$83,196**	**$684,844**	**$233,277**	**5,211,753**
Arizona	$1,831	$27,532	$7,632	179,037
California	$27,732	$214,227	$73,060	1,608,052
Colorado	$2,326	$17,944	$6,386	150,932
Connecticut	$4,607	$27,246	$10,458	213,018
Delaware	$883	$6,189	$1,685	39,270
District of Columbia	$44	$136	$82	2,207
Idaho	$603	$8,748	$2,359	63,092
Illinois	$6,837	$97,575	$31,187	758,159
Maryland	$2,407	$18,595	$6,715	149,859
Massachusetts	$7,374	$45,811	$17,205	346,279
Michigan	$13,499	$92,907	$33,567	721,371
Minnesota	$3,976	$41,426	$14,650	351,882
New Hampshire	$983	$9,031	$3,596	86,095
New Jersey	$7,770	$50,703	$17,022	355,315
Oregon	$2,327	$26,774	$7,674	187,185
Non-IP Intensive	**$45,896**	**$1,251,419**	**$368,902**	**9,742,652**
Alabama	$525	$30,220	$10,061	296,506
Alaska	$3	$1,366	$374	10,582
Arkansas	$160	$22,260	$6,461	217,498
Florida	$1,930	$42,047	$14,277	388,430
Georgia	$1,114	$58,869	$16,118	468,320
Hawaii	NA	$1,236	$460	14,480
Indiana	$3,677	$78,985	$23,602	577,378
Iowa	$772	$32,319	$8,374	229,060
Kansas	$1,542	$20,976	$6,959	181,983
Kentucky	$452	$33,943	$10,303	270,582
Louisiana	$189	$31,012	$6,596	153,596
Maine	NA	$7,749	$2,615	70,078
Mississippi	$499	$17,105	$5,579	190,171
Missouri	$1,235	$42,062	$11,414	320,454
Montana	$29	$1,977	$645	19,448
Nebraska	$117	$12,091	$3,449	105,400
Nevada	$185	$4,637	$1,552	40,275
New Mexico	$213	$8,613	$1,241	35,070
New York	$4,881	$81,330	$26,267	646,293
North Carolina	$2,234	$90,176	$21,205	639,653
North Dakota	NA	$2,614	$746	23,296
Ohio	$4,563	$112,429	$36,403	881,523
Oklahoma	$268	$17,860	$5,378	152,661
Pennsylvania	$5,157	$92,091	$28,579	727,911
Rhode Island	NA	$6,078	$2,317	62,663
South Carolina	$746	$36,089	$10,961	301,652
South Dakota	$34	$4,507	$1,275	41,351
Tennessee	$896	$50,644	$15,239	423,774
Texas	$7,039	$131,382	$36,365	891,224
Utah	$467	$12,845	$4,179	114,521
Vermont	$74	$5,021	$1,717	43,032
Virginia	$2,454	$50,393	1$2,295	324,212
Washington	$2,072	$37,613	$12,708	280,367
West Virginia	$178	$8,139	$2,646	70,450
Wisconsin	$2,200	$63,195	$20,169	518,875
Wyoming	$6	$1,547	$374	9,883

23 State manufacturing R&D data from 2003 and 2004, and include R&D spending by the federal government as well as private firms. Company and Other Non-federal Funds for R&D, Employment in R&D Performing Companies, National Science Foundation, http://www.nsf.gov/statistics/nsf07314/content.cfm?pub_id=2488&id=2; and County Business Pattern, U.S. Census Bureau, http://censtats.census.gov/cgi-bin/cbpnaic/cbpsel.pl.

Annual R&D Expenditures, by Manufacturing Subsector and Industry, 2000-2004 ($ millions)[24]

Table C

	NAICS	2000	2001	2002	2003	2004
Manufacturing	**31–33**	**$113,173**	**$112,733**	**$101,344**	**$108,079**	**$131,887**
Food, beverages, tobacco	311,312	$1,562	1,970	2,204	2,160	2,804
Textiles, apparel, leather	313–16	$266	255	248	309	568
Wood	321	$105	181	132	138	152
Paper, printing	322, 323	$2,700	2,664	2,620	2,909	2,308
Petroleum, coal	324	$1,172	1,057	1,233	1,308	1,595
Chemicals	325	$20,768	17,713	20,395	22,693	39,070
Basic chemicals	3251	$2,050	1,835	1,710	1,991	2,312
Resin, synthetic rubber, fibers	3252	$2,842	2,745	2,413	2,390	2,080
Pharmaceuticals	3254	$12,793	10,137	14,186	15,949	31,444
Plastics, rubber	326	$1,675	2,245	1,508	1,729	1,879
Nonmetallic minerals	327	$845	978	420	470	783
Primary metals	331	598	479	461	518	705
Fabricated metals	332	1,631	1,545	1,251	1,329	1,465
Machinery	333	6,539	6,337	6,366	6,224	6,473
Computers and electronics	334	44,526	44,744	33,411	32,495	40,691
Computers, peripherals	3341	5,162	3,165	3,015	2,561	5,707
Communications equipment	3342	16,156	18,721	9,524	8,932	8,433
Semiconductors	3344	12,787	14,210	11,871	12,607	17,524
Navigational, measuring equipment	3345	10,114	7,565	8,549	7,834	7,882
Electrical equipment, appliances	335	3,390	4,680	1,978	2,002	2,622
Transportation equipment	336	22,917	21,004	21,452	26,111	26,019
Motor vehicles, trailers, parts	3361–63	18,306	16,089	15,199	16,874	15,610
Aerospace products	3364	3,895	4,083	5,349	8,203	9,224
Furniture	337	284	301	251	275	406
Miscellaneous manufacturing	339	4,195	6,581	7,414	7,408	4,348

24 Company and Other Non-federal Funds for R&D Performing Companies, National Science Foundation, http://www.nsf.gov/statistics/nsf07314/content.cfm?pub_id=2488&id=2.

Table D

Annual Value Added in Manufacturing, by Subsector and Industry, 2000-2004 ($ millions)[25]

	NAICS	2000	2001	2002	2003	2004
Manufacturing	**31–33**	**$1,973,622**	**$1,853,929**	**$1,889,290**	**$1,923,414**	**$2,041,433**
Food, beverages, tobacco	311,312	256,419	270,958	270,170	284,810	298,491
Textiles, apparel, leather	313–16	67,652	60,679	54,758	54,703	50,597
Wood	321	36,104	33,129	35,121	37,077	43,733
Paper, printing	322, 323	141,368	133,519	134,575	129,776	131,910
Petroleum, coal	324	43,830	47,346	37,076	48,325	66,387
Chemicals	325	232,652	226,614	256,228	267,318	297,206
Basic chemicals	3251	46,468	37,575	45,712	47,764	61,819
Resin, synthetic rubber, fibers	3252	25,891	22,070	22,616	23,966	29,261
Pharmaceuticals	3254	81,511	91,696	104,300	115,012	118,599
Plastics, rubber	326	91,221	86,557	92,550	92,284	93,150
Nonmetallic minerals	327	55,508	53,194	54,764	55,211	59,290
Primary metals	331	63,282	53,111	57,168	53,642	73,829
Fabricated metals	332	138,792	148,874	138,714	137,451	144,994
Machinery	333	146,053	131,103	129,159	126,706	133,929
Computers and electronics	334	280,095	223,718	200,288	203,194	216,968
Computers, peripherals	3341	43,480	34,394	34,411	30,310	31,793
Communications equipment	3342	62,599	50,756	32,424	30,927	32,094
Semiconductors	3344	105,642	71,289	69,189	73,431	77,512
Navigational, measuring equipment	3345	60,543	60,034	56,299	60,349	68,293
Electrical equipment, appliances	335	62,881	56,304	52,853	51,276	52,921
Transportation equipment	336	234,392	227,675	253,415	256,414	250,145
Motor vehicles, trailers, parts	3361–63	155,979	137,121	167,542	166,748	165,292
Aerospace products	3364	59,534	71,839	64,151	61,797	62,673
Furniture	337	41,823	39,848	42,886	42,152	43,730
Miscellaneous manufacturing	339	71,458	71,372	78,556	83,064	84,142

25 County Business Pattern, U.S. Census Bureau, http://censtats.census.gov/cgi-bin/cbpnaic/cbpsel.pl.

Annual Employment by Manufacturing Subsector and Industry, 2000-2004[26]

Table E

	NAICS	2000	2001	2002	2003	2004
Manufacturing	**31–33**	**$16,473,994**	**$15,950,424**	**$14,393,609**	**$14,132,020**	**$13,821,976**
Food, beverages, tobacco	311,312	1,637484	1,641,010	1,607,161	1,651,159	1,636,964
Textiles, apparel, leather	313–16	1,134,057	1,012,821	850,098	790,131	719,252
Wood	321	597,684	557,507	534,011	523,984	534,799
Paper, printing	322, 323	1,367,332	1,317,771	1,202,409	1,182,453	1,138,199
Petroleum, coal	324	109,223	103,570	100,403	98,334	103,927
Chemicals	325	885,848	869,761	827,430	841,375	823,020
Basic chemicals	3251	191,979	183,249	172,964	170,579	165,209
Resin, synthetic rubber, fibers	3252	113,573	107,863	96,808	100,336	93,947
Pharmaceuticals	3254	227,461	233,503	237,905	251,855	246,297
Plastics, rubber	326	1,056,507	1,002,503	925,607	921,392	908,100
Nonmetallic minerals	327	523,698	524,230	475,476	467,644	472,133
Primary metals	331	601,627	572,512	501,038	479,693	451,142
Fabricated metals	332	1,790,817	1,761,358	1,582,399	1,518,266	1,514,595
Machinery	333	1,377,950	1,332,854	1,166,221	1,129,140	1,087,944
Computers and electronics	334	1,557,087	1,593,307	1,300,411	1,189,485	1,108,339
Computers, peripherals	3341	193,897	199,637	155,137	170,349	125,859
Communications equipment	3342	256,501	269,498	206,255	167,421	151,193
Semiconductors	3344	571,377	603,160	458,945	386,824	373,729
Navigational, measuring equipment	3345	461,516	453,496	417,552	403,693	401,333
Electrical equipment, appliances	335	589,406	575,413	502,400	459,993	439,064
Transportation equipment	336	1,872,630	1,753,445	1,578,707	1,606,713	1,625,742
Motor vehicles, trailers, parts	3361–63	1,198,065	1,087,564	988,398	1,032,461	1,049,744
Aerospace products	3364	446,243	449,383	391,273	375,169	372,643
Furniture	337	640,444	619,197	575,128	564,414	555,368
Miscellaneous manufacturing	339	732,200	713,165	664,710	707,844	703,388

26 County Business Pattern, U.S. Census Bureau, http://censtats.census.gov/cgi-bin/cbpnaic/cbpsel.pl.

Table F

Employment of Scientists and Engineers, by Manufacturing Subsector and Industry, 2000-2004[27]

	NAICS	2000	2001	2002	2003	2004
Manufacturing	**31–33**	**616,000**	**627,000**	**597,700**	**649,500**	**717,000**
Food, beverages, tobacco	311,312	10,000	13,000	13,900	NA	16,400
Textiles, apparel, leather	313–16	2,000	3,000	2,500	4,000	5,800
Wood	321	2,000	2,000	1,500	1,100	1,000
Paper, printing	322, 323	13,000	11,000	17,900	16,000	16,000
Petroleum, coal	324	3,000	3,000	4,300	3,900	4,000
Chemicals	325	83,000	82,000	86,900	91,300	120,000
Basic chemicals	3251	13,000	9,000	8,500	NA	10,600
Resin, synthetic rubber, fibers	3252	10,000	11,000	12,800	NA	9,400
Pharmaceuticals	3254	43,000	40,000	51,800	56,300	79,900
Plastics, rubber	326	13,000	12,000	11,000	11,900	14,100
Nonmetallic minerals	327	8,000	7,000	7,000	6,100	6,500
Primary metals	331	5,000	5,000	4,000	4,100	4,900
Fabricated metals	332	11,000	10,000	13,100	13,500	15,700
Machinery	333	54,000	56,000	56,500	55,300	62,600
Computers and electronics	334	261,000	268,000	221,500	228,400	274,000
Computers, peripherals	3341	24,000	16,000	15,100	13,800	45,100
Communications equipment	3342	92,000	102,000	52,800	56,000	49,900
Semiconductors	3344	65,000	83,000	73,300	76,000	97,400
Navigational, measuring equipment	3345	78,000	64,000	75,900	78,200	74,600
Electrical equipment, appliances	335	24,000	34,000	14,000	16,400	19,400
Transportation equipment	336	109,000	100,000	123,100	144,500	134,100
Motor vehicles, trailers, parts	3361–63	76,000	74,000	83,200	NA	89,000
Aerospace products	3364	25,000	19,000	32,500	40,600	37.900
Furniture	337	3,000	2,000	2,000	2,600	2,900
Miscellaneous manufacturing	339	17,000	22,000	22,600	24,600	21,800

27 Full-time Equivalent Scientists and Engineers, National Science Foundation, http://www.nsf.gov/statistics/nsf07314/content.cfm?pub_id=2488&id=2.

Annual Wage, by Manufacturing Subsector and Industry, 2000-2004 ($ millions)[28]

Table G

	NAICS	2000	2001	2002	2003	2004
Manufacturing	**31–33**	**$643,954**	**$617,699**	**$580,356**	**$576,058**	**$592,830**
Food, beverages, tobacco	311,312	$51,091	$51,343	$51,634	$53,704	$54,750
Textiles, apparel, leather	313–16	$26,992	$24,220	$22,142	$20,692	$19,891
Wood	321	$16,511	$15,829	$15,922	$15,891	$17,194
Paper, printing	322, 323	$51,609	$49,552	$46,875	$46,701	$46,587
Petroleum, coal	324	$6,386	$6,336	$6,456	$6,487	$7,776
Chemicals	325	$45,610	$46,395	$46,431	$48,532	$48,816
Basic chemicals	3251	$10,878	$10,771	$10,517	$10,594	$10,648
Resin, synthetic. rubber, fibers	3252	$5,977	$5,660	$5,296	$5,455	$5,218
Pharmaceuticals	3254	$13,276	$14,585	$15,878	$17,414	$17,683
Plastics, rubber	326	$34,110	$32,641	$32,036	$32,126	$33,160
Nonmetallic minerals	327	$19,123	$19,350	$18,120	$18,087	$18,963
Primary metals	331	$25,545	$23,642	$21,623	$20,863	$21,486
Fabricated metals	332	$64,244	$61,803	$57,682	$55,778	$58,581
Machinery	333	$58,387	$54,714	$50,101	$48,994	$50,459
Computers and electronics	334	$90,397	$84,522	$71,698	$66,583	$66,318
Computers, peripherals	3341	$11,813	$11,372	$9,549	$9,415	$8,111
Communications equipment	3342	$17,433	$16,175	$13,346	$10,611	$9,713
Semiconductors	3344	$31,941	$28,297	$21,933	$19,370	$20,160
Navigational, measuring equipment	3345	$26,496	$26,072	$24,256	$24,797	$25,998
Electrical equipment, appliances	335	$21,853	$20,873	$18,849	$17,617	$17,797
Transportation equipment	336	$88,632	$83,440	$78,771	$79,967	$85,128
Motor vehicles, trailers, parts	3361–63	$55,275	$48,954	$47,509	$49,725	$52,282
Aerospace products	3364	$25,026	$26,205	$23,250	$22,306	$24,419
Furniture	337	$17,964	$17,434	$16,806	$16,796	$17,221
Miscellaneous manufacturing	339	$25,500	$25,605	$25,208	$27,239	$28,702

28 County Business Pattern, U.S. Census Bureau, http://censtats.census.gov/cgi-bin/cbpnaic/cbpsel.pl.

Table H

R&D Expenditures per Employee, by Manufacturing Subsector and Industry, 2000-2004 ($ millions)[29]

	NAICS	2000	2001	2002	2003	2004
Manufacturing	**31–33**	**$6,870**	**$7,068**	**$7,041**	**$7,648**	**$9,542**
Food, beverages, tobacco	311,312	$954	$1,200	$1,371	$1,308	$1,713
Textiles, apparel, leather	313–16	$235	$252	$292	$391	$790
Wood	321	$176	$325	$247	$263	$284
Paper, printing	322, 323	$1,975	$2,022	$2,179	$2,460	$2,028
Petroleum, coal	324	$10,730	$10,206	$12,281	$13,302	$15,347
Chemicals	325	$23,444	$20,365	$24,649	$26,971	$47,472
Basic chemicals	3251	$10,678	$10,014	$9,886	$11,672	$13,994
Resin, synthetic rubber, fibers	3252	$25,024	$25,449	$24,926	$23,820	$22,140
Pharmaceuticals	3254	$56,243	$43,413	$59,629	$63,326	$127,667
Plastics, rubber	326	$1,585	$2,239	$1,629	$1,877	$2,069
Nonmetallic minerals	327	$1,614	$1,866	$883	$1,005	$1,658
Primary metals	331	$994	$837	$920	$1,080	$1,563
Fabricated metals	332	$911	$877	$791	$875	$967
Machinery	333	$4,745	$4,754	$5,459	$5,512	$5,950
Computers and electronics	334	$28,596	$28,082	$25,693	$27,319	$36,713
Computers, peripherals	3341	$26,622	$15,854	$19,434	$15,034	$45,344
Communications equipment	3342	$62,986	$69,466	$46,176	$53,351	$55,776
Semiconductors	3344	$22,379	$23,559	$25,866	$32,591	$46,890
Navigational, measuring equipment	3345	$21,915	$16,682	$20,474	$19,406	$19,640
Electrical equipment, appliances	335	$5,752	$8,133	$3,937	$4,352	$5,972
Transportation equipment	336	$12,238	$11,979	$13,588	$16,251	$16,004
Motor vehicles, trailers, parts	3361–63	$15,280	$14,794	$15,377	$16,343	$14,870
Aerospace products	3364	$8,728	$9,086	$13,671	$21,865	$24,753
Furniture	337	$443	$486	$436	$487	$731
Miscellaneous manufacturing	339	$5,729	$9,228	$11,154	$10,466	$6,182

29 Company and Other Non-federal Funds for R&D Performing Companies, Employment in R&D Performing Companies, National Science Foundation, http://www.nsf.gov/statistics/nsf07314/content.cfm?pub_id=2488&id=2.

Value Added per Employee, by Manufacturing Subsector and Industry, 2000-2004 ($ millions)[30]

Table I

	NAICS	2000	2001	2002	2003	2004
Manufacturing	**31–33**	**$119,802**	**$116,231**	**$131,259**	**$136,103**	**$147,695**
Food, beverages, tobacco	311,312	$156,593	$165,117	$168,104	$172,491	$182,344
Textiles, apparel, leather	313–16	$59,655	$59,911	$64,414	$69,233	$70,347
Wood	321	$60,407	$59,423	$65,768	$70,760	$81,775
Paper, printing	322, 323	$103,390	$101,322	$111,921	$109,752	$115,894
Petroleum, coal	324	$401,289	$457,140	$369,272	$491,437	$638,785
Chemicals	325	$262,632	$260,547	$309,667	$317,716	$361,116
Basic chemicals	3251	$242,047	$205,049	$264,286	$280,011	$374,187
Resin, synthetic rubber, fibers	3252	$227,968	$204,611	$233,617	$238,857	$311,463
Pharmaceuticals	3254	$358,352	$392,697	$438,410	$456,660	$481,528
Plastics, rubber	326	$86,342	$86,341	$99,988	$100,157	$102,577
Nonmetallic minerals	327	$105,992	$101,471	$115,177	$118,062	$125,579
Primary metals	331	$105,185	$92,768	$114,099	$111,826	$163,649
Fabricated metals	332	$77,502	$84,522	$87,661	$90,532	$95,731
Machinery	333	$105,993	$98,363	$110,750	$112,215	$123,103
Computers and electronics	334	$179,884	$140,411	$154,019	$170,825	$195,760
Computers, peripherals	3341	$224,243	$172,283	$221,810	$177,929	$252,608
Communications equipment	3342	$244,050	$188,335	$157,203	$184,726	$212,272
Semiconductors	3344	$184,890	$118,193	$150,757	$189,831	$207,402
Navigational, measuring equipment	3345	$131,183	$132,380	$134,831	$149,492	$170,165
Electrical equipment, appliances	335	$106,685	$97,850	$105,201	$111,471	$120,531
Transportation equipment	336	$125,167	$129,844	$160,521	$159,589	$153,865
Motor vehicles, trailers, parts	3361–63	$130,192	$126,081	$169,509	$161,505	$157,459
Aerospace products	3364	$133,412	$159,861	$163,955	$164,718	$168,185
Furniture	337	$65,303	$64,354	$74,568	$74,683	$78,741
Miscellaneous manufacturing	339	$97,594	$100,078	$118,181	$117,348	$119,624

30 County Business Pattern, U.S. Census Bureau, http://censtats.census.gov/cgi-bin/cbpnaic/cbpsel.pl.

Table J

Annual Wage per Employee, by Manufacturing Subsector and Industry, 2000-2004 ($)[31]

	NAICS	2000	2001	2002	2003	2004
Manufacturing	**31–33**	**39,089**	**38,726**	**40,320**	**40,763**	**42,890**
Food, beverages, tobacco	311,312	31,201	31,288	32,128	32,525	33,446
Textiles, apparel, leather	313–16	23,801	23,914	26,046	26,188	27,656
Wood	321	27,626	28,393	29,817	30,328	32,150
Paper, printing	322, 323	37,745	37,603	38,984	39,495	40,931
Petroleum, coal	324	58,465	61,175	64,305	65,966	74,825
Chemicals	325	51,487	53,342	56,114	57,682	59,313
Basic chemicals	3251	56,664	58,778	60,805	62,106	64,452
Resin, synthetic rubber, fibers	3252	52,631	52,475	54,708	54,367	55,545
Pharmaceuticals	3254	58,367	62,463	66,742	69,144	71,794
Plastics, rubber	326	32,286	32,560	34,611	34,867	36,515
Nonmetallic minerals	327	36,515	36,911	38,108	38,678	40,164
Primary metals	331	42,459	41,295	43,157	43,492	47,625
Fabricated metals	332	35,874	35,088	36,452	36,738	38,677
Machinery	333	42,372	41,050	42,960	43,390	46,380
Computers and electronics	334	58,056	53,048	55,135	55,977	59,835
Computers, peripherals	3341	60,924	56,965	61,553	55,271	64,448
Communications equipment	3342	67,966	60,020	64,708	63,379	64,240
Semiconductors	3344	55,901	46,915	47,789	50,074	53,942
Navigational, measuring equipment	3345	57,410	57,491	58,090	61,426	64,779
Electrical equipment, appliances	335	37,076	36,275	37,519	38,298	40,534
Transportation equipment	336	47,330	47,586	49,896	49,770	52,363
Motor vehicles, trailers, parts	3361–63	46,137	45,013	48,066	48,162	49,804
Aerospace products	3364	56,082	58,313	59,422	59,456	65,530
Furniture	337	28,049	28,155	29,221	29,758	31,009
Miscellaneous manufacturing	339	34,827	35,903	37,924	38,482	40,806

31 County Business Pattern, U.S. Census Bureau, http://censtats.census.gov/cgi-bin/cbpnaic/cbpsel.pl.

ABOUT THE AUTHORS

Robert J. Shapiro is the chairman of Sonecon, LLC, a private firm that advises U.S. and foreign businesses, governments and nonprofit organizations. Dr. Shapiro has advised, among others, U.S. President Bill Clinton and British Prime Minister Tony Blair; private firms, including MCI, Inc., Amgen, Gilead Sciences, New York Life Insurance Co., SLM Corporation, Google, Nordstjernan of Sweden, and Fujitsu of Japan; and nonprofit organizations, including the American Public Transportation Association, the Education Finance Council, and the U.S. Chamber of Commerce. He is also Senior Fellow of the Progressive Policy Institute (PPI), director of the NDN Globalization Initiative, co-chair of Argentina Task Force America, and a director of the Ax:son-Johnson Foundation in Sweden. From 1997 to 2001, he was Under Secretary of Commerce for Economic Affairs. Prior to that, he was co-founder and vice president of PPI. Dr. Shapiro also served as the principal economic adviser to Bill Clinton in his 1991-1992 presidential campaign, senior economic advisor to Albert Gore, Jr. in 2000 and John Kerry in 2004, legislative director for Senator Daniel P. Moynihan, and associate editor of *U.S. News & World Report*. He has been a Fellow of Harvard University, the Brookings Institution and the National Bureau of Economic Research. He holds a Ph.D. from Harvard, as well as degrees from the University of Chicago and the London School of Economics.

Nam D. Pham is the founder and president of NDP Group, LLC, an economics consulting firm that specializes in assessing complex issues in finance, international trade and economics development, and an affiliated scholar of Sonecon. Clients of NDP Group include U.S. and foreign corporations, financial institutions, federal and local governments, trade associations and multinational organizations. Prior to founding NDP Group in 2000, Dr. Pham was vice president at Scudder Kemper Investments in Boston, where he was responsible for research, asset allocations and currency hedges for Scudder's global and international bond funds. Before that he was chief economist of the Asia Region for Standard & Poor's DRI in Boston. Dr. Pham has over a decade of experience in multinational organizations and government agencies in Washington, DC. This tenure includes time as an economist at the World Bank, as well as a consultant to the Department of Commerce and the Federal Trade Commission. In addition, Dr. Pham has been an adjunct professor at The George Washington University, where he has taught undergraduate and graduate courses in monetary economics, international trade and finance, macroeconomics and microeconomics. Dr. Pham earned a Ph.D. in economics from The George Washington University with concentrations in international trade and finance, economic development and applied microeconomics, a M.A. degree from Georgetown University and a B.A. degree from the University of Maryland.

Alan S. Blinder is the Gordon S. Rentschler Memorial Professor of Economics at Princeton University and co-director and founder of Princeton's Center for Economic Policy Studies. He is also a partner in Promontory Financial Group, vice chairman of the Promontory Interfinancial Network, and vice chairman of the G7 Group. Dr. Blinder served as vice chairman of the Board of Governors of the Federal Reserve System from June 1994 until January 1996. Before becoming a member of the Board, Dr. Blinder served as a member of President Clinton's original Council of Economic Advisers from January 1993 until June 1994. During the 2000 and 2004 presidential campaigns, he served as an economic adviser to Al Gore and John Kerry. He also served briefly as deputy assistant director of the Congressional Budget Office when that agency started in 1975. Dr. Blinder is the author or co-author of 17 books, including the textbook *Economics: Principles and Policy* with William J. Baumol, now in its 10th edition. Dr. Blinder is the immediate past president of the Eastern Economic Association, a member of the Bretton Woods Committee, the Bellagio Group, and the Council on Foreign Relations, and a former governor of the American Stock Exchange. He earned his A.B. degree at Princeton University, M.Sc. at London School of Economics, and Ph.D. at the Massachusetts Institute of Technology.

REFERENCES

Bryan, Lowell and Zanini, Michele, "Strategy in an Era of Global Giants," McKinsey Global Institute, Number 4, 2005.

Congressional Budget Office, *The Budget and Economic Outlook, Fiscal Years 2001-2010.*

Council of Economic Advisors*, The Economic Report of the President,* February 2000. 3.

Grabowski, Henry G., Statement before the House Oversight and Government Reform Committee, March 26, 2007.

Greenhalgh, Christine and Rogers, Mark, "The Value of Innovation: The Interaction of Competition, R&D and IP," *Research Policy,* Elsevier, May 2006.

Greenhalgh, Christine and Longland, M., "Intellectual Property in UK Firms: Creating Intangible Assets and Distributing the Benefits via Wages and Jobs", *Oxford Bulletin of Economics and Statistics,* 2001.

Hall, B.H., "Innovation and Market Value," Working Paper, 1998. Revised in 2000 and published in R. Barrell, G. Mason, and M. O'Mahony, eds., *Productivity, Innovation and Economic Performance,* New York: Cambridge University Press, 2000.

Jorgenson, Dale and Stiroh, Kevin, "Raising the Speed Limit: U.S. Economic Growth in the Information Age," May 2000.

Lichtenberg, Frank, "Pharmaceutical Innovation, Mortality Reduction, and Economic Growth," National Bureau of Economic Research, Working Paper No. 6569, May 1999.

Mansfield, E., "Industrial Research and Development Expenditures: Determinants, Prospects, and Relation to Size of Firm and Inventive Output," *Journal of Political Economy,* August 1964.

National Science Foundation, Industrial R&D Performance in the United States, By Source of Funds: 1953–2004, www.nsf.gov/statistics/nsf07314/content.cfm?pub_id=2488&id=2.

________, Funds for R&D by State, http://www.nsf.gov/statistics/nsf07314/content.cfm?pub_id=2488&id=2.

________, Federal Funds for Industrial R&D Performance in the United States, by Industry and Company Size: 1999–2003, www.nsf.gov/statistics/nsf07314/content.cfm?pub_id=2488&id=2.

________, Company and Other Non-federal Funds for R&D, National Science Foundation, http://www.nsf.gov/statistics/nsf07314/content.cfm?pub_id=2488&id=2.

________, Company and Other Non-federal Funds for R&D Performing Companies, Employment in R&D Performing Companies, http://www.nsf.gov/statistics/nsf07314/content.cfm?pub_id=2488&id=2.

________, Company and Other Non-federal Funds for R&D, Employment in R&D Performing Companies, Full-time Equivalent Scientists and Engineers by Industry, http://www.nsf.gov/statistics/nsf07314/content.cfm?pub_id=2488&id=2.

Oliner, Stephen and Sichel, Daniel, "The Resurgence of Growth in the Late 1990s: Is Information Technology the Story?" Federal Reserve Board, May 2000.

Pakes, A., "On Patents, R&D, and the Stock Market Rate of Return,*" Journal of Political Economy,* April 1985.

Rogers, M., "The Definition and Measurement of Innovation," Melbourne Institute Working Paper, 1998.

U.S. Census Bureau, County Business Pattern, http://censtats.census.gov/cgi-bin/cbpnaic/cbpsel.pl.

U.S. Department of Commerce, "The Emerging Digital Economy II," Economics and Statistics Administration, June 1999.

Whelan, Karl, "Computers, Obsolescence and Productivity," February 2000.

WORLD GROWTH

World Growth is a non-profit, non-governmental organization established with an educational and charitable mission to expand the education, information and other resources available to disadvantaged populations to improve their health and economic welfare. At World Growth, we embrace and celebrate the new age of globalization and the power of free trade to eradicate poverty and improve living conditions for people in the developing world.

World Growth was launched in December 2005 at the World Trade Organization's Doha Ministerial Trade Round in Hong Kong. As an accredited NGO, World Growth hosted a number of events during the ministerial and publicized its first paper, *Make Trade Free – How the Doha Round Can Reduce Poverty*. The paper was authored by Alan Oxley, Chairman of World Growth, and included a foreword by Mike Moore, the former Director General of the WTO.

Alan Oxley is a native of Australia and was formerly Chairman of the GATT, predecessor to the World Trade Organization and is recognized as a global expert on trade related issues. Since its launch in December of 2005, the leaders of World Growth have been quoted and/or featured in more than 100 media outlets, including: *BBC; CNBC; CNN; Financial Times; Wall Street Journal; South China Morning Post; China News Daily* and *Die Welt*.

Economic Effects of Intellectual Property-Intensive Manufacturing

July 2007