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The Importance of IP-Intensive Manufacturing Industries to the U.S. Economy

October 2021

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About the Author

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Abstract

Recently updated R&D and economic performance data once again confirm the crucial contributions of innovation to productivity and long-term economic growth, while reinforcing the importance of protecting intellectual property (IP) to innovation.

IP-intensive (or "innovative") industries continue to commit more resources to R&D and outperform non-IP-intensive industries across key economic measures. Workers in innovative industries punch well above their weight, creating more economic value and, accordingly, earning higher wages than their counterparts in other manufacturing industries. Firms in IP-intensive industries cut fewer jobs during economic contractions and add more jobs during economic expansions than their counterparts in non-IP-intensive industries.

Given the well-established relationship between R&D and innovation and between innovation and economic growth, public policies should continue to underpin this IP ecosystem by ensuring the preservation of robust IP protections.

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Highlights of the Report

Firms in innovative industries drive U.S. economic growth. Much of the success of those firms can be attributed to the economic returns from their sizable investments in research and development (R&D) and intellectual capital. Those investments are made possible by our continued commitment to protecting intellectual property (IP).

R&D investment is the wellspring of economic and human progress. It nurtures the innovation ecosystem, enables creation of better products and services, and generates new revenues and returns that help fund the next generation of R&D. In the process, successful companies create more and better jobs, seek and obtain workers with higher skills, and provide compensation that anchors and seeds broader economic activity in the communities in which those industries are located. It is a virtuous cycle, underpinned by a legal and policy landscape that protects the rights of IP creators and provides opportunity for wealth creation and higher living standards.

During the pandemic, the value to society of our IP-intensive industries has been demonstrated in spades. The rapidity with which vaccines for a previously unknown virus were developed, tested, produced, and distributed, and the advent and dissemination of new communications and collaboration technologies which have enabled business to continue and people to see one another despite travel bans would have been impossible but for the investments in R&D and intellectual capital from our innovative industries.

This report relies upon the most recent official data to measure and compare manufacturing industrial investment in innovation and assess its economic impact in the United States. Those data indicate that IP-intensive industries outperform their counterparts with respect to virtually all relevant economic metrics during 2008-19. Highlights of our report findings are:

- **Higher R&D investment**. IP-intensive manufacturing industries invested 12.4 times more R&D per employee than non-IP-intensive manufacturing industries ($51,257 vs. $4,118 per year).
- **More job creation**. IP-intensive manufacturing industries added more jobs during the most recent economic recovery period than did non-IP-intensive manufacturing industries.
- **Higher wages**. IP-intensive manufacturing industries pay 45% higher wages than non-IP-intensive manufacturing industries ($70,096 compared to $48,354 per employee annually).
- **Higher productivity**. Gross output per IP-intensive manufacturing employee is 40% higher than that of their non-IP-intensive counterparts ($594,513 vs. $423,795 per year) and “net economic contribution” (or value added) per employee in IP-intensive manufacturing industries is 60% greater than in non-IP-intensive manufacturing industries ($280,427 vs. $171,592 per year).
- **More exports**. The value of exports per employee in IP-intensive manufacturing industries is 2.6 times greater than that of their non-IP-intensive counterparts ($166,281 vs. $63,733 per year).

Innovation is the product of R&D investment and it generates better economic performance. During the period between 2008 and 2019, gross output, value-added, exports, and wages per employee were all higher in IP-intensive manufacturing industries than in non-IP-intensive manufacturing industries. All told, industries that invest more in R&D per employee generate better outcomes and contribute more to the U.S. economy. Consequently, policies that protect IP and enable this ecosystem to flourish are very much in the public interest. (Figure 1)

Figure 1.
Economic Performance per Employee, IP-Intensive and Non-IP-Intensive Industries, 2008-19

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INTRODUCTION

Research and development (R&D) is essential to innovation. The innovation process and its commercial application raises productivity and living standards and is imperative for long-term, sustainable economic growth. Numerous empirical studies find positive links between innovation and growth.[1] According to the U.S. Department of Commerce, three-quarters of U.S. economic growth since World War II is attributable to technological innovations.[2]

Innovative companies invest in R&D, which leads to efficient new production processes on the supply side, and new and better products and services on the demand side. Meanwhile, this process stimulates value added activity and job creation in other industries and regions—spillover growth attributable to improvements in the supply chain and commercial application of that innovation.

Over 60% of private R&D investment is spent on human capital in the form of salaries and wages, benefits, stock-based compensation, and temporary staffing.[3] Accordingly, innovative industries support over 57.6 million American jobs—20 million directly and another 37.6 million indirectly—through these spillover and supply chain effects. Workers in innovative industries are highly productive, reflecting the high-skilled labor required and relative capital intensity of innovative work.[4]

Figure 2 below depicts changes in R&D investment, GDP, and employment since 1960. The three metrics tend to move in tandem.

[1] European Patent Office and European Union Intellectual Property Office. 2021. "Intellectual property rights and firm performance in the European Union." EPO and EUIP; Congressional Research Service. 2020. "Intellectual Property Rights and International Trade." CRS Report.

[2] Enzell, Stephen and Nigel Cory. 2019. "The Way Forward for Intellectual Property Internationally." Information Technology & Innovation Foundation. April 25.

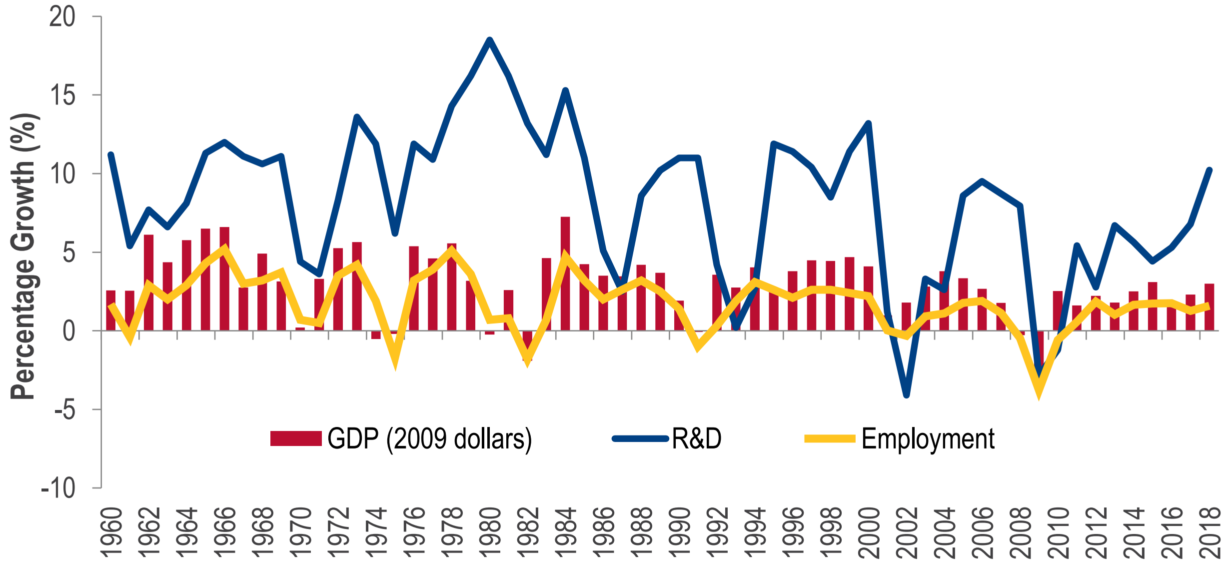
[3] National Science Foundation: BERD Survey. "Business Research and Development: 2018: Table 1."

[4] Pham, Nam. 2015. "IP-Intensive Manufacturing Industries: Driving U.S. Economic Growth." ndp | analytics; Pham, Nam. 2012. "IP Creates Jobs for America." ndp | analytics; U.S. Department of Commerce. 2012. "Intellectual Property and the U.S. Economy: Industries in Focus."

Figure 2.

R&D, GDP, and Employment, Annual Growth Rates, 1960-2018[5]

R&D investment correlates with GDP growth and employment



The positive correlation between innovation and growth is evident in economies throughout the world. Research shows that countries with higher levels of patenting activity (those registering more patents) tend to experience higher rates of economic growth and that growth accelerates over time as patenting activity increases. Researchers measuring the impact of innovation across 35 economies found that R&D spending leads to more patent applications and positively contributes to national development.[6]

This report relies upon the most recent official data to measure investment in innovation and assess its economic impact on U.S. manufacturing industries.[7] We consider R&D investment a proxy for "innovative intensity" across industries, and R&D investment per employee as determinative of whether an industry is IP-intensive or not. In this report, manufacturing industries in which R&D investment per employee is greater than the average manufacturing-sector R&D investment per employee are considered IP-intensive and all others are considered non-IP-intensive. We compare the economic performance of these two groups of manufacturing industries, during periods of economic contraction and expansion, by looking at employment, wages, gross output/sales, value-added/economic contributions, and exports. Overall, the close association of IP and R&D to positive movements in these measures should be of utmost interest to policymakers concerned about sustaining and growing the U.S. economy.

[5] National Science Foundation: BRDIS Survey; U.S. Bureau of Economic Analysis: National Economic Accounts; U.S. Bureau of Labor Statistics: Current Population Survey.

[6] Fabio de Oliveira Paula and Jorge Ferreira da Silva. 2021. "R&D spending and patents: levers of national development." Innovation and Management Review. Emerald Publishing Limited. 18(2).

[7] The dataset includes detailed R&D data from 2000 to 2018 (published by the National Science Foundation) and a variety of economic data from 2000 to 2019 (published by the Census Bureau).

METHODOLOGY

Innovation can be measured by its inputs, outputs, or a combination of both. Inputs, starting with R&D investment, are the effort needed to produce innovation, while outputs measure the fruits of innovation. In some cases, inputs tell us more about innovation and, in others, outputs are more revealing.

Three observable and measurable outputs are the numbers and value of patents, trademarks, and copyrights. The "number" of these IP protections is a straightforward metric but it is important to keep in mind that there are patents, trademarks, and copyrights that never get commercialized. Sometimes the economic value of IP outputs, which is determined by the value of the products and services created by the innovation process, is a more useful measure.

However, there are advantages to measuring innovation by its inputs. R&D investment, a direct input to IP output, is observable and widely used to measure IP intensity. R&D is a reliable indicator of innovative capacity and is positively correlated with IP outputs.[8] These outputs are just as important to start-ups as they are to multinational corporations; investments in R&D and patents allow companies of all sizes to create, manufacture, and market their products.[9] Furthermore, the evidence from high-tech industries reveals a relationship between past and prospective R&D spending: success at earlier stages in the R&D process tends to increase the value of future R&D commitments, which means that R&D success breeds more innovation, leads to new life-enhancing products, raises our living standards and makes us more efficient and productive.

Definitions and Data Sources

R&D: Research and development expenses of a manufacturing sector, subsector, or industry used in the production of intellectual property published by the National Science Foundation.

Employment: Total number of employees in a manufacturing sector, subsector, or industry published by the Census Bureau.

Wages: Total wages paid to employees of a manufacturing sector, subsector, or industry published by the Census Bureau.

Gross output: Total sales or revenues of a manufacturing sector, subsector, or industry published by the Census Bureau.

Value added: The economic contributions of a manufacturing sector, subsector, or industry as measured by total sales minus intermediate inputs such as the cost of raw materials and services published by the Census Bureau.

Exports: Total sales abroad of a manufacturing sector, subsector, or industry (i.e. total sales minus domestic sales) published by the International Trade Commission.

We evaluate the R&D and economic data at the 2-, 3-, and 4-digit NAICS levels. Based on its classification system, the 2-digit NAICS level refers to the economic sector (e.g., manufacturing sector), the 3-digit NAICS

[8] For example, National Science Board. 2020. "Invention, Knowledge Transfer, and Innovation." National Science Foundation. January 15; Mairesse, Jacques and Pierre Mohnen. 2004. "The Importance of R&D for Innovation: A Reassessment Using French Survey Data." NBER Working Paper No. 10897; Steinberg, Rolf and Olaf Arndt. 2001. "What Determines the Innovation Behavior of European Firms?" Economic Geography.

[9] For example, McDole, Jaci and Stephen Enzell. 2021. "Ten Ways IP Has Enabled Innovations That Have Helped Sustain the World Through the Pandemic." Information Technology & Innovation Foundation. April 29; Chakrabarti, Alok K. and Michael R. Halperin. 1990. "Technical Performance and Firm Size: Analysis of Patents and Publications of U.S. Firms," Small Business Economics, Vol. 2, No. 3, pp. 183-190.

level refers to the economic subsector (e.g., chemical manufacturing subsector), and the 4-digit NAICS level refers to the economic industry (e.g., pharmaceutical manufacturing industry). For consistency with other "per employee" economic performance metrics (i.e., output, value-added, wages, and exports), we use the Census employment data to calculate R&D per employee by manufacturing industry.[10] To assess the robustness of our IP classifications, we also use the NSF employment figures (at the company level) to calculate R&D per employee.[11]

MEASURING IP-INTENSITY ACROSS U.S. MANUFACTURING INDUSTRIES

Following our previous studies, we defined IP-intensive industries as those industries in which ***R&D investment per employee*** exceeds the manufacturing sector's average R&D investment per employee. Based on our definition and 2008-18 data, we identified three manufacturing subsectors (3-digit NAICS level) – chemical products, computer and electronic products, and transportation equipment – as well as their industries (4-digit NAICS level) such as pharmaceuticals, communications equipment, and aerospace met the definition of IP-intensive. In addition, we identified the medical device manufacturing industry (4-digit NAICS level) in the miscellaneous manufacturing subsector (3-digit NAICS level) also met the definition. All other manufacturing subsectors and industries are classified as non-IP-intensive industries in this report. Although the value of R&D investment per employee differs, the IP-industry classification remains unchanged.

For simplicity, our tables and figures present numbers of all 15 manufacturing subsectors (3-digit NAICS level), containing 3 IP-intensive subsectors and 12 non-IP-intensive subsectors. On the industry level (4-digit NAICS level), we present only figures of the highest R&D investment per employee industries of IP-intensive subsectors. Lastly, our analysis below uses the terms subsector and industry interchangeably where appropriate.

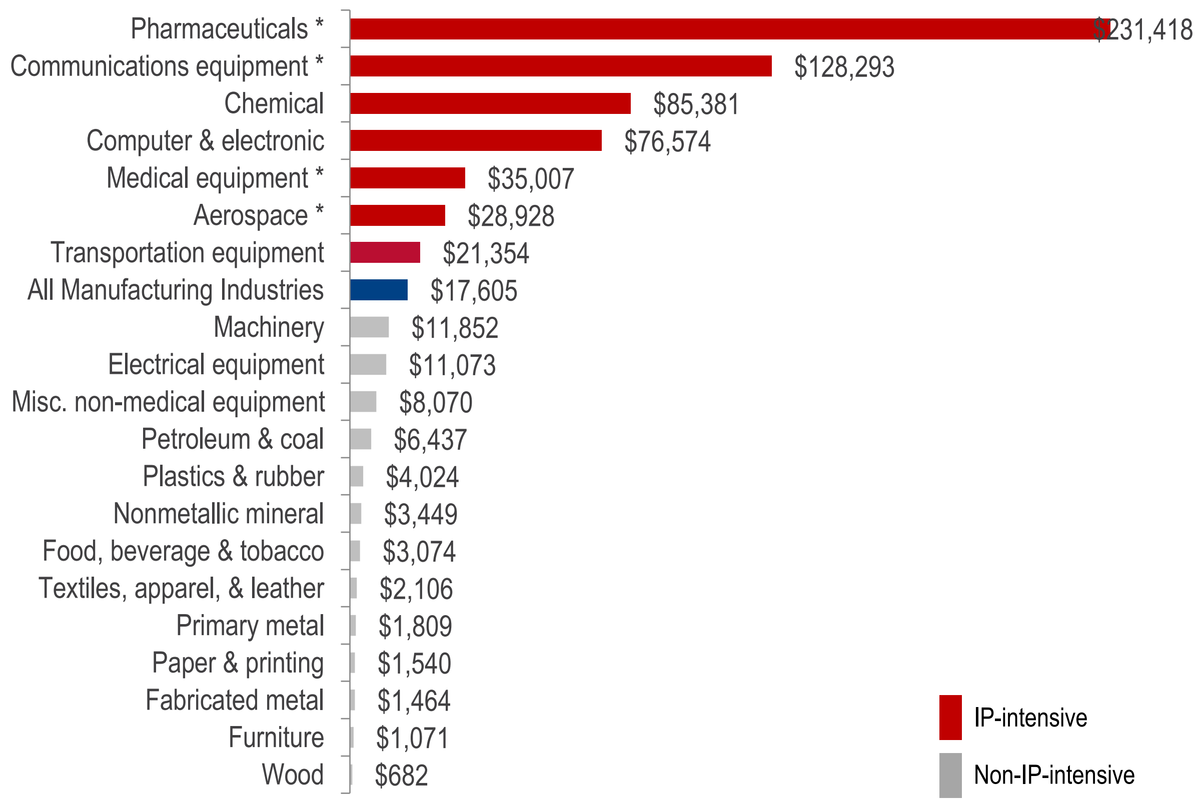
Between 2008 and 2018, annual R&D investment per employee for the U.S. manufacturing sector increased by more than 62%, from $13,175 to $21,375; the annual average during this period was $17,605 per employee. But the difference between IP-intensive and non-IP-intensive industries was vast. R&D per employee was over 12-times greater in IP-intensive than in non-IP-intensive industries. (Figure 3) As will be shown, this metric is a key determinant of future innovation and related positive economic outcomes.

[10] Note that the Census Bureau publishes employment data by industry at the "establishment level," which tends to be slightly different from the "company level" employment data published by the NSF.
[11] Although the value of R&D investment per employee differs, the IP-industry classification remains unchanged.

Figure 3.

Annual Average R&D Investment per Employee, by Selected Industries, 2008-18[12]

IP-intensive industries, led by the pharmaceutical industry, invest twelve times more R&D per employee than non-IP-intensive industries



**Subset of another industry. Pharmaceutical manufacturing is a subset of the chemical manufacturing industry; communications equipment manufacturing is a subset of the computer & electronic manufacturing industry; aerospace manufacturing is a subset of the transportation manufacturing industry, and medical equipment manufacturing is a subset of miscellaneous manufacturing.*

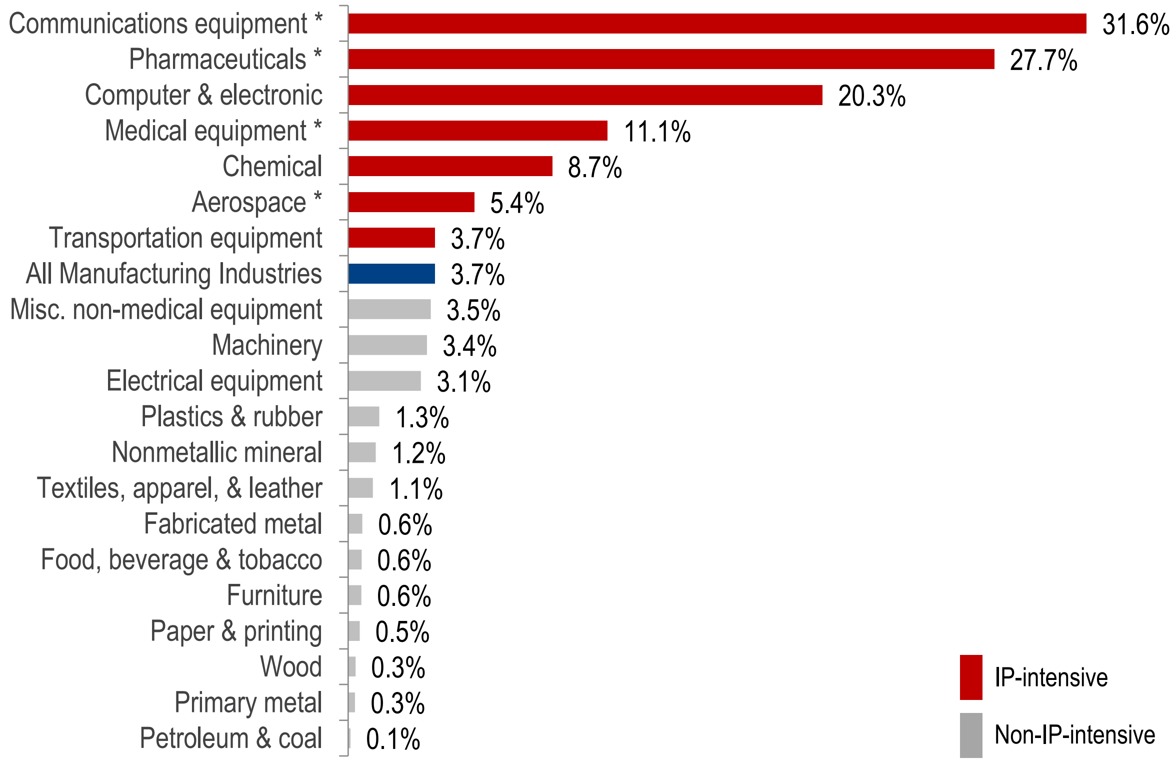
R&D investment in the U.S. manufacturing sector increased from 3.2% of sales in 2008 to 4.3% in 2018, averaging 3.7% for the whole manufacturing sector over those 16 years. However, the distinctions between the two groups of industries were pronounced. IP-intensive industries invested 8.6% of sales in R&D, while non-IP-intensive industries invested a mere 1.0%. Standing out were pharmaceutical manufacturers and communication equipment manufacturers—two of the most innovative industries—who invested an average of nearly $56 billion a year on R&D (27.7% of their annual sales) and nearly $13 billion a year on R&D (nearly 31.6% of their annual sales), respectively. This measure of "R&D intensity" reflects both the concentration of effort deployed in these industries to discover and develop new products and services and their success with innovation and economic performance. (Figure 4)

[12] National Science Foundation: BRDIS Survey; U.S. Census Bureau: County Business Patterns.

Figure 4.

Annual Average R&D Investment as a Share of Sales, by Selected Industries, 2008-18[13]

The ratio of R&D to sales for the communications equipment and pharmaceutical manufacturing industries is over seven times greater than the manufacturing average



**Subset of another industry. Pharmaceutical manufacturing is a subset of the chemical manufacturing industry; communications equipment manufacturing is a subset of the computer & electronic manufacturing industry; aerospace manufacturing is a subset of the transportation manufacturing industry, and medical equipment manufacturing is a subset of miscellaneous manufacturing.*

ECONOMIC IMPACTS OF INTELLECTUAL PROPERTY PRODUCTS ON U.S. MANUFACTURING INDUSTRIES

IP-intensive manufacturing industries consistently outperform non-IP-intensive manufacturing industries in all relevant economic measures. IP-intensive industries invest heavily in R&D to produce new products and services, improve existing products and services, and to produce them more efficiently. With greater demand and corresponding increases in revenues, these companies can offer higher wages to attract more talented workers, who make larger contributions to the U.S. economy. This insight and the supporting data contained

[13] National Science Foundation: BRDIS Survey; U.S. Census Bureau: County Business Patterns.

herein hold important implications that reinforce the importance of maintaining incentives for innovation, including robust IP protections. Key economic measurements are summarized in Table 1, along with an "IP-intensive multiple," which captures the performance differentials between the two groups of industries.

Table 1.
Economic Performance per Employee: IP-Intensive versus Non-IP-Intensive Manufacturing Industries, 2008-19[14]

	IP-intensive industries	Non-IP-intensive industries	Difference	IP-intensive multiple
R&D Investment	$51,257	$4,118	$47,140	12.4
Wages	$70,096	$48,354	$21,742	1.4
Exports	$166,281	$63,733	$102,548	2.6
Value-Added	$280,427	$171,592	$108,835	1.6
Gross Output	$594,513	$423,795	$170,718	1.4

Measuring R&D Investment

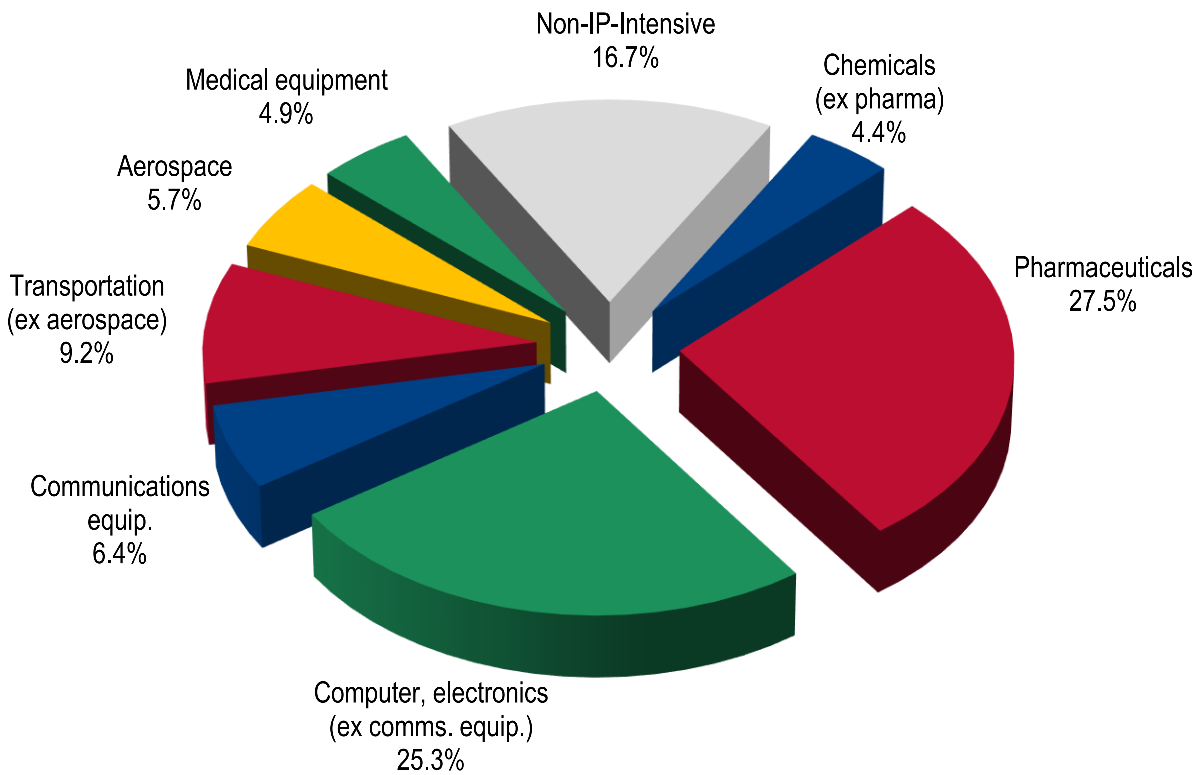
R&D expenditures that are supported by intellectual property protections have become important enough to be a separate item in the national accounts. After creating R&D satellite accounts to gauge R&D investment and its larger economic effects, the Bureau of Economic Analysis (BEA) in 2013 expanded its measurement of intellectual property products in U.S. national accounts. In conjunction with the National Science Foundation, the BEA developed measurements of innovative activity and began recording expenditures on R&D, software, entertainment, literacy, and artistic originals as fixed investment in the national accounts. BEA also worked with the Bureau of Labor Statistics to construct a deflator to enable estimation of real R&D investment. Intellectual property expenditures in the U.S. rose nearly 60% from $691.9 billion in 2013 to $1,078.5 billion in 2020, accounting for 35% of nonresidential fixed investment.[15]

During the period 2008-18, R&D investment in the aggregate U.S. manufacturing sector averaged $203.5 billion per year. IP-intensive industries accounted for over 83% of total R&D investment. At the 3-digit NAICS level, the chemical manufacturing and the computer and electronic products manufacturing industries accounted for approximately 64% of total R&D investment. At the 4-digit NAICS level, the pharmaceutical industry, which falls within the chemical manufacturing industry, had the highest share (27.5%) of total R&D investment. (Figure 5)

[14] National Science Foundation: BRDIS Survey; R&D investment (2008-18); U.S. Census Bureau: Annual Survey of Manufactures, County Business Patterns, and Economic Census; U.S. International Trade Commission: DataWeb.
[15] Aizcorbe, Anna M., Carol E. Moylan, and Carol A. Robbins. 2009. "Toward Better Measurement of Innovation and Intangibles." BEA Briefing, Survey of Current Business; Bureau of Economic Analysis. 2013. "Preview of the 2013 Comprehensive Revision of the National Income and Product Accounts – Changes in Definitions and Presentations."; Bureau of Economic Analysis: National Income and Product Accounts.

Annual R&D investment in IP-intensive industries averaged 5 times that of non-IP-intensive industries.

Figure 5.
Composition of R&D Investment, by Selected Industries, 2008-18[16]
IP-intensive manufacturing industries account for over 83% of manufacturing R&D investment in the U.S.



Between 2008 and 2018, manufacturing R&D investment averaged $203.5 billion per year. The preponderance of that investment occurred in IP-intensive industries, which was five times the R&D invested in non-IP-intensive industries ($169.5 billion per year vs. $33.9 billion per year. Bucking the trend, somewhat, the food and beverage industry (part of the non-IP-intensive subsector) experienced more than a 7% annual increase in R&D investment over the period. (Table 2)

[16] National Science Foundation: BRDIS Survey.

Table 2.
R&D Investment and Growth Rates, by Selected Industries, 2008-18[17]

	R&D (Millions)	Annual Growth Rate
All Manufacturing Industries	**$203,474**	**4.0%**
IP-Intensive	**$169,548**	**4.2%**
Chemical	$64,949	3.7%
Pharmaceutical & medicine	$55,932	4.5%
Computer & electronic	$64,413	3.5%
Communications equipment	$12,961	0.6%
Transportation equipment	$30,194	4.7%
Aerospace	$11,533	0.8%
Medical equipment & supplies (misc.)	$9,992	10.6%
Non-IP-Intensive	**$33,927**	**3.0%**
Petroleum & coal	$656	0.5%
Food, beverage, & tobacco	$5,052	7.2%
Textiles, apparel, & leather	$747	2.0%
Wood	$258	-2.9%
Paper, printing, & support activities	$1,300	-2.2%
Plastics & rubber	$2,933	4.2%
Nonmetallic mineral	$1,288	-1.0%
Primary metal	$696	2.0%
Fabricated metal	$2,067	-0.3%
Machinery	$12,298	3.9%
Electrical equipment & appliances	$3,812	3.9%
Furniture	$395	-1.6%
Misc. non-medical equipment	$2,199	2.8%

R&D investment per employee in IP-intensive manufacturing industries averaged more than 12 times that of non-IP-intensive manufacturing industries.

Between 2008 and 2018, annual R&D investment in the manufacturing sector averaged $17,605 per employee, but the difference between two industry groups is stark. Annual R&D investment per employee in IP-intensive manufacturing industries ($51,257) was more than 12 times that of non-IP-intensive

[17] National Science Foundation: BRDIS Survey.

manufacturing industries ($4,118). At $231,418 per employee, the pharmaceutical manufacturing industry invested more than any other manufacturing industry. At the opposite end of the spectrum, the wood product manufacturing industry invested only $682 per employee during the same period. (Table 3)

Table 3.
Annual Average R&D Investment per Employee, by Selected Industries, 2008-18[18]

	R&D (Millions)	Employment (Persons)	Annual Average R&D per Employee
All Manufacturing Industries	**$203,474**	**11,572,674**	**$17,605**
IP-Intensive	**$169,548**	**3,306,376**	**$51,257**
Chemical	$64,949	759,620	$85,381
Pharmaceutical & medicine	$55,932	241,175	$231,418
Computer & electronic	$64,413	854,892	$76,574
Semiconductor & other	$12,961	103,877	$128,293
Transportation equipment	$30,194	1,403,982	$21,354
Aerospace	$11,533	398,109	$28,928
Medical equipment & supplies (misc.)	$9,992	287,882	$35,007
Non-IP-Intensive	**$33,927**	**8,266,298**	**$4,118**
Petroleum & coal	$656	101,800	$6,437
Food, beverage, & tobacco	$5,052	1,641,046	$3,074
Textiles, apparel, & leather	$747	364,541	$2,106
Wood	$258	383,856	$682
Paper, printing, & support activities	$1,300	845,446	$1,540
Plastics & rubber	$2,933	731,247	$4,024
Nonmetallic mineral	$1,288	374,359	$3,449
Primary metal	$696	385,359	$1,809
Fabricated metal	$2,067	1,408,228	$1,464
Machinery	$12,298	1,040,086	$11,852
Electrical equipment & appliances	$3,812	346,239	$11,073
Furniture	$395	369,556	$1,071
Misc. non-medical equipment	$2,199	274,534	$8,070

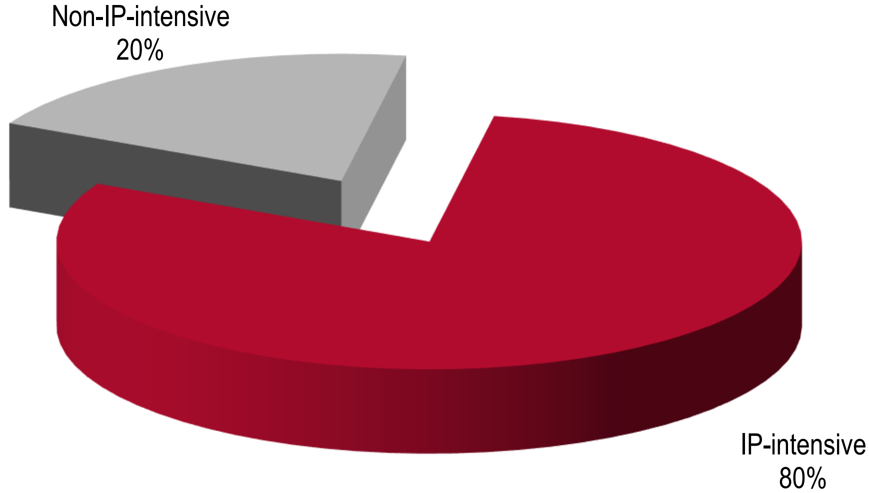
18 National Science Foundation: BRDIS Survey; U.S. Census Bureau: County Business Patterns.

IP-intensive manufacturing industries own approximately 80% of the U.S. manufacturing sector's IP assets.

In 2013 when R&D expenditures began to be treated as fixed investment, the BEA also recorded a new investment category called "intellectual property products" or "IP assets." While annual R&D investment measures investment flows (i.e., new R&D investment each year), IP assets measure the value of total accumulated R&D investment over time, which is typically used to measure rates of return on R&D.[19]

U.S. manufacturing industries had accumulated over $1.45 trillion of IP assets by the end of 2019 – up from $867.9 billion in 2008. As of 2019, IP-intensive manufacturing industries owned $1.16 trillion of IP assets, accounting for 80% of the total value of IP assets. (Figure 6)

Figure 6.
Outstanding IP Assets in the U.S. Manufacturing Sector, as of 2019[20]
IP-intensive industries account for 80% of the value of the entire U.S. manufacturing sector's IP assets



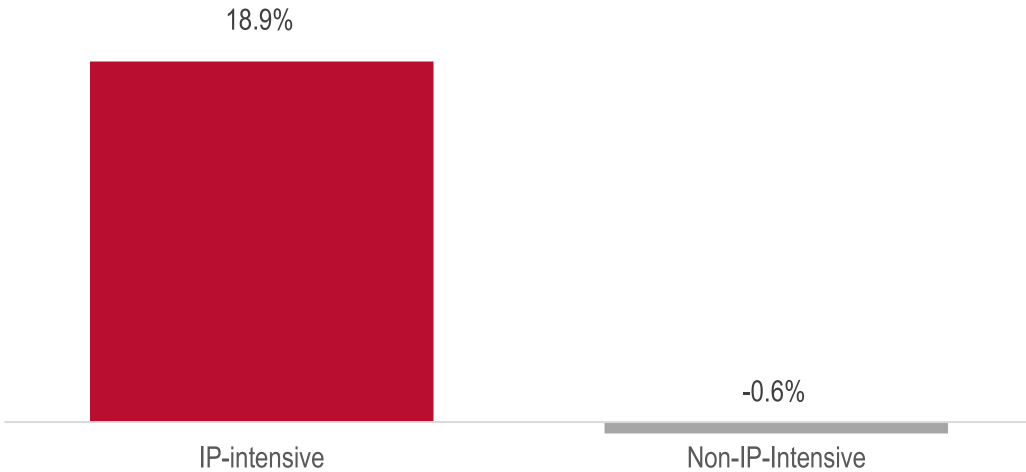
Real output of IP-intensive industries is growing while it is declining in non-IP-intensive industries.

After hitting its low level in 2009, real output of the manufacturing sector rebounded over the next decade. The recovery was driven entirely by the IP-intensive manufacturing industries. Between 2008 and 2019, real output of IP-intensive manufacturing industries grew by 18.9% while real output of non-IP-industries declined by 0.6%. (Figure 7)

[19] BEA. 2016. NIPA Handbook: Concepts and Methods of the U.S. National Income and Product Accounts, Chapter 6: Private Fixed Investment. https://www.bea.gov/national/pdf/chapter6.pdf

[20] Bureau of Economic Analysis.

Figure 7.
Real Output of Manufacturing Industries, 2008-19[21]
IP-intensive industries grew by 18.9% while non-IP-intensive industries declined by 0.6%



Sales (output) per employee in IP-intensive manufacturing industries was 40% higher than non-IP-intensive manufacturing industries.

Economic resources tend to be channeled toward industries that are an economy's most productive. Worker productivity (measured as output per employee) is a key indicator of an industry's prospects and sustainability. In the national accounts, gross output refers to sales or revenue from production. Between 2008 and 2019, the annual sales of IP-intensive manufacturing industries averaged $594,513 per employee, as compared to $423,795 per employee in non-IP-intensive manufacturing industries. With the exception of the petroleum and coal manufacturing industry, the chemical manufacturing industry—including pharmaceuticals—has the highest sales per employee in the U.S. manufacturing sector ($971,630 per employee per year). (Table 4)

Worker productivity is enhanced by R&D and tracks closely with R&D intensity – the degree to which a firm or industry concentrates its efforts in R&D. Overall, between 2008 and 2018, annual R&D investment in the U.S. manufacturing sector averaged 3.7% of sales (gross output). For IP-Intensive industries, R&D investment accounted for 8.6% of sales while the corresponding figure for non-IP-intensive manufacturing industries was a mere 1.0%. During this period, the industry with the highest level of sales per employee, the pharmaceuticals industry, invested 27.7% of sales in R&D. (Table 4) The greater an industry's R&D intensity, the more productive its workers tend to be and the more resilient and sustainable is the industry and its workforce.

[21] U.S. Bureau of Economic Analysis, "Real Gross Output by Industry," (data published June 24, 2021).

Table 4.
Annual Average Sales (Output) per Employee and Shares of R&D, by Selected Industries, 2008-19[22]

	Gross Output (Billions)	Output per Employee	R&D as % of Sales
All Manufacturing Industries	**$5,482.2**	**$472,719**	**3.7%**
IP-Intensive	**$1,975.3**	**$594,513**	**8.6%**
Chemical	$741.3	$971,630	8.7%
Pharmaceutical & medicine	$202.0	$830,731	27.7%
Computer & electronic	$320.0	$377,262	20.3%
Communications equipment	$41.2	$409,537	31.6%
Transportation equipment	$824.3	$576,642	3.7%
Aerospace	$216.2	$539,848	5.4%
Medical equipment & supplies (misc.)	$89.6	$311,757	11.1%
Non-IP-Intensive	**$3,506.8**	**$423,795**	**1.0%**
Petroleum & coal	$664.7	$6,531,743	0.1%
Food, beverage, & tobacco	$880.1	$530,930	0.6%
Textiles, apparel, & leather	$69.9	$196,142	1.1%
Wood	$90.3	$233,888	0.3%
Paper, printing, & support activities	$264.8	$317,528	0.5%
Plastics & rubber	$221.2	$300,332	1.3%
Nonmetallic mineral	$111.4	$295,723	1.2%
Primary metal	$242.6	$629,300	0.3%
Fabricated metal	$340.3	$240,798	0.6%
Machinery	$366.0	$351,025	3.4%
Electrical equipment & appliances	$123.0	$355,660	3.1%
Furniture	$70.2	$191,003	0.6%
Misc. non-medical equipment	$62.5	$229,139	3.5%

The value added per employee in IP-intensive manufacturing industries is more than 62% higher than it is for non-IP-intensive manufacturing industries.

A firm's or an industry's sales (or gross output) includes the value of intermediate goods plus the value added to those intermediate goods by the firm or industry. The net value or "value-added" by an industry represents

[22] National Science Foundation: BRDIS Survey; U.S. Census Bureau: Annual Survey of Manufactures, County Business Patterns and Economic Census.

that industry's contribution to GDP. The U.S. manufacturing sector's value-added increased from less than $2.3 trillion in 2008 to nearly $2.6 trillion in 2019, roughly 13.8%, and averaged $2.35 trillion per year over that period.

IP-intensive manufacturing industries accounted for nearly 40% of the manufacturing sector's contribution to the U.S economy. Between 2008 and 2019, the chemical industry (including the pharmaceutical industry), the transportation equipment industry (including the aerospace industry), and the computer industry (including the semiconductor industry) accounted for 16%, 13%, and 8%, of the manufacturing sector's contribution to the economy. The medical device manufacturing industry added another 2.6%.

Between 2008 and 2019, the manufacturing sector contributed an annual average of $202,751 per employee to the U.S. economy. The value-added of IP-intensive workers averaged $280,427, as compared to $171,592 for workers in non-IP-intensive manufacturing industries. Manufacturers of petroleum and pharmaceuticals registered the largest net economic contributions per employee, at $1.1 million and $592,539, respectively.

The greater productivity experienced in the IP-intensive industries reflects, nontrivially, the deeper commitment to research and development and the innovation it generates in those industries. Overall, R&D investment in the U.S. manufacturing sector averaged 8.7% of value-added. But in IP-intensive manufacturing industries, R&D investment was 18.2% of value added, while it was merely 2.4% in non-IP-intensive manufacturing industries. The highest ratios of R&D-to-value-added were observed in the communications equipment and pharmaceutical industries. (Table 5)

Table 5.
Annual Average Value-Added and Share of R&D, by Selected Industries, 2008-19[23]

	Value-Added (Billions)	Value-Added per Employee	R&D as % of Value-Added
All Manufacturing Industries	**$2,352.2**	**$202,751**	**8.7%**
IP-Intensive	**$931.7**	**$280,427**	**18.2%**
Chemical	$377.1	$493,558	17.2%
Pharmaceutical & medicine	$144.2	$592,539	39.0%
Computer & electronic	$187.2	$220,426	34.8%
Communications equipment	$21.7	$216,417	60.1%
Transportation equipment	$306.5	$215,067	9.9%
Aerospace	$119.3	$297,768	9.9%
Medical equipment & supplies (misc.)	$61.0	$211,878	16.5%
Non-IP-Intensive	**$1,420.4**	**$171,592**	**2.4%**
Petroleum & coal	$108.8	$1,065,142	0.6%
Food, beverage, & tobacco	$363.8	$219,229	1.4%
Textiles, apparel, & leather	$31.1	$87,294	2.4%
Wood	$38.0	$98,414	0.8%
Paper, printing, & support activities	$132.8	$159,206	1.0%
Plastics & rubber	$105.2	$142,655	2.8%
Nonmetallic mineral	$62.2	$165,090	2.1%
Primary metal	$84.5	$219,571	0.9%
Fabricated metal	$182.3	$129,304	1.1%
Machinery	$177.5	$170,241	7.0%
Electrical equipment & appliances	$59.9	$173,407	6.4%
Furniture	$37.7	$102,377	1.1%
Misc. non-medical equipment	$36.3	$133,171	6.1%

[23] National Science Foundation: BRDIS Survey; U.S. Census Bureau: Annual Survey of Manufactures, County Business Patterns and Economic Census.

IP-intensive jobs are more secure from economic contractions and more responsive to economic expansions than are non-IP-intensive jobs.

U.S. manufacturing employment peaked in 1979 when 19.4 million people worked in U.S. factories. Over the years, employment steadily dwindled (before rebounding somewhat in more recent years). In 2008, manufacturing employment was down to 13.1 million when the Great Recession struck. Between 2008 and 2010, U.S. manufacturing shed another 2.2 million jobs—a decline of about 17 percent—to an all-time low of 10.9 million jobs. Jobs in non-IP-intensive manufacturing industries, such as textiles, furniture, electrical equipment, and wood and paper products, were hit hardest. IP-intensive manufacturing industries also suffered job losses, but on a smaller scale.

After 2010, manufacturing employment began to recover and, by the end of 2019, the number of manufacturing jobs exceeded 12 million, which was still 7.5% below the 2008 level. In 2019, employment in IP-intensive industries was 3.3% below its 2008 level, but 9.2% lower for non-IP-intensive industries. The recovery after 2010 added 742,663 jobs to the manufacturing sector, which was a 14.7% increase for IP-intensive industries and a 10.2% increase for non-IP intensive industries. (Table 6)

Table 6.
Average Manufacturing Employment and Percentage Changes, 2008-19[24]

	Average Employment 2008-19	Change in Employment (%)		
		2008-19	2008-10	2010-19
All Manufacturing Industries	**11,617,435**	**-7.5%**	**-17.1%**	**11.5%**
IP-Intensive	**3,326,053**	**-3.3%**	**-15.7%**	**14.7%**
Non-IP-Intensive	**8,291,382**	**-9.2%**	**-17.6%**	**10.2%**

Wages in IP-intensive manufacturing industries are more than 45% higher than those in non-IP-intensive manufacturing industries.

Greater productivity means higher wages. Workers in IP-intensive manufacturing industries earn higher wages than their counterparts in non-IP-intensive manufacturing industries. During 2008-19, American manufacturing workers earned an average of $54,583 per year. Among them, workers in IP-intensive manufacturing industries made $70,096 per year. Their annual wages were over 45% higher than the wages of workers in non-IP-intensive manufacturing industries. IP-intensive manufacturing industries with the highest wages were the pharmaceutical manufacturing industry ($90,033 per employee). In contrast, the textile, apparel, and leather manufacturing industry had the lowest pay, $33,796 per employee per year. (Table 7)

[24] U.S. Census Bureau: County Business Patterns and Economic Census.

R&D investment is positively correlated with wages. During 2008-2019, R&D investment averaged 32.4% of wages in the U.S. manufacturing sectors. R&D investment was 73.5% total wages paid in IP-intensive manufacturing industries, led by 259% of wages paid in the pharmaceutical and medicine industry. During the same period, R&D investment was only 8.6% of total wages paid in non-IP-intensive manufacturing industries and merely 1.9% of total wages paid in the wood products industry. (Table 7)

Table 7.

Annual Average Wages per Employee and Shares of R&D, by Selected Industries, 2008-19[25]

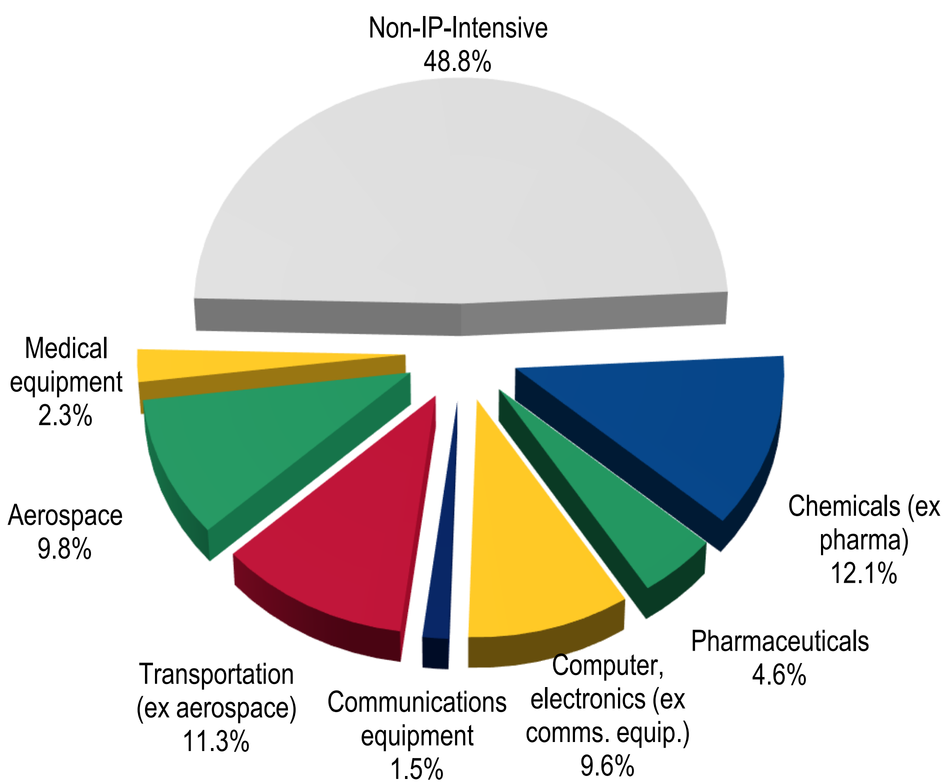
	Wages (Billions)	Wages per Employee	R&D as % of Wages
All Manufacturing Industries	**$634.1**	**$54,583**	**32.4%**
IP-Intensive	**$233.3**	**$70,096**	**73.5%**
Chemical	$58.0	$75,818	113.5%
Pharmaceutical & medicine	$21.9	$90,033	258.7%
Computer & electronic	$66.7	$79,022	97.1%
Communications equipment	$8.9	$88,234	146.2%
Transportation equipment	$90.7	$63,547	33.7%
Aerospace	$343.0	$84,882	34.6%
Medical equipment & supplies (misc.)	$17.8	$61,751	56.5%
Non-IP-Intensive	**$400.8**	**$48,354**	**8.6%**
Petroleum & coal	$9.8	$96,099	7.0%
Food, beverage, & tobacco	$69.6	$41,799	7.4%
Textiles, apparel, & leather	$12.0	$33,796	6.2%
Wood	$14.8	$38,221	1.9%
Paper, printing, & support activities	$41.8	$50,029	3.1%
Plastics & rubber	$33.6	$45,562	8.9%
Nonmetallic mineral	$18.7	$49,655	7.1%
Primary metal	$23.1	$59,865	3.1%
Fabricated metal	$70.4	$49,806	3.0%
Machinery	$61.1	$58,502	20.4%
Electrical equipment & appliances	$19.1	$55,149	20.2%
Furniture	$14.4	$39,005	2.8%
Misc. non-medical equipment	$12.5	$45,913	17.8%

[25] National Science Foundation: BRDIS Survey; U.S. Census Bureau: County Business Patterns and Economic Census.

IP-intensive manufacturing industries accounted for more than half of total manufacturing exports between 2008 and 2019.

During 2008-2019, IP-intensive manufacturing industries accounted for more than half of $1.1 trillion exported goods in the manufacturing sector each year. Among IP-intensive industries, the top exporters were transportation equipment manufacturers, including aerospace (21.2%); chemical manufacturers, including pharmaceuticals (16.7%); computer and electronic manufacturers, including communications equipment (11.1%); and medical device manufacturers (2.3%). (Figure 8)

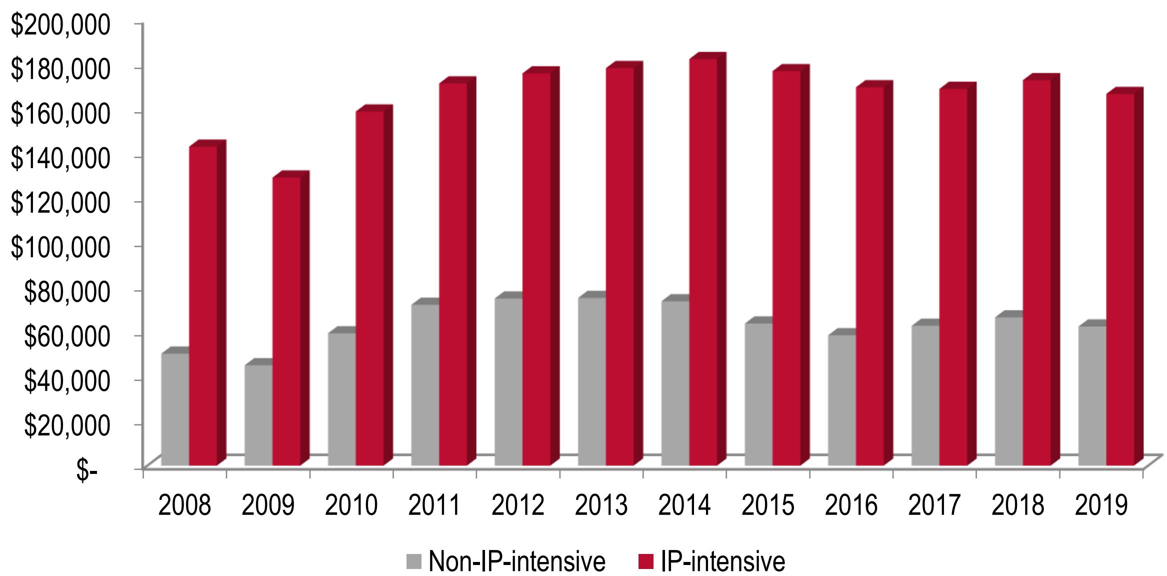
Figure 8.
Composition of Exports, by Selected Industries, 2008-19[26]
IP-intensive industries account for more than 51% of U.S. manufacturing exports



Exports of IP-intensive manufacturing industries have grown continuously over the years. From 2008 to 2019, IP-intensive exports averaged $166,281 per employee, which was 2.6 times greater than the average of $63,733 per employee in non-IP-intensive manufacturing industries. (Figure 9)

[26] U.S. Census Bureau: County Business Patterns and Economic Census; U.S. International Trade Commission: DataWeb

Figure 9.
Annual Average Exports per Employee in IP- and Non-IP-Intensive Industries, 2008-19[27]
Exports per employee in IP-intensive manufacturing industries were 2.6 times greater than in the non-IP-intensive industries



DISCUSSION AND CONCLUSION

The latest R&D and economic data reaffirm and accentuate previous findings that IP-intensive industries contribute significantly and comprehensively to the U.S. economy. IP-intensive manufacturing industries punch well above their weight, outperforming non-IP-intensive manufacturing industries with respect to key economic performance metrics. Gross output and value-added per worker are both 50% greater in IP-intensive manufacturing industries. The value of exports per worker is far greater in IP-intensive manufacturing industries. Workers in those industries earn approximately 45% higher wages than their counterparts in non-IP-intensive manufacturing industries. And IP-intensive manufacturing industry employment is more insulated from economic contractions and more resilient in times of economic expansion than is employment in non-IP-intensive industries.

These findings reinforce the importance of public policies that support the innovation ecosystem. Large amounts of R&D investment are necessary to generate new innovation. But that innovation supports stronger, more sustainable economic growth. In turn, that growth generates a fresh dividend of resources to be invested in R&D, which maintains this virtuous cycle. But the fact that innovation leads to stronger and faster economic growth does not mean that the R&D is always going to be forthcoming. R&D does not always

27 U.S. Census Bureau: County Business Patterns and Economic Census; U.S. Census Bureau: USA Trade.

succeed. There are all types of risks that must be taken into account before firms deploy resources in pursuit of innovation. Some of those risks can and should be mitigated, including the risk that other entities may feel entitled to the fruits of another company's R&D investments, thereby limiting the firm's capacity to even cover its investments. Without adequate protection of the right of companies to earn returns commensurate with the innovation they create, the higher risks would deter investment and diminish the innovation ecosystem.

Protection of intellectual property serves a crucial purpose. It helps protect the earnings that derive from expensive and uncertain R&D investments, and it incentivizes greater investment in research. Without those investments and the innovation it generates, economic stagnation is the likely alternative.

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APPENDIX

Table A.1. Economic Performance per Employee Compared to the Average of the U.S. Manufacturing Sector, 2008-19

• indicates that performance is above the average of the U.S. manufacturing sector during the relevant period

	R&D Investment /1	Wages	Exports	Value-Added	Sales (Gross Output)
IP-Intensive	•	•	•	•	•
Chemical	•	•	•	•	•
Basic chemical	•	•	•	•	•
Pharmaceutical & medicine	•	•	•	•	•
Computer & electronic	•	•	•	•	
Communications equipment	•	•	•	•	
Semiconductor & other	•	•	•	•	
Navigational, measure, electromed	•	•	•	•	
Transportation equipment	•	•	•	•	•
Motor vehicles, trailers	•	•	•		•
Aerospace product	•	•	•	•	•
Medical equipment & supplies (miscellaneous)	•	•		•	
Non-IP-Intensive					
Petroleum & coal		•	•	•	•
Food, beverage & tobacco				•	•
Textiles, apparel, & leather					
Wood					
Paper, printing, & support					
Plastics & rubber					
Nonmetallic mineral					
Primary metal		•	•	•	•
Fabricated metal					
Machinery		•	•		
Electrical equipment & appliances		•	•		
Furniture					
Misc non-medical equipment					

1/ Data only available from 2008-18

Table A.2. Economic Performance per Employee in 24 IP-Intensive and Non-IP-Intensive Industries, 2008-19

	R&D Investment /1	Wages	Exports	Value-Added	Sales (Gross Output)
All Manufacturing Sector	**$17,605**	**$54,583**	**$93,108**	**$202,751**	**$472,719**
IP-Intensive	***$51,257***	***$70,096***	***$166,281***	***$280,427***	***$594,513***
Chemical	$85,381	$75,818	$236,627	$493,558	$971,630
Basic chemical	$16,720	$82,831	$374,345	$597,835	$1,491,584
Pharmaceutical & medicine	$231,418	$90,033	$205,654	$592,539	$830,731
Computer & electronic	$76,574	$79,022	$141,838	$220,426	$377,262
Communications equipment	$128,293	$88,234	$166,685	$216,417	$409,537
Semiconductor & other	$98,850	$69,817	$138,424	$208,012	$358,428
Navigational, measure, electromed	$29,011	$84,182	$101,334	$227,479	$362,413
Transportation equipment	$21,354	$63,547	$159,383	$215,067	$576,642
Motor vehicles, trailers	$21,154	$55,029	$139,287	$188,257	$653,688
Aerospace product	$28,928	$84,882	$263,629	$297,768	$539,848
Medical equipment & supplies (miscellaneous)	$35,007	$61,751	$85,214	$211,878	$311,757
Non-IP-Intensive	***$4,118***	***$48,354***	***$63,733***	***$171,592***	***$423,795***
Petroleum & coal	$6,437	$96,099	$841,222	$1,065,142	$6,531,743
Food, beverage & tobacco	$3,074	$41,799	$40,152	$219,229	$530,930
Textiles, apparel, & leather	$2,106	$33,796	$48,075	$87,294	$196,142
Wood	$682	$38,221	$16,294	$98,414	$233,888
Paper, printing, & support	$1,540	$50,029	$34,514	$159,206	$317,528
Plastics & rubber	$4,024	$45,562	$37,927	$142,655	$300,332
Nonmetallic mineral	$3,449	$49,655	$27,133	$165,090	$295,723
Primary metal	$1,809	$59,865	$144,649	$219,571	$629,300
Fabricated metal	$1,464	$49,806	$27,404	$129,304	$240,798
Machinery	$11,852	$58,502	$122,754	$170,241	$351,025
Electrical equipment & appliances	$11,073	$55,149	$113,052	$173,407	$355,660
Furniture	$1,071	$39,005	$11,712	$102,377	$191,003
Misc non-medical equipment	$8,070	$45,913	$68,163	$133,171	$229,139

1/ Data only available from 2008-18

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