



NATIONAL SCIENCE BOARD
Science & Engineering Indicators



Innovation

Translation to Impact: U.S. and Global Science, Technology, and Innovation Output

NSB-2026-2 | May 01, 2026

The National Science Board (Board) is required under the National Science Foundation (NSF) Act, 42 U.S.C. § 1863 (j) (1) to prepare and transmit the biennial *Science and Engineering Indicators (Indicators)* report to the President and Congress every even-numbered year. The report is prepared by the National Center for Science and Engineering Statistics (NCSES) within NSF under the guidance of the Board. It is subject to extensive review.

Table Of Contents

Executive Summary	5
Economic Impact of Science and Engineering Activities	5
Innovation Commercialization and Technology Transfer	5
Global Innovation and Patent Landscapes	5
Global Market Dynamics and Investment Patterns	6
Introduction	7
Productivity Impacts and General-Purpose Technologies	8
Artificial Intelligence as a GPT	9
Knowledge and Technology Transfer	14
Technology Transfer Metrics	14
Patents as Invention Indicators	20
Innovation	40
Trademarks	40
Open-Source Software	41
Business-Reported Innovation	47
Business Dynamics and Investment	50
Startups and Small Business Innovation Research	50
Venture Capital	52
Production Patterns of Knowledge- and Technology-Intensive Industries	57
U.S. Industries	57
Industries in the Global Economy	58
Sectoral and Industry Distributions	62
Global Semiconductor Production	64
Global Trade by KTI Industries	66
Conclusion	70
Glossary	71
Definitions	71
Key to Acronyms and Abbreviations	74
References	77
Notes	86

Acknowledgments and Citation 87

Acknowledgments	87
Citation	87

Contact Us 88

NCSES	88
-------	----

List of Sidebars

Measuring Short- and Long-Term Impacts of S&E Activity	12
Intellectual Property Measures in Context	38
Global Contributions and Collaborations in Open-Source Software	42
Comparing Innovation across Countries	48

List of Tables

TRN-1	"Translation" thematic report indicators and their sources	11
TRN-2	U.S. federal agencies cited in the funding acknowledgement section of S&E articles, by citation frequency: 2002–22	15
TRN-3	U.S. federal agency activity in granted patents, S&E articles, and articles cited by patents, by inventor's or author's affiliated agency: 2013–24	16
TRN-4	Top cited organizations at USPTO, according to the share of patents in top 1% most cited: 2021	22
TRN-5	Top venture capital–funded firms headquartered in the United States: 2024	56
TRN-6	Global KTI industries, by value added and share of global GDP: 2018–24	60

List of Figures

TRN-1	Total factor productivity, U.S. nonfarm business sector and information: 2000–24	9
TRN-2	Use of artificial intelligence as a production technology for goods and services, by selected industry: 2020-22	10
TRN-3	Use of artificial intelligence as a production technology for goods and services, by company size: 2020-22	11
TRN-4	University technology licenses or license options executed, by company characteristic: 2014–24	17
TRN-5	Startup companies based on licensed university technology, by company location: 2000–24	18
TRN-6	Citations of U.S. academic S&E articles in USPTO utility patents, by S&E field of the articles cited: 2024	20
TRN-7	USPTO utility patents granted to owners, by nationality and U.S. sector: 2004–24	21
TRN-8	Priority patent families granted in artificial intelligence, machine learning, autonomy, and related advances, for the world and China: 2010–24	24
TRN-9	Utility patents granted in artificial intelligence, machine learning, autonomy, and related advances, by selected region, country, or economy: 2024	25
TRN-10	Highly cited patents granted in artificial intelligence, machine learning, autonomy, and related advances, by selected region, country, or economy: 2010 and 2021	26
TRN-11	Priority patent families granted in biotechnology, medical technology, genomics, and synthetic biology, by selected country or economy: 2010–24	27
TRN-12	Utility patents granted in biotechnology, medical technology, genomics, and synthetic biology, by selected country or economy: 2024	28
TRN-13	Highly cited patents granted in biotechnology, medical technology, genomics, and synthetic biology, by selected country or economy: 2010 and 2021	29
TRN-14	Priority patent families granted in semiconductors, by selected country or economy: 2010–24	30
TRN-15	Utility patents granted in semiconductors, by selected country or economy: 2024	31

TRN-16	Highly cited patents granted in semiconductors, by selected country or economy: 2010 and 2021	32
TRN-17	Priority patent families granted in quantum information science and technology, by selected country or economy: 2010–24	33
TRN-18	Utility patents granted in quantum information science and technology, by selected country or economy: 2024	34
TRN-19	Highly cited patents granted in quantum information science and technology, by selected country or economy: 2010 and 2021	35
TRN-20	Priority patent families granted in advanced nuclear technologies, by selected country or economy: 2010–24	36
TRN-21	Utility patents granted in advanced nuclear technologies, by selected country or economy: 2024	37
TRN-22	Highly cited patents granted in advanced nuclear technologies, by selected country or economy: 2010 and 2021	38
TRN-23	U.S.-registered USPTO trademarks, by business sector: 2024	41
TRN-24	Share of U.S. companies reporting product or business process innovation, by selected industry: 2020–22	47
TRN-25	Annual economywide business startups: 2000–23	50
TRN-26	Firms receiving Phase II SBIR or STTR awards: 2013–24	51
TRN-27	Firms receiving Phase II SBIR or STTR awards, by awarding agency: 2013–24	52
TRN-28	Venture capital investment received by firms headquartered in selected regions, countries, and economies: 2013–24	53
TRN-29	Venture capital investment received by firms headquartered in the United States, by deal stage: 2003–24	54
TRN-30	Firms headquartered in the United States receiving venture capital investment, by critical and emerging technologies: 2013–24	55
TRN-31	Industry share of U.S. total KTI value added, by selected industries: 2002–24	58
TRN-32	Country share of global KTI manufacturing value added, by KTI industry: 2024	61
TRN-33	Country share of global KTI services value added for selected regions, countries, or economies: 2002–24	62
TRN-34	Country share of global KTI manufacturing value added for selected regions, countries, or economies: 2002–24	63
TRN-35	Country share of global KTI services value added, by KTI industry: 2024	64
TRN-36	Global share of value added for semiconductor manufacturing, by region, country, or economy: 2002–24	65
TRN-37	Country share of global KTI manufacturing exports for selected regions, countries, or economies: 2002–24	66
TRN-38	Gross exports of KTI manufacturing industries for selected regions, countries, or economies: 2002–24	67
TRN-39	Industry composition of KTI manufacturing exports for selected regions, countries, or economies: 2024	68
TRN-A	New GitHub repositories contributed by the United States and the rest of the world: 2009–24	43
TRN-B	Share of new GitHub repositories, by region, country, or economy of contributor: 2024	44
TRN-C	Open-source software collaboration networks in GitHub, by region, country, or economy: 2024	46

Executive Summary

Economic Impact of Science and Engineering Activities

Science and engineering (S&E) activities continue to be strong drivers of economic growth in the United States and abroad, with research-intensive sectors demonstrating particularly strong performance across multiple measures of economic value creation.

- Total factor productivity (TFP) is a broad measure of the impact of S&E activities (beyond labor and capital) on economic growth. Between 2017 and 2024, TFP grew faster in the high-R&D information sector (13%) in the United States than in the domestic nonfarm economy as a whole (8%).
- Knowledge- and technology-intensive (KTI) industries (based on Organisation for Economic Co-operation and Development measures of R&D intensity) worldwide produced \$11.7 trillion of value added (net economic output) in 2024, in current dollars, a 4% increase from 2023. In the United States, KTI industries produced \$3.3 trillion of value added in 2024, accounting for 11% of U.S. gross domestic product.

Innovation Commercialization and Technology Transfer

Commercialization, technology transfer, and adoption data highlight variations across industries and time periods. Firms in high-R&D industries within the information and manufacturing sectors reported higher new product or service introduction rates compared to all industries.

- The number of university licenses and options granted in the United States to private-sector entities peaked in 2021 but have declined since then. University-related startups similarly peaked in 2020 and have decreased since then through 2024.
- Industries in the information sector, such as software publishing, telecommunications, data processing, and Internet providers, posted above-average rates of introducing new products and services. In 2022, over half (54%) of software publishers reported introducing a new product or service in the past 3 years, compared with 23% for all industries.
- Within the manufacturing sector in 2022, firms producing navigational, measuring, electromedical, and control instruments reported the highest rate (46%) of introducing a new product or service in the past 3 years.
- Artificial intelligence (AI) adoption was more widespread in larger U.S. companies (measured by employees) and in companies in particular industries, such as software, where 20% of companies reported using the technology as a production technology between 2020 and 2022.

Global Innovation and Patent Landscapes

International competition to develop critical technologies is intense, with different regions establishing leadership in specific technologies as evidenced by patterns in U.S. and international patent data. U.S. inventors show particular strength in biotechnology and the biomedical and health sciences, an area with historically high shares of federal government research funding. Citations to both publications and patents provide an indicator of research impact.

- Articles from the biological and biomedical sciences were cited in Patent and Trademark Office (USPTO) patents more often than articles from any other S&E field in 2024, accounting for 27% of all citations, followed by articles from the health sciences at 23%.
- Priority patent data are an international data source that allows each patented innovation to be counted once as a priority patent family, based on the first filing globally. Inventors from China attributed the largest number of AI priority patent families, averaging three-fourths (75%) of the patents granted in AI technologies in 2024.

- Patents granted to U.S. inventors in biotechnology and related technologies consistently have high impact, as measured by the share of these priority patent families in the top 1% of all cited priority patent families. The highly cited patent (HCP) share for U.S. inventors has risen from 2.6% in 2010 to 3.1% in 2021. As inventive activity spreads across the globe, the HCP share for U.S. inventors in AI had decreased from 2.7% of the top 1% list in 2010 to 1.7% in 2021.

Global Market Dynamics and Investment Patterns

International market dynamics, the location of production capabilities, and collaborative networks reflect the evolving geography of technical innovation and economic competitiveness in a global economy.

- The United States, China, the European Union (EU-27), Japan, and South Korea accounted for about 80% of global KTI value added in 2024. The United States and China were the top two overall producers of KTI output in 2024, with \$3.3 trillion (or 28%) and \$2.9 trillion (or 25%), respectively.
- China was the largest KTI manufacturing producer in 2024, with a 31% global share, followed by the United States, with a 21% share.
- The United States was the top KTI services producer in 2024, with a 43% global share, followed by China at 11%. Within KTI services industries, the U.S. global share was largest for software publishing (75%).
- In 2024, just over half (52%) of global semiconductor production, measured as value added, occurred in China (30%) and Taiwan (22%). The United States (19%) and South Korea (11%) completed the top four locations.
- Global KTI goods exports were more resilient than overall goods exports in 2023, declining by less than 1% that year and increasing by 3% in 2024 to \$11.7 trillion in current U.S. dollars. All manufactured goods declined 4% in 2023 and increased 2% in 2024.
- In 2024, the United States, China, the United Kingdom, India, and Germany reported the highest volume of venture capital (VC) deals globally. Investments in software consistently comprised the largest share of U.S. VC funding in critical and emerging technology areas (classification by the U.S. National Science Foundation Directorate for Technology, Innovation and Partnerships), representing over 80% each year between 2013 and 2024.
- Though freely distributed, open-source software contributes considerable value to innovation by providing critical tools for modern software and analysis. At the end of 2024, almost 140 million developers globally were contributing to open-source computer code on the GitHub platform, increasing from 45 million developers at the beginning of 2020.

Introduction

Science, technology, and innovation activities expand the frontiers of fundamental and technical knowledge. Research and development (R&D) activities, as well as organized science and engineering (S&E) activities, often lead to new outputs, such as research publications (see the *Science and Engineering Indicators 2026* report “[Discovery: R&D Activity and Research Publications](#)” [NSB 2025]), new products and services, licensed technologies, and companies, which in turn impact economic output, productivity, and global trade. These outputs, along with the scientists, engineers, and skilled workers (see the *Indicators 2026* report “[STEM Talent: Education, Training, and Workforce](#)” [NSB 2026]) that enable them, contribute to the economic competitiveness and national security of the United States. Economic competitiveness, national security, and geopolitical considerations influence the science, technology, trade, and defense policies of national governments globally, as they attempt to shape innovation ecosystems and control supply chains for critical and emerging technologies (CETs) (Chatterji and Murray 2025). These policies affect the direction and location of global R&D activity, innovation, and knowledge- and technology-intensive (KTI) industrial production (based on Organisation for Economic Co-operation and Development [OECD] measures of R&D intensity; see the [Glossary](#) section for KTI definition).

This report focuses on indicators that provide insight into the science, technology, and innovation activities of businesses, governments, and academia. Innovation activities include all the steps taken to develop, deploy, or bring new processes, products, and services to market. In addition to R&D activities (described in the *Indicators 2026* report “[Discovery: R&D Activity and Research Publications](#)” [NSB 2025]), these may be technological, organizational, financial, or commercial (OECD/Eurostat 2018). This report also identifies trends in output and international trade by KTI industries to provide context for R&D and innovation trends across economic sectors. The report addresses R&D and other innovation activities in CET areas, such as artificial intelligence (AI), biotechnology, semiconductors, quantum information science and technology (QIST), and nuclear energy, overlapping with the priorities of the current administration (Vought and Kratsios 2025). The original taxonomy used for critical technologies was introduced in the *Indicators 2024* report “[Invention, Knowledge Transfer, and Innovation](#)” (NSB 2024) and has been expanded for this report. The U.S. National Science Foundation’s (NSF’s) Directorate for Technology, Innovation and Partnerships (TIP) developed and refined this taxonomy, which is used to link critical technologies to patent classes (NSF/TIP 2025). Data in the report cover U.S. and international indicators on production, trade, innovation, technology transfer, and related activities of businesses, governments, and academia.

The first section of the report focuses on *knowledge and technology transfer* activities—the collaborative process through which research, technology, and intellectual property (IP) generated by fundamental research flow from laboratories, universities, or other research institutions to private or public users, where they can be developed into commercial products or services (USPTO 2025b; WIPO n.d.). Citations in research publications to federally supported R&D activities are an indicator of the flow of public knowledge into useful inventions. Open-source software (OSS), such as Linux or Apache, is estimated to support much of the corporate software currently in use, saving companies billions in software development costs, with savings estimated to be \$8.8 trillion for 2020 (Hoffman, Nagle, and Zhou 2024). However, because much of it is not produced for sale, it is difficult to estimate the value of OSS. Analysis of major OSS repositories, however, allows tracking of the broad growth in OSS development and collaboration patterns between developers, which can help identify the aggregate impacts of OSS. IP protections for the rights of inventors, such as patents and trademarks, can be used to track innovative capacity. The *technology transfer* section of the report addresses patents registered in the United States, including patents granted to individuals and foreign entities, as well as international patent data. The section highlights invention activities for five CET areas identified by policymakers because of their role in national and economic security.

Innovation is the translation of knowledge arising from R&D activities into new or improved products, processes, or services with real-world applications. The *innovation* section of the report includes three additional indicators of the incidence of innovation to complement the patent data presented previously: newly registered trademarks, contributions to OSS repositories, and business survey data on the introduction of new products and processes. As an indicator of innovation

activity, trademarks complement patenting, and academic studies have consistently found trademarking to be correlated with innovation, especially for firms in R&D-intensive industries. OSS is accessed, modified, and distributed freely, with the intent of being widely shared and expanded. Increasingly, private-sector employees play an active role in OSS development, as it has become a critical part of many industries' software R&D processes. Although OSS is distributed freely, many technology companies, including those providing cloud services, have incorporated it into their business models (Lifshitz-Assaf and Nagle 2021). A key indicator of business-sector innovation is the proportion of companies within a given industry that report introducing new or significantly improved products and processes within a specific time frame. New and existing companies solicit investment to support the translation of R&D activities into commercial products and services. Access to financing is an essential component of the translation of new knowledge into innovations.

The *business dynamics and investment* section presents a range of indicators of innovation activities, starting with data on the funding of innovation through federal programs and through private venture capital (VC). Often, these two kinds of funding work together, with federal funding providing the earliest, highest-risk stage of financial capital. This section of the report presents the number of business firms created in a given year (startup firms), an indicator of job growth. It also highlights U.S. and international VC funding, which often supports startups and pre-revenue firms. VC funding is an indicator of innovation activity, as a disproportionate number of companies that ultimately make public offerings and have high rates of recorded R&D expenditures are backed by VC.

The final two sections of the report examine *production and trade patterns* of firms in KTI industries. Firms in KTI industries are important funders and performers of R&D, produce high-value products and services and intangible assets, and contribute to the national economic competitiveness in global markets. They often operate in global markets characterized by complex supply chains and rapid technological change that result in the introduction of disruptive products and services, such as AI, and new production practices, such as increased automation. These sections examine patterns of production associated with KTI industries, measured as value-added output, and international trade of KTI goods.

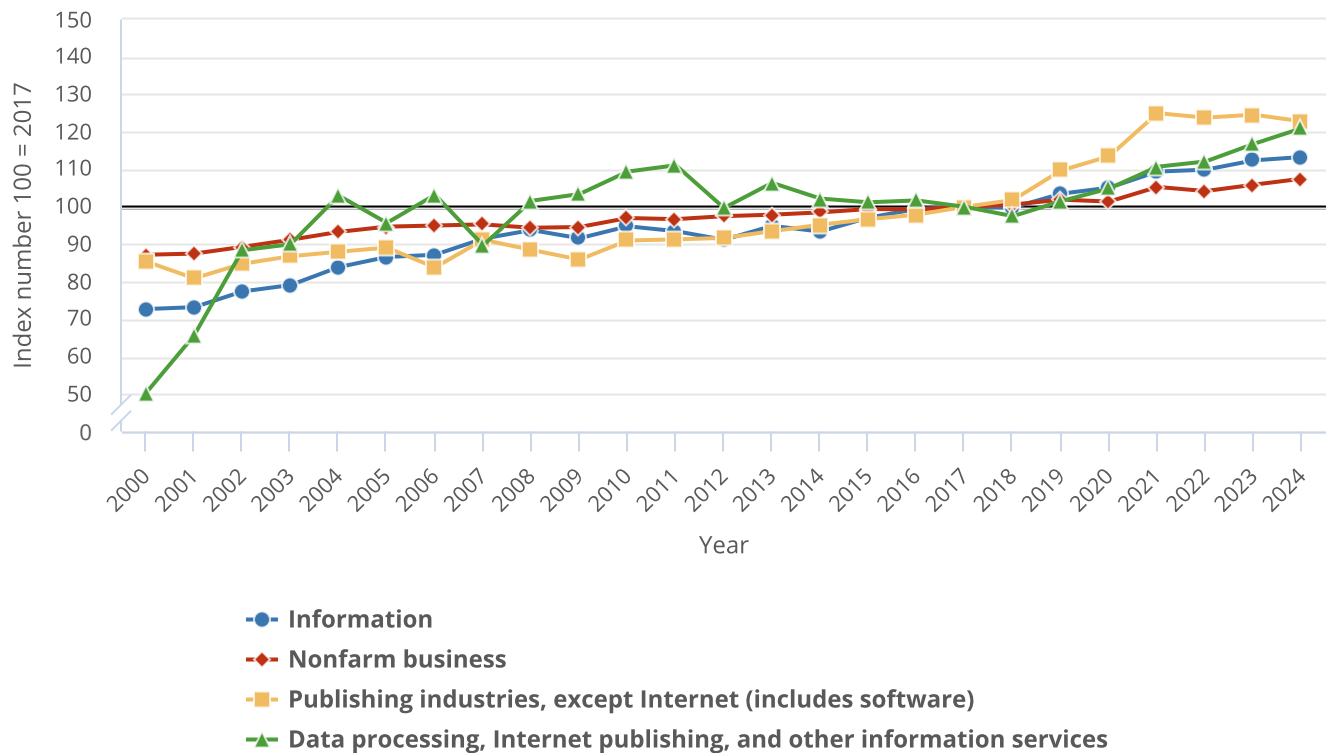
The rest of the introduction of the report discusses the economic concepts that link economic output and growth to R&D and innovation activities through *productivity impacts* and *general-purpose technologies (GPTs)*. GPTs—that is, new technologies that are widely adopted through the economy—can have particularly large economic impacts. Business survey data presented in this section describe the early adoption of AI by industry and company size. A sidebar provides a discussion of the ways that economic impacts of research are measured in the short term and in the longer term.

Productivity Impacts and General-Purpose Technologies

Although the data and indicators in this report provide a multidimensional picture of translation activities, total factor productivity (TFP) is an internationally comparable indicator of the impact of innovation and technological change on growth within an economic sector. TFP is calculated by dividing output measures by input measures. Any excess output isolated in this calculation is commonly used in economics to interpret how efficiently labor and capital are used to produce goods and services (Acemoglu and Johnson 2023). This excess output is also often used to gauge the effect of R&D activity on technological change (Hall 2011).

TFP can fluctuate over time, along with the pace of technological advances and their applications to the economy (Gordon 2017). Recently, businesses in the information sector of the economy have seen faster TFP growth than the broader economy. As measured by the Bureau of Labor Statistics, information sector TFP grew 13% between 2017 and 2024, compared with nearly 8% for the nonfarm business sector overall. Components of this sector that are heavily reliant on the use of semiconductors and Internet technology have experienced particularly rapid growth in TFP. Within the information sector, TFP for the publishing industry increased 23% between 2017 and 2024. For data processing, Internet publishing, and other information services, the increase since 2017 has been 21% (Figure TRN-1).

Figure TRN-1. Total factor productivity, U.S. nonfarm business sector and information: 2000–24



Source(s):
Bureau of Labor Statistics.

Science and Engineering Indicators

Semiconductors and the Internet are examples of technologies that are widely used, continually improved, and used to enable applications in other sectors. As such, they are referred to often as *general-purpose technologies (GPTs)*. Other historical examples of GPTs include electricity and computers. By complementing advances in other technologies, GPTs are often widely adopted across industries and may lead to productivity growth (NASEM 2025). Their impact on economic growth and productivity is influenced by factors like application across sectors, the deployment of capital, and workforce effects (Bresnahan 2010).

As an example, semiconductors enable other technologies and have experienced increasing returns over time as they are used in new applications, like semiconductors originally optimized for graphics being used for AI applications. In the mid-20th century, as technology for creating electronic circuits led to miniaturization, the uses of semiconductors expanded. Early applications included hearing aids and televisions (Bresnahan and Trajtenberg 1992). The widely cited “Moore’s Law,” attributed to Intel co-founder Gordon Moore, predicted that semiconductor processing power would double roughly every 2 years as prices declined (Moore 1965). Improvements in processing power have been accompanied by a decades-long decline in semiconductor prices, leading to broad applications in computing, communications, and other products (Jorgenson 2001).

Artificial Intelligence as a GPT

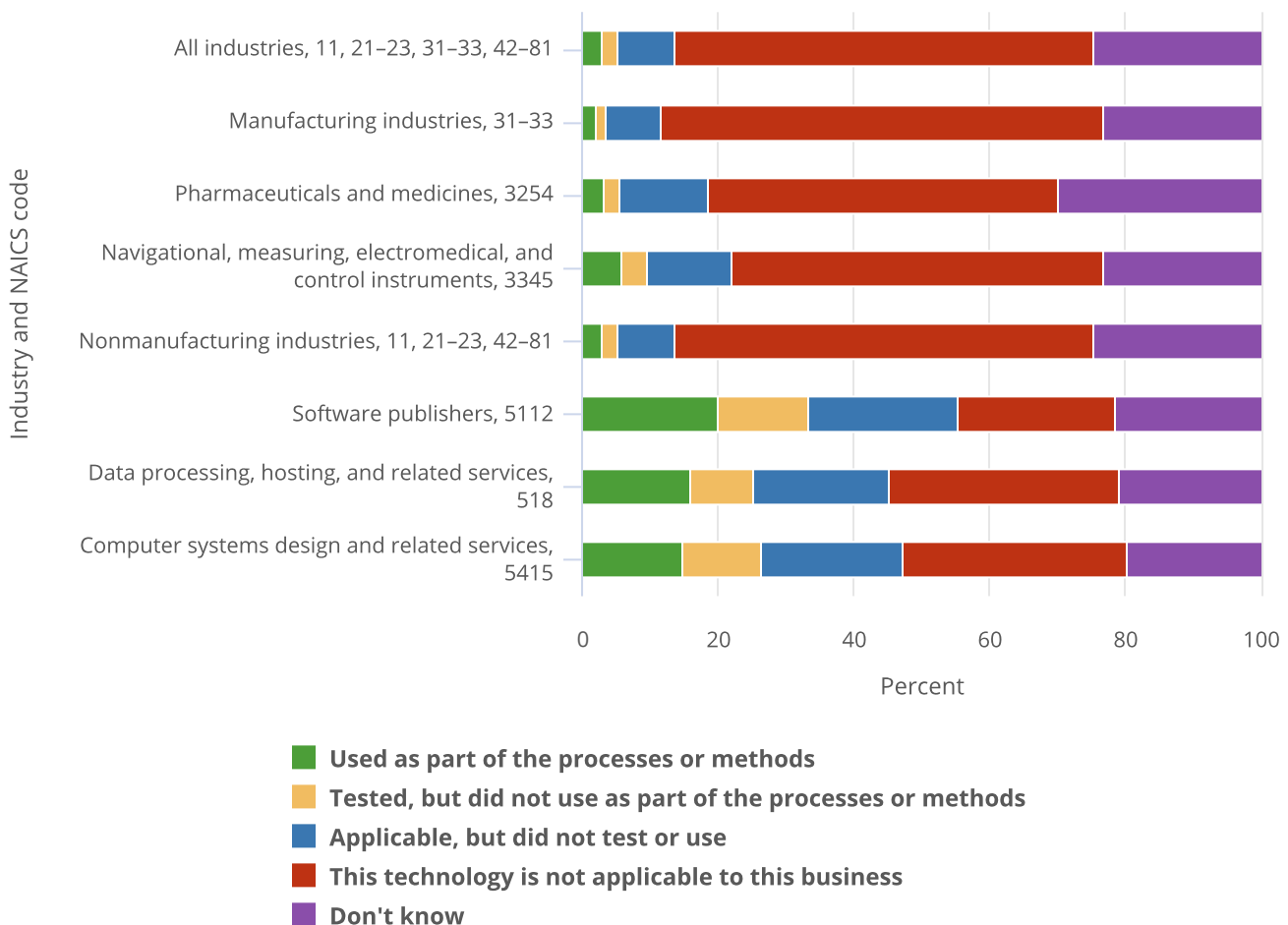
Built on the foundation of semiconductor and Internet technologies, AI has more recently been identified as a rapidly growing GPT with implications for productivity and employment (Brynjolfsson and McAfee 2016; NASEM 2025; Trajtenberg 2018). In November 2022, ChatGPT, the first widely available AI software tool, was released to the public (Heaven 2023). The number of computer and information science degrees at the bachelor’s and master’s levels awarded by U.S. universities has

increased concurrently with the growth in information and communications industries that have given rise to AI technology. Between 2013 and 2023, the numbers of these degrees awarded have more than doubled (see the *Indicators 2026* report “STEM Talent: Education, Training, and Workforce” [NSB 2026: [Figure TAL-23](#), [Figure TAL-24](#)]). Although reliable data on AI’s impact on the workforce as a whole are scarce thus far, questions likely relevant to consider when addressing AI’s potential impact on the workforce include the following:

- To what extent will specific skills within occupations become obsolete?
- Which specific skills within occupations may be enhanced?
- What skills will employers recruit for with the implementation of AI within their industry?
- What is the likely feasibility of workers within certain occupations to upgrade their implicated skills (NASEM 2025)?

Business survey data provide insight into the extent of AI’s use within specific industries. According to the 2023 Annual Business Survey (ABS), 2.9% of companies reported using AI as a production technology for goods and services between 2020 and 2022. During the same period, 1 in 5 firms (20.1%) in the software industry reported using the technology ([Figure TRN-2](#)). For firms with more than 10,000 employees, 22.2% of firms reported using AI between 2020 and 2022, while for microbusinesses (1–9 employees) and small businesses (10–49 employees), 2.9% and 2.5% reported utilizing the technology, respectively ([Figure TRN-3](#)).

Figure TRN-2. Use of artificial intelligence as a production technology for goods and services, by selected industry: 2020-22



NAICS = 2017 North American Industry Classification System.

Note(s):

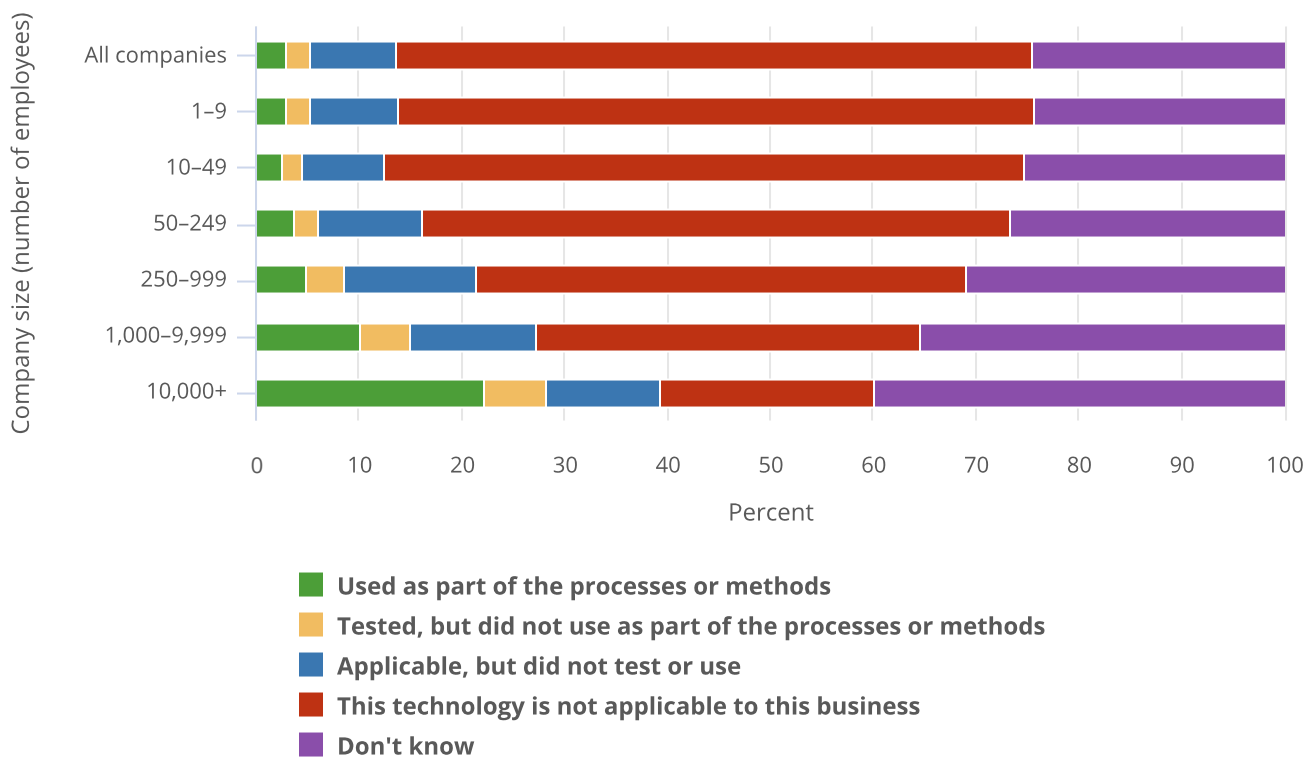
Industry classification is based on dominant establishment payroll. Statistics are representative of companies located in the United States.

Source(s):

National Center for Science and Engineering Statistics and Census Bureau, 2023 Annual Business Survey (ABS): Data year 2022.

Science and Engineering Indicators

Figure TRN-3. Use of artificial intelligence as a production technology for goods and services, by company size: 2020-22



Note(s):

Statistics are representative of companies located in the United States.

Source(s):

National Center for Science and Engineering Statistics and Census Bureau, 2023 Annual Business Survey (ABS): Data year 2022.

Science and Engineering Indicators

A summary of the indicators used in this report and their sources is found in [Table TRN-1](#); see also the sidebar [Measuring Short- and Long-Term Impacts of S&E Activity](#).

Table TRN-1. "Translation" thematic report indicators and their sources

(Indicator and source)

Section	Indicator	Source
Knowledge and Technology Transfer	Total factor productivity, U.S. nonfarm business sector, manufacturing, and information	BLS
	Companies using artificial intelligence as a production technology	NCSES, Census Bureau
	University technology transfer	AUTM
	Federal agency publications	Scopus
	Citations of U.S. academic S&E articles in USPTO utility patents	Scopus, USPTO
	Utility patents granted	USPTO, EPO
	Highly cited patents granted	USPTO, EPO

Table TRN-1. "Translation" thematic report indicators and their sources

(Indicator and source)

Section	Indicator	Source
Innovation	Trademarks	USPTO
	Open-source software repositories	GitHub
	Open-source software collaborations	GitHub
	Industries introducing product or process innovations	NCSES, Census Bureau
Business Dynamics and Investment	Total number of U.S. establishment startups	Census Bureau
	SBIR and STTR program funding awards	Small Business Administration
	Venture capital	PitchBook
Production Patterns of Knowledge- and Technology-Intensive Industries	Knowledge- and technology-intensive industry value added	S&P Global Comparative Industry Service
Global Trade by KTI Industries		Knowledge- and technology-intensive industry exports

BLS = Bureau of Labor Statistics; EPO = European Patent Office; NCSES = National Center for Science and Engineering Statistics; SBIR = Small Business Innovation Research; STTR = Small Business Technology Transfer; USPTO = Patent and Trademark Office.

Science and Engineering Indicators

SIDEBAR

Measuring Short- and Long-Term Impacts of S&E Activity

Many of the indicators included in this thematic report represent S&E activities that cannot be measured monetarily. This sidebar provides an overview of the kinds of analyses that are used to assess economic impact across a variety of metrics, including their strengths and limitations. Overall, patenting in aggregate has great economic value, but an individual patent may go unused and thus have its value unrealized. Open-source software is a substitute for purchased software, but its value cannot be captured neatly by looking at total revenues from sales or licensing. The value of a trademark depends on the revenue its use can generate. The economic value of each of these activities may not be realized until long after they are created, adding to the difficulty in assessing their impact. Short-term impacts are those that can be estimated at the time spending takes place, whereas long-term impacts take time for their impact to manifest.

Some S&E indicators, like the number of employed S&E professionals and their levels of income, intrinsically measure the economic impact of S&E activity. Other indicators, such as R&D expenditures, can be used as inputs to estimate economic impacts. There are ways to estimate short- and long-term economic impacts. Economic impact analysis with multipliers, as described below, is the most common way to estimate short-term economic impacts. Econometric methods, which use model-based statistical analysis of large data sets, are most frequently used for long-term analysis.

Economic impact analysis using multipliers is a well-established approach to measuring short-term impacts on economic activity. *Multipliers* are economic ratios that show an average historical relationship between spending and related economic activity. In the United States, industry- and location-level input-output data from the Bureau of Economic Analysis are used to develop ratios that estimate a *multiplier effect*, which considers subsequent rounds of spending that take place when purchases are made. For example, the purchase of consulting services leads to further rounds of spending as the consulting firm hires workers, rents offices, and purchases goods and services. When consumer spending associated with the wages paid is added to the estimated effect, the multiplier increases further. If the multiplier for an activity is estimated to be 1.2, then \$100 of spending would generate \$120 of activity.

Economic impact analyses using payroll data from research universities or other organizations can show the number of workers employed and wages directly supported by grants or other funding sources. These analyses can show (1) the direct effect of spending and associated jobs, (2) the supply chain effect from consuming the output of other industries, and (3) the effect of employee spending in the economy.

A 2023 economic impact study for the National Aeronautics and Space Administration (NASA) used this approach to estimate economic impacts of NASA activities for 50 states and the District of Columbia (PCI Productions 2024). Using industry-level multipliers, the report estimated that NASA paid \$3.5 billion in wages in 2023 and generated an additional \$23.3 billion in purchases (procurement). NASA's Moon to Mars program is estimated to account for 33% of these total impacts. Using industry-level employment multipliers, the report estimates that each full-time equivalent job at a NASA facility supports 16 additional jobs (PCI Productions 2024).

A limitation of this kind of model is that it estimates impacts of public investment with the same ratios as it does for impacts of private investment. For some types of economic activity, this may not be appropriate. Counterfactual analysis is a further step in evaluating whether public expenditure is more efficient than private investment in generating the relevant technology. This method compares with a baseline of what activity would exist without the public investment and is particularly useful when investment is intended to produce outcomes that the private sector cannot entirely appropriate (Link and Scott 2012).

When private returns to an investor are different from returns to the public at large, these differences can be measured as *spillovers*, which can be positive (beneficial) or negative (costly). The creation of new and sharable knowledge can be the source of positive spillovers as firms take advantage of knowledge created by other firms or by other institutions (Griliches 1991). Over the long run, knowledge creation increases the quantity of output that can be created through increased productivity, which in turn leads to growth in average living standards (Solow 1956). *Multifactor productivity*—aggregate economic benefits in excess of cost after removing the effects of capital and labor—is an indicator calculated with economic data that can be used to estimate these long-run effects. Long-term multifactor productivity effects can be calculated in two ways: (1) an econometric method that attributes all excess returns as due to innovation, and (2) assuming a rate of return to innovation similar to that of other investments (Hall 2011).

The proximate cause of these long-term effects can be hard to pin down. The framework used by the Congressional Budget Office accounts for five factors that influence the timing and size of impact. These are the timing of outlays, how outlays are financed, how much they affect productivity, how quickly they affect productivity, and how state and local governments respond (Gullo et al. 2025). Based on the results of decades of productivity analysis and reasonable assumptions, Gullo and coauthors (2025) conclude that federal R&D increases the benefit of private R&D.

Just how big is this benefit? A broadly applicable method by Jones and Summers (2020) estimates the average economic return from different types of innovation investments, finding that \$1 in R&D investment creates between approximately \$5 and \$10 in economy-wide benefits, with a likely delay of 3–6 years. The exact amount of these benefits depends on the type of investment and the amount of time for impact to take place, with the impact of basic research taking longer to realize returns and having greater uncertainty than experimental development.

Knowledge and Technology Transfer

Knowledge arising from publicly funded R&D supports the production of new technologies and processes as that knowledge is adopted by the private sector. This takes place through formal mechanisms, such as licensing agreements and cooperative R&D agreements, as well as through coauthorship between private- and public-sector researchers. Technology developed in universities and government laboratories can be licensed and used by private-sector companies, including startups. Federal agencies collect technology transfer metrics for technologies that they license and then report them to the National Institute of Standards and Technology (NIST). Many universities report data on these activities to the professional society AUTM, which serves the university technology transfer community (AUTM 2025); its data are used in this report.

Additional indicators on federal agency, federal laboratory, and university technology transfer included in this section are tabulated from the Scopus bibliometric database, the Patent and Trademark Office (USPTO), and GitHub. In addition to these indicators, the overall number of publications in the United States with business sector authors is reported in the *Indicators 2026* report “[Discovery: R&D Activity and Research Publications](#)” (NSB 2025: [Figure DISC-25](#)). These publications have decreased in recent years, from over 58,000 in 2008 to just over 51,000 in 2023, while an increasing share of these articles was published collaboratively with authors outside the business sector. These trends show that while output from the business sector is declining as total output has mostly grown, there is growing collaboration with business and nonbusiness interests thus promoting knowledge transfer in scientific publications.

Lastly, data on patenting serves as a useful indicator for knowledge and technology transfer. In this section, both utility patents from the USPTO and priority patent families, an international patent classification, are presented alongside the international impact of priority patent families through citation analysis. Indicators are presented for five highlighted CETs: AI, biotechnology, semiconductors, QIST, and nuclear energy.

Technology Transfer Metrics

Federal Agency Activity

U.S. federal agencies frequently engage in processes and activities that support the translation of knowledge arising from R&D for wider use. Federal agencies achieve this through funding R&D activities broadly, and employees of agencies engage in activities such as patenting, publishing, and creating OSS to move the S&E enterprise forward. These contributions create scientific impact by creating new knowledge, in the case of federal funding, or by translating federal R&D expenditures into an array of outputs and are important to track in terms of scientific impact.

Past reports have presented technology transfer data from NIST, which released data provided by individual agencies on these topics, including *Federal Laboratory Technology Transfer, Fiscal Year 2020: Summary Report to the President and the Congress* (2022). Since the publication of the *Indicators 2024* report “[Invention, Knowledge Transfer, and Innovation](#)” (NSB 2024), NIST has not released a new report summarizing these data, but the previous report displayed trends on cooperative R&D agreements (CRADAs) and invention disclosures from employees at select federal agencies. Researchers at federal agencies are required to report the development of new techniques and technologies in the form of invention disclosures, whereas CRADAs involve the coordination of a federal agency or laboratory with one or more nonfederal organizations in which the nonfederal organization provides resources for research activities and in exchange receives the option of exclusive license of any newly produced technologies. Together, these indicators help track federal R&D expenditures or research space—this results in future instances of technology transfer through the development of new technologies and how they are shared.

Federal agencies obligate billions of dollars yearly to support basic and applied research (NSB *Indicators 2026: Figure DISC-16*), and an observable outcome of these obligations is the creation of new knowledge shared in peer-reviewed scientific articles that cite federal support. *Table TRN-2* displays the number of published scientific articles from 2002 to 2022 that acknowledged receiving funding from federal agencies, as well as the concentration of those articles that are among the most highly cited articles (HCAs) globally. Nine federal agencies had more than 20,000 scientific articles that acknowledged federal funding. The top agencies included the Department of Health and Human Services (HHS), largely driven by the National Institutes of Health (1,886,755 articles supported), NSF (879,448 articles), and the Department of Energy (DOE) (245,185 articles). The HCA ratio shows the concentration of those articles, which are among the top 1% most cited globally. For an article to be classified in the top 1% globally, it must receive more citations in future work than 99% of the articles in its given scientific field (NSB *Indicators 2026: Figure DISC-27*).¹ An HCA ratio greater than 1.0 means that more than 1% of those articles featured in the global top 1%, demonstrating considerable scientific impact. In this case, all nine agencies identified earlier had an HCA ratio greater than 1.0, and six agencies had a ratio greater than 2.0. The agencies with the highest HCA ratios were the Department of Defense (DOD) (3.70), DOE (2.94), and NSF (2.71). For more detail and subagency components, see *Table STRN-1*.

Table TRN-2. U.S. federal agencies cited in the funding acknowledgement section of S&E articles, by citation frequency: 2002–22

(Number and index)

Name	All publications (number)	Publications in the top 1% most-cited journal articles (number)	Highly cited article ratio
HHS	1,886,755	46,492	2.53
NSF	879,448	20,029	2.71
DOE	245,185	6,087	2.94
DOD	179,833	5,047	3.70
NASA	90,141	1,853	2.46
USDA	69,728	1,197	1.77
VA	38,226	728	1.94
DOC	31,071	693	2.44
DOI	24,922	349	1.47
EPA	17,245	319	1.93

DOC = Department of Commerce; DOD = Department of Defense; DOE = Department of Energy; DOI = Department of the Interior; EPA = Environmental Protection Agency; HHS = Department of Health and Human Services; NASA = National Aeronautics and Space Administration; NSF = National Science Foundation; USDA = Department of Agriculture; VA = Department of Veterans Affairs.

Note(s):

Articles are classified by their year of publication. Whole counting is used. An article is considered to be federally funded if the funding information tied with the publication record in Scopus links it with one of the U.S. federal agencies. Not all Scopus publications have funding information available, and coverage has evolved with time; for more information, see *Figure SATRN-1*. The count of publications linked to funding from each parent agency includes those linked to its child entities. Child entities are not shown. Because publications that are not thematically classified do not have citation scores, the relative citation index is not simply the ratio of the count of publications in the top 1% over the total number of publications because publications without a citation score are excluded in the denominator.

Source(s):

National Center for Science and Engineering Statistics; Science-Matrix (Elsevier); Scopus abstract and citation database, accessed August 2025.

Science and Engineering Indicators

Other indicators of federal activities that support knowledge transfer include U.S. patents granted to employees at federal agencies, S&E articles with federal authors, and S&E articles with federal authors cited in granted U.S. patents (*Table TRN-3*). Between 2013 and 2024, the federal agencies with the greatest number of employee-granted U.S. patents were DOD (6,468 patents granted), DOE (5,345 patents), and HHS (2,008 patents). During this period, federal authors at DOE (233,739 articles), HHS (166,439 articles), and the Department of Veterans Affairs (VA) (140,910 articles) published the greatest number of S&E articles relative to their counterparts at other agencies. The same three agencies, albeit in a different order, had the most S&E articles published by their employees cited in granted U.S. patents between 2013 and 2022: HHS (180,861 articles), DOE (130,094 articles), and VA (77,774 articles).

Table TRN-3. U.S. federal agency activity in granted patents, S&E articles, and articles cited by patents, by inventor's or author's affiliated agency: 2013–24

(Number)

Agency	Patents granted to U.S. federal agencies	S&E articles with authors from U.S. federal agencies	S&E articles with authors at federal agencies cited by granted U.S. patents
DHS	203	1,766	608
DOC	309	53,359	16,914
DOD	6,468	119,617	61,843
DOE	5,345	233,739	130,094
DOI	31	33,826	1,621
DOT	16	2,661	331
EPA	62	9,845	1,607
HHS	2,008	166,439	180,861
NASA	1,315	80,000	17,650
USDA	586	78,946	25,036
VA	689	140,910	77,774

DHS = Department of Homeland Security; DOC = Department of Commerce; DOD = Department of Defense; DOE = Department of Energy; DOI = Department of the Interior; DOT = Department of Transportation; EPA = Environmental Protection Agency; HHS = Department of Health and Human Services; NASA = National Aeronautics and Space Administration; USDA = Department of Agriculture; VA = Department of Veterans Affairs.

Note(s):

Patents are classified by their grant year and articles are classified by their year of publication. An article or patent is linked to federal agencies through author and ownership information on the publication record in Scopus and PatentsView. Citation counts are based on an 11-year window with a 5-year lag (e.g., citations for 2022 are references in Patent and Trademark Office (USPTO) patents issued in calendar year 2022 to articles published in 2007–17). Articles and patents are credited on a whole-count basis (i.e., each participating federal agency receives one count).

Source(s):

National Center for Science and Engineering Statistics; Science-Matrix (Elsevier); PatentsView, USPTO, accessed March 2025; Scopus abstract and citation database, accessed August 2025.

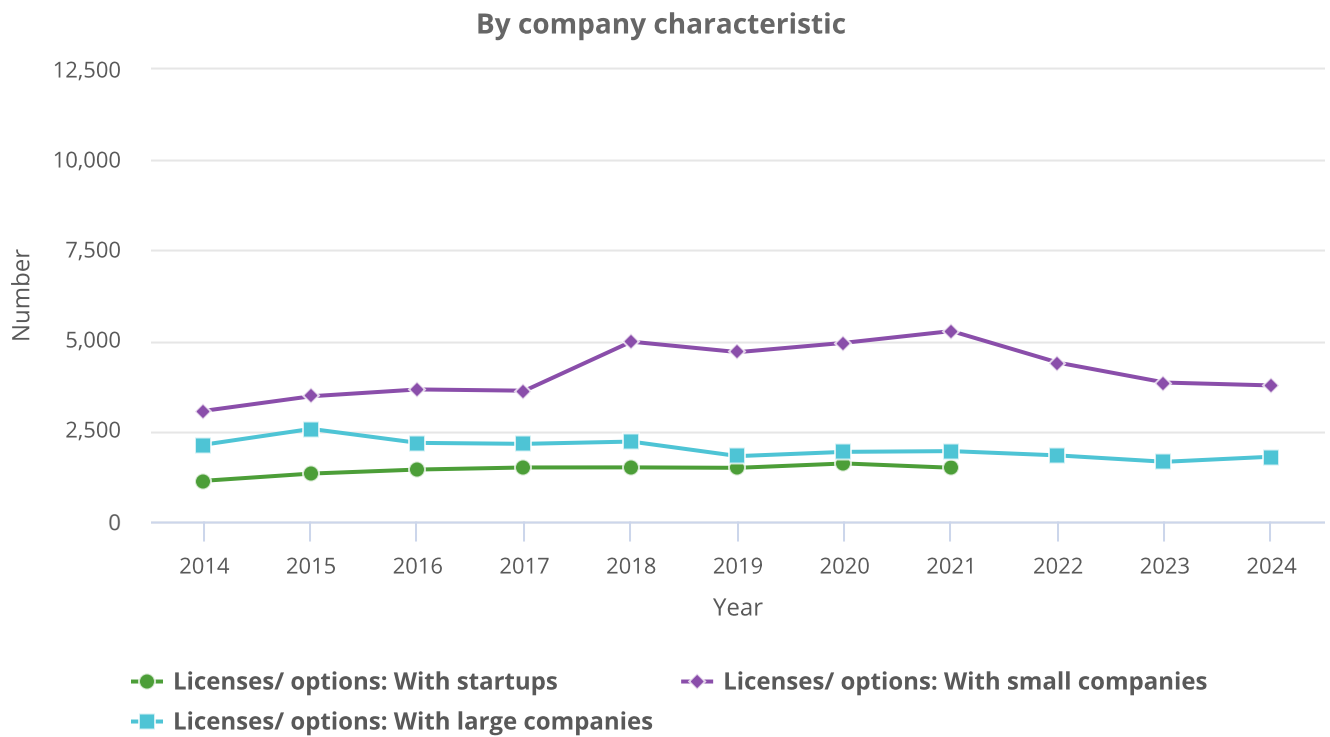
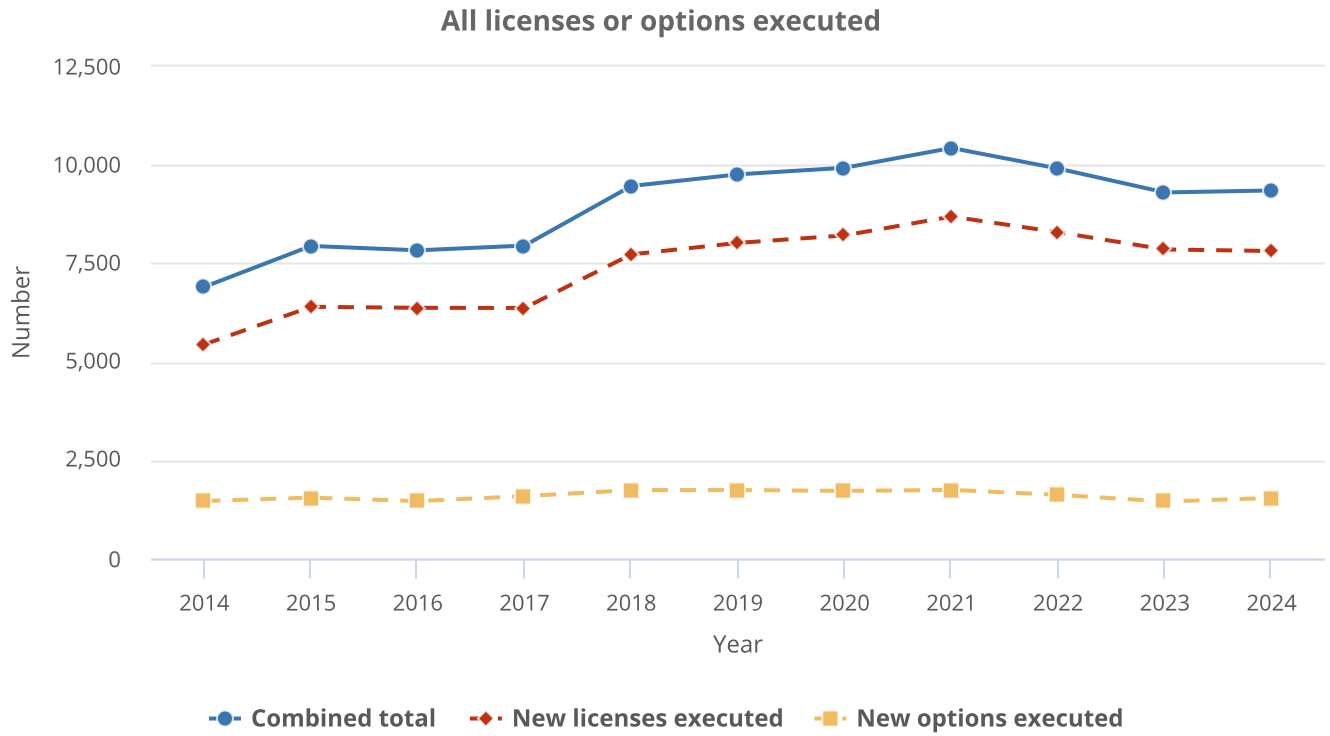
Science and Engineering Indicators

Employees of federal agencies also engage in the production of OSS repositories, a further knowledge and technology transfer activity. Software uploaded to the GitHub platform is an open resource for the research community, enabling the reuse of previously developed code to support scientific research and analyses. From 2009 to 2024, almost 20,000 new contributions were made to software repositories on GitHub from at least one employee from each federal agency, with about 3,000 posted in 2024.² Employees from DOE accounted for 52% (9,959) of all instances of federal contributions to GitHub repositories from 2009 to 2024 (Table STRN-2).

University Transfer Metrics

As major performers of R&D (see the *Indicators 2026* report “[Discovery: R&D Activity and Research Publications](#)” section [Academic R&D](#) [NSB 2025]), universities frequently envision their research contribution to the broader public as a critical element of their mission (Compagnucci and Spigarelli 2020). University technology transfer can occur informally, including through engagement or consulting with nonacademic organizations or firms (Perkmann et al. 2013), but the licensing of university patented technologies may provide a quantifiable measure of the extent that university research may be developed into private-sector innovations. Patented inventions can be immediately licensed to a firm or an exclusive option can be granted for licensing rights at a future date. According to AUTM, U.S. universities issued 7,813 new licenses and 1,538 options in 2024, each of which represents a decrease from the peak year in 2021 (with 8,688 licenses and 1,743 options executed) ([Figure TRN-4](#)). The share and number of university technology licenses or license options executed by large firms (those with 500 or more employees) decreased from 2014 (31%, or 2,127) to 2024 (19%, or 1,793) ([Figure TRN-4](#)).³ Startups have the smallest share of licenses and options, with 1,487 (14%) in 2021.⁴ Small firms (with fewer than 500 employees) consistently executed a larger share of licenses and options (between 40% and 53% from 2014 to 2024) than large companies and startups, though their number of licenses and options has decreased sharply in recent years from 5,268 in 2021 to 3,763 in 2024.

Figure TRN-4. University technology licenses or license options executed, by company characteristic: 2014–24



Note(s):

AUTM collects data on invention and patent-related activities of its member universities and hospitals. Responding institutions may report for any 12-month period ending in the identified year. A subset of the total license and options executed are held by the three company types designated by AUTM. Startup companies reported by universities in AUTM data refer only to those companies that were formed in the reporting year specifically to develop the technology being licensed. Counts of licenses to startups and small companies are mutually exclusive. Small companies are those with fewer than 500 employees. Data are not available for licenses or license options executed with startups from 2022 to 2024. Data are not available for new licenses executed for 2022 and 2023 in the current data pull, so data from a prior data pull in July 2025 are included to bridge the gap.

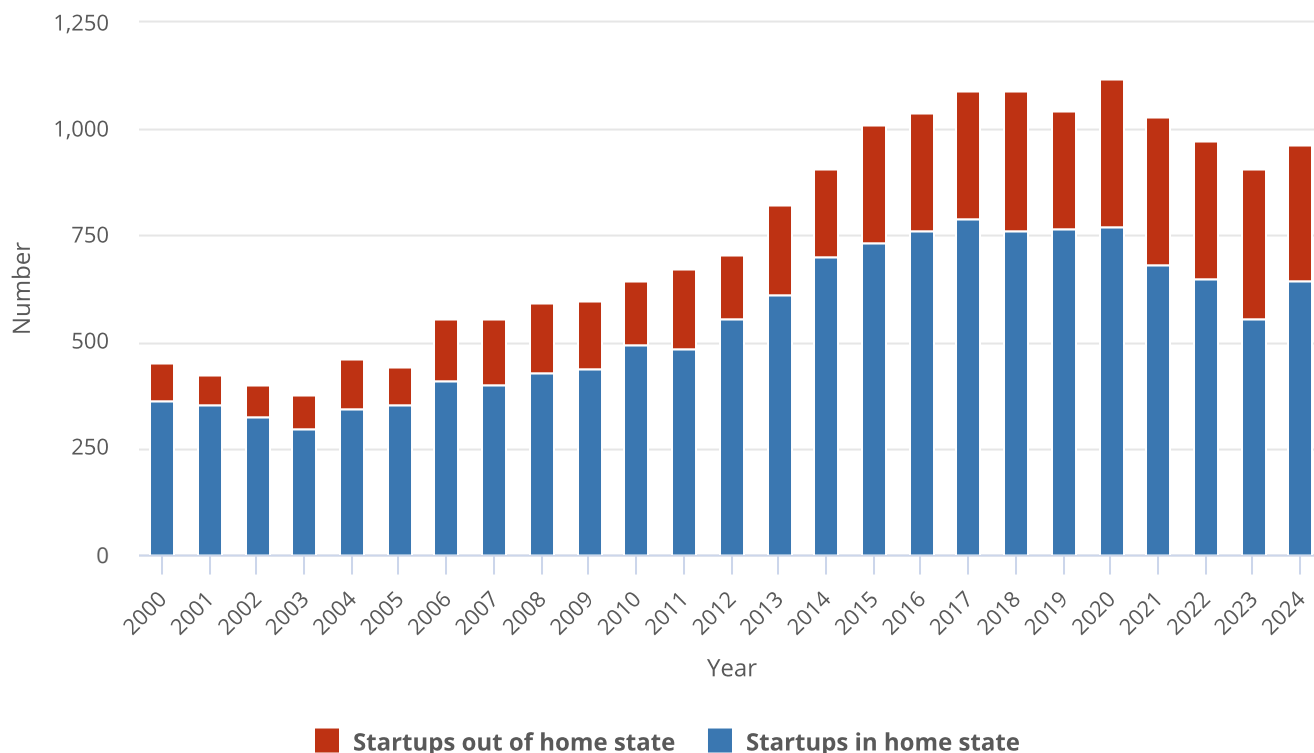
Source(s):

AUTM, AUTM Licensing Survey (various years), accessed January 2026.

Science and Engineering Indicators

Startups formed specifically to develop university technology are a small subset of new firms in the United States, comprising less than 0.2% of firm startups each year through 2022 (Table STRN-3). However, these startups, often launched by university faculty and students, are one of the most direct means of translating findings and innovation from universities to the private sector (Stephan 2012), using university patents that might not be licensed otherwise (Swamidass 2013). The number of startups based on university technology peaked in 2020, when 1,119 were launched. Since then, the number has dipped below 1,000 since 2022, and 2024 saw the launch of 962 startups (a 14% decrease between 2020 and 2024). The majority of university-related startups launched since 2000 are in the home state of the research university from which the technology was transferred, ranging from 83% in 2001 to 61% in 2023 (Figure TRN-5). In 2024, 67% of all university-related startups were in the state of the affiliated university. Since 2000, the share of out-of-state startups has oscillated but has gradually risen, with the share of out-of-state startups rising by more than 10 percentage points since 2000 (from 20% in 2000 to 33% in 2024). As with any business venture, university-founded startups are affected by a complicated mixture of personal, market, and structural factors (Bruneel et al. 2020; Sansone et al. 2021). However, as university R&D is characteristically more independent of commercial considerations, university technology transfer to the private sector may have a more complicated pipeline to market with a longer timeline (Stephan 2012; Swamidass 2013).

Figure TRN-5. Startup companies based on licensed university technology, by company location: 2000–24



Note(s):

The survey question asks how many startup companies were formed in a given year that were dependent on the licensing of the institution's technology for initiation. Startup companies reported by universities in AUTM data refer only to those companies that were formed in the reporting year specifically to develop the technology being licensed.

Source(s):

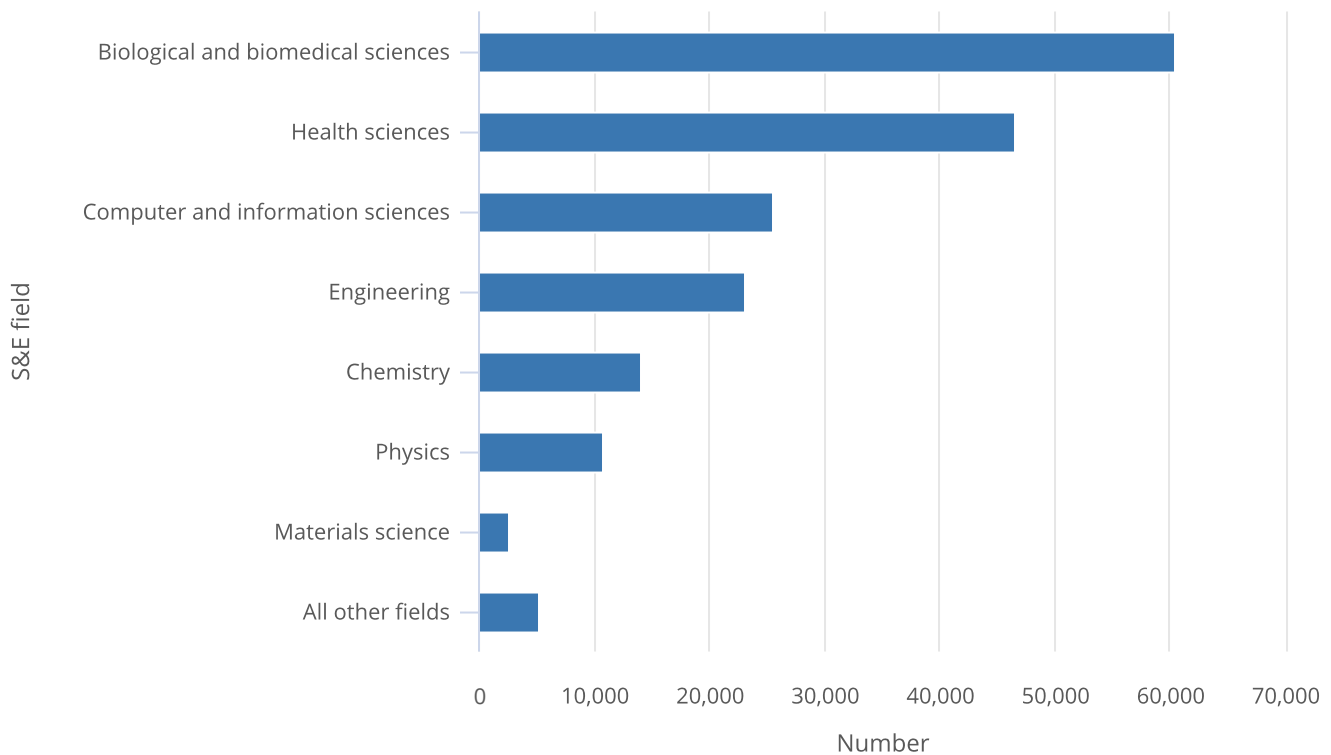
AUTM, Statistics Access for Technology Transfer (STATT) Database, accessed January 2026.

Science and Engineering Indicators

Impact of Publicly Funded Research: Citations in Patents

Publicly funded knowledge also flows into the market through its contribution to patents for useful inventions. When peer-reviewed publications from any author are cited in the reference section of patent documents, the linkage suggests that scientific literature may have contributed knowledge to the patented invention. The number of academic publications cited in patents points to the importance of academic research in invention. Of about 642,000 citations to S&E articles in U.S. patents in 2024, about 29% were to articles from the U.S. academic sector (Table STRN-4).

Biotechnology and the biomedical and health sciences are areas of high scientific article output from authors in the United States, and this work is cited in utility patents (see the *Indicators 2026* report "[Discovery: R&D Activity and Research Publications](#)" sidebar [Biotechnology R&D and Publications Output](#) and the section [Output by Geography, S&E Field, and Sector](#)) (NSB 2025). By field of science, articles from the biological and biomedical sciences were cited in U.S.-granted patents more often than articles from any other S&E field in 2024, accounting for 27% of all citations (Table STRN-4). For citations to articles from just U.S. academic authors, 32% of all citations were to biological and biomedical sciences articles ([Figure TRN-6](#)). Articles from the health sciences were the second-most frequently cited in granted U.S. patents, accounting for 23% of all citations in 2024 (Table STRN-4). However, the volume of citations in U.S. patents varied substantially by type of author. Of the about 171,000 biological and biomedical sciences articles cited in U.S. patents in 2024, 52% had authors from the United States; over 35% had authors in the U.S. academic sector specifically, 7% had authors from the U.S. business sector, about 5% had authors from U.S. nonprofits, and over 3% had federal authors (Table STRN-4). U.S. academic authors accounted for 31% of the almost 150,000 health sciences articles cited in granted U.S. patents in 2024, U.S. business-sector authors accounted for 6%, and U.S. federal agency authors accounted for 2% (Table STRN-4).

Figure TRN-6. Citations of U.S. academic S&E articles in USPTO utility patents, by S&E field of the articles cited: 2024

USPTO = Patent and Trademark Office.

Note(s):

See Table STRN-4 for additional detail.

Source(s):

National Center for Science and Engineering Statistics; Science-Metrix (Elsevier); PatentsView, USPTO, accessed March 2025; Scopus abstract and citation database, accessed August 2025.

Science and Engineering Indicators

Federal health agencies play an important role in knowledge transfer: S&E articles by HHS authors received about 15,700 citations in granted U.S. patents in 2024 (37% of all citations to S&E articles authored by federal agency employees). DOE authors received about 11,900 citations (28%) (Table STRN-5). Inventors at DOD and DOE were granted more than 400 utility patents in 2024 (Table STRN-6). Additional detail on the patents and publications activity of federal agencies by field or technology area, as well as articles cited in patents, is shown in Table STRN-5–Table STRN-10. The USPTO patent records used in the analysis above also provide geographical inventor information for all patents registered in the United States, including patents granted to individuals and foreign entities.

Patents as Invention Indicators

Three dimensions of patenting are reported here—priority patent families that reflect the international scope of global patenting, USPTO patents that are particularly relevant to the U.S. market for technology, and one that focuses on impact—through highly cited patents (HCPs).

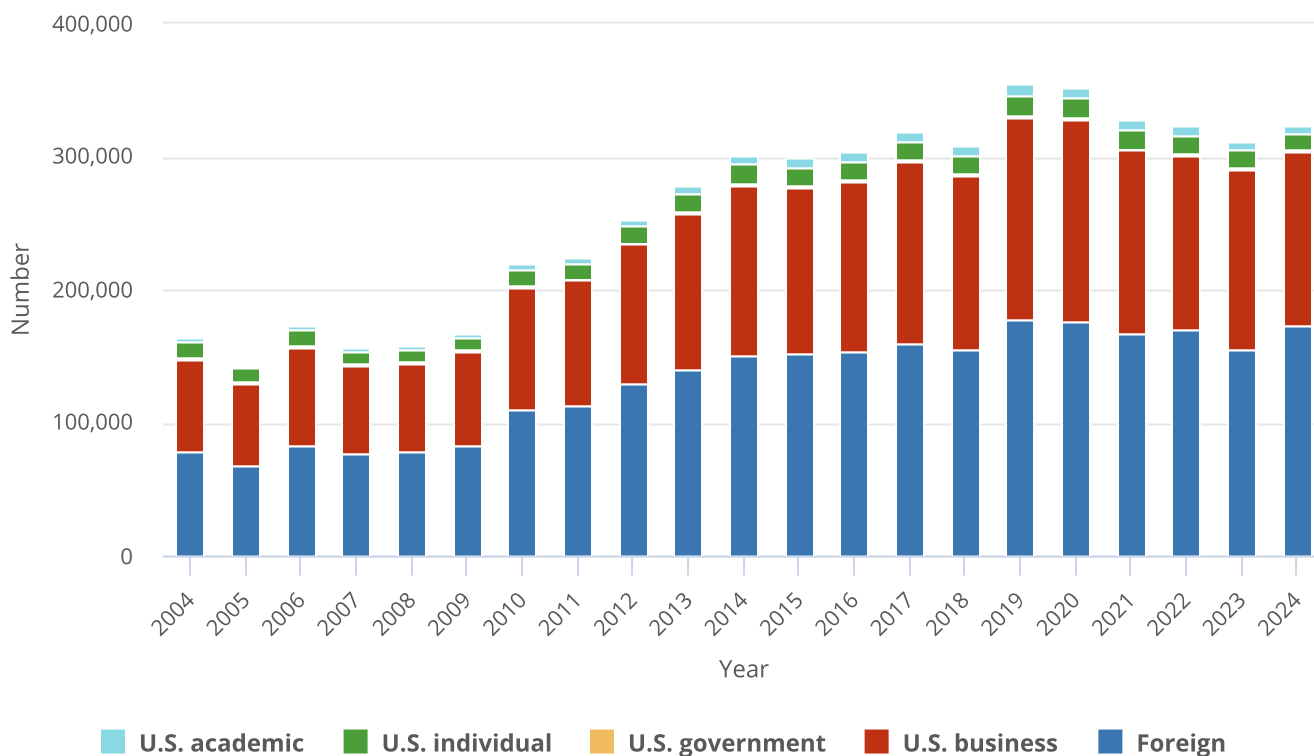
The USPTO grants protection for inventions in the U.S. market. Globally, the Patent Cooperation Treaty (PCT) and the World Intellectual Property Organization (WIPO) provide for international recognition of priority patent families, which protect inventions that have not been previously patented in any jurisdiction and are accessible through the PATSTAT database (EPO 2025). As an indicator, these priority patent families provide a more globally representative picture of patenting of inventions

compared with USPTO patents; not all inventors chose to protect their inventions in the U.S. market. Simultaneously, owners of USPTO patents may not necessarily pursue priority patent families, and patents by U.S. inventors that have national security implications are prohibited from being patented outside of the United States, so they will only be counted in the USPTO data (USPTO 2026). Both USPTO and priority patent families are quantity indicators; priority patent families more fully describe the international landscape of patenting.

This report introduces a quality indicator for patents, highly cited priority patent families based on country of the inventor. The HCP share goes beyond raw counts of technology and location to provide a kind of impact indicator that reflects the relevance of a particular patent in subsequent patent filings (Science-Metrix, Patent and Trademark Documentation 2026 [link when available]). Because they identify the scope of prior patent claims, citations to prior patents within patent documents provide a kind of ex post value of the patent document (Trajtenberg 2002).

USPTO awarded 326,000 utility patents in 2024, of which 152,000 (47%) were assigned to domestic U.S. owners. Of U.S. patent holders, business owners received the most patents (85%) in 2024, whereas individual filers and those in academia and government accounted for much smaller shares (Figure TRN-7; Table STRN-11). The number of USPTO utility patents awarded to U.S. owners decreased between 2023 (159,000) and 2024 (152,000). However, the annual total awarded to U.S. owners has yet to surpass the total in 2019, the year prior to the COVID-19 pandemic, when 179,000 were granted. Patents assigned to U.S. businesses declined 15% between 2019 and 2022, in contrast to a general upward trend from 2000 to 2019 (Table STRN-11).

Figure TRN-7. USPTO utility patents granted to owners, by nationality and U.S. sector: 2004–24



USPTO = Patent and Trademark Office.

Note(s):

Patents are allocated according to patent ownership information. Patents are credited on a fractional-count basis (i.e., for patents with collaborating institutions, each institution receives fractional credit on the basis of the proportion of institutions). Unclassified patents are not shown. See Table STRN-11 and the "Technical Appendix" for additional detail.

Source(s):

National Center for Science and Engineering Statistics; Science-Matrix (Elsevier); PatentsView, USPTO, accessed March 2025.

Science and Engineering Indicators

Table TRN-4 shows the 20 entities with the highest share of their USPTO patents in the top 1% most cited in other patents for 2021. Patents in the top 1% by patent citations are designated as HCPs. For each entity, the proportion of HCPs relative to its total patenting output is represented by an index number, called its *HCP share*, calculated for year and technology area. An HCP share of 1.0 means that 1% of an entity's cited patents in the year and technology were in the top 1% of all patents in the year and technology class. An HCP share of 2.0, for example, would mean that 2% of the entity's patents were among the top 1% most cited. HCPs are only reported after a minimum of 3 years have passed, which provides sufficient time for a meaningful number of citations to accumulate while still providing a degree of currentness to the data presented (Hall, Jaffe, and Trajtenberg 2002).

Table TRN-4. Top cited organizations at USPTO, according to the share of patents in top 1% most cited: 2021

(Number and percent)

Entity	Country	Number of patents	HCP (top 1%)
True Velocity IP Holdings, Inc.	United States	37	100.00
SunCoke Technology and Development LLC	United States	20	100.00
Narrative Science LLC	United States	15	100.00
Antecip Bioventures II LLC	United States	28	96.43
Prognosys Biosciences, Inc.	United States	15	93.33
Curiouser Products Inc.	United States	17	88.24
BJ Energy Solutions, LLC	United States	35	85.71
Invensas Bonding Technologies, Inc.	United States	19	84.21
Axsome Therapeutics, Inc.	United States	26	80.77
Resonant Inc.	United States	31	80.65
Eagle Harbor Technologies, Inc.	United States	15	80.00
Välinge Innovation AB	Sweden	38	76.32
Zeno Semiconductor, Inc.	United States	15	73.33
Heartflow, Inc.	United States	28	71.43
Pratt Retail Specialties, LLC	United States	22	63.64
Cilag GmbH International	Switzerland	275	55.64
Oshkosh Corporation	United States	60	53.33
Ethicon, Inc.	United States	258	41.09
Manufacturing Resources International, Inc.	United States	20	35.00
Lyten, Inc.	United States	15	33.33

HCP = highly cited patent; USPTO = Patent and Trademark Office.

Note(s):

Patents are allocated according to patent ownership information. Patents are credited on a full-count basis (i.e., for patents with collaborating institutions, each institution receives full credit). Institutions are ordered in decreasing order according to the share of HCP patents. Curated profiles of institutions are based on the disambiguation information available in PatentsView.

Source(s):

National Center for Science and Engineering Statistics; Science-Matrix (Elsevier); PatentsView, USPTO, accessed March 2025.

Science and Engineering Indicators

This report provides data on patents granted by USPTO and on patents granted internationally through the PCT and accessed in the PATSTAT database, referred to here as *priority patent families*. USPTO patents provide registration, examination, and protection in the U.S. market; priority patents provide registration and examination internationally. The examination process for priority patents provides a check on the patentability of the invention and a search for prior references. Although protection in individual national markets requires additional protection, the priority patent centralizes application and examination. Thus, foreign inventors who apply for USPTO patents are seeking protection for their inventions in the U.S. market, and inventors who apply for PCT patents are implicitly preparing for seeking protection in more than one international market.

A supplemental machine-readable file released with this report contains USPTO and priority patent family data for a 47-category classification of CETs, developed for the *Indicators 2024* report “[Invention, Knowledge Transfer, and Innovation](#)” sidebar [Patenting That Addresses CHIPS and Science Act Technologies](#) (NSB 2024), with input from NSF TIP, SRI International, and Science-Metrix and Elsevier (Table STRN-13). Another existing classification scheme using WIPO’s 35 technology categories is utilized in this thematic report (WIPO 2026). The data released include the region’s, country’s, or economy’s HCP share for priority patent families for each technology area.

Spotlight on Invention in Critical and Emerging Technologies

In addition to the economic growth implications of GPTs such as the Internet and AI, the development, deployment, and use of emerging technologies have a range of potential downstream impacts, both positive and negative. Examples of these risks can include health consequences, national security concerns, facilitation of criminal activity, or environmental effects. As a result, policymakers seek to identify and follow current trends in emerging technology development, deployment, and use, especially where the range of potential outcomes are uncertain or unknown.

This section highlights invention activities for five technology areas identified as critical and emerging. Policymakers identify technologies as critical because of their role in security, prosperity, and resilience, whereas emerging technologies are often identified through data analysis.

AI, QIST, semiconductors, and nuclear technology were among the topics identified by the current administration as CETs in which the administration aspires to technological leadership (Trump 2025; Vought and Kratsios 2025). The CHIPS and Science Act of 2022 (P.L. 117-167) identified domestic production of semiconductors as a national security concern and provided funding to support the domestic semiconductor supply chain and workforce as well as research into basic energy sources and AI (Congress.gov 2022; NSTC 2025). Biotechnology and biomanufacturing have been identified in this administration and in the previous one as additional areas where the United States aims to maintain global competitiveness (Biden 2022; Kratsios 2025; Vought and Kratsios 2025). NSF TIP has been developing a taxonomy of critical technologies identified as key technology areas (NSF/TIP 2025). This taxonomy appears in the *Indicators 2024* report “[Invention, Knowledge Transfer, and Innovation](#)” (NSB 2024), and NSF TIP has expanded it for this report. The key technology areas and 47 underlying categories or foci are shown in Table STRN-12, their linkage to patent classification codes is shown in Table STRN-13, and the HCP share for these areas is shown in Table STRN-14 for priority patent families granted in 2021.

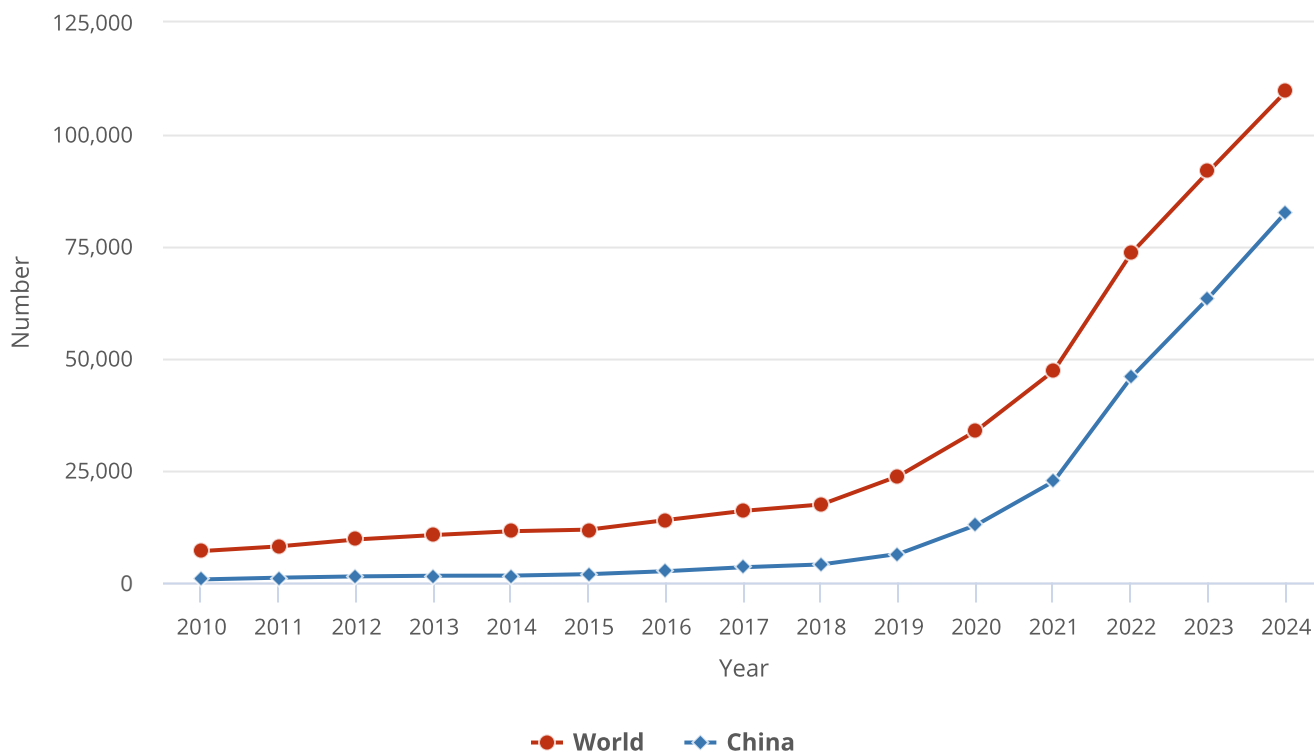
The figures in the section show selected countries and regions that are most active in patenting globally: the United States, China, the European Union (EU-27), Japan, and South Korea. Additional geographic information is provided for the top 20 highest patenting regions, countries, or economies in supplemental tables; the analysis that follows describes information both in the figures and in the cited supplemental tables.

Artificial Intelligence

AI is widely understood as a rapidly growing GPT, and many nations have set policy goals for achieving competitive advantages through development of AI. For example, China released a development plan in 2017 that calls for it to achieve technological leadership by 2030 (Green and Parker 2026). Several additional nations, including Australia and Brazil, aim to become leaders in AI by 2028 (BCA 2025; IDS 2024).

Business R&D investment devoted specifically to AI applications totaled \$37 billion in 2022, or 5% of U.S. business R&D that year (NSB 2025; NCSSES *BERD 2022*: Table 21). Internationally, growth in priority patent families granted in AI, machine learning, autonomy, and related advances accelerated in the years preceding the COVID-19 pandemic. By 2022, priority patent families attributed to China accounted for more than half of all the priority patent families granted (Figure TRN-8; Table STRN-15). In 2024, of the 110,000 AI priority patent families granted globally, 7,600 were granted to U.S. inventors. Inventors from South Korea were granted almost 6,400 and inventors from Japan were granted almost 5,800 in the same year. Compared with priority patent families, relatively fewer USPTO patents are granted to foreign inventors. The USPTO granted 12,000 patents to U.S. inventors in 2024, while inventors from Japan were granted 2,700 patents (Figure TRN-9; Table STRN-16).

Figure TRN-8. Priority patent families granted in artificial intelligence, machine learning, autonomy, and related advances, for the world and China: 2010–24



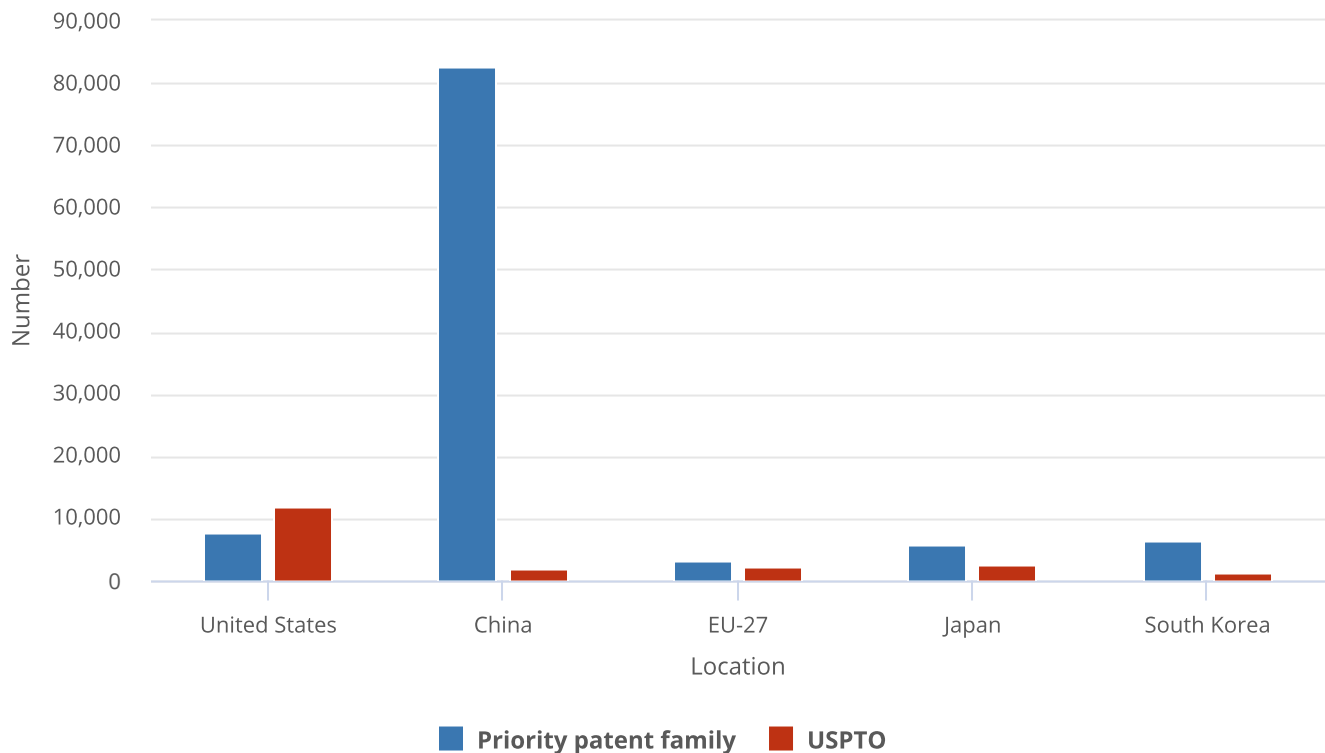
Note(s):

Priority patents are International Patent Documentation (INPADOC) patent families granted across all patent offices covered in the Worldwide Patent Statistical Database (PATSTAT). Locations are allocated according to patent inventorship information found on the priority patent of the INPADOC patent families and patents counted according to the year of the first granted patent in the patent family. This category is based on the 2025 classification of Key Technology Areas developed by the National Science Foundation's Technology Innovation Partnership program and shown in Table STRN-12. The 20 countries with the highest number of priority patents in this category are shown in Table STRN-15. China includes Hong Kong.

Source(s):

National Center for Science and Engineering Statistics; Science-Matrix (Elsevier); PATSTAT, spring 2025, accessed September 2025.

Figure TRN-9. Utility patents granted in artificial intelligence, machine learning, autonomy, and related advances, by selected region, country, or economy: 2024



EU-27 = European Union; USPTO = Patent and Trademark Office.

Note(s):

Priority patents are International Patent Documentation (INPADOC) patent families granted across all patent offices covered in the Worldwide Patent Statistical Database (PATSTAT). Locations are allocated according to patent inventorship information found on the priority patent of the INPADOC patent families and patents counted according to the year of the first granted patent in the patent family. Utility patents are allocated to location based on the residence of the inventor. This category is based on the 2025 classification of Key Technology Areas developed by the National Science Foundation's Technology Innovation Partnership program and shown in Table STRN-12. The 20 countries with the highest number of priority patents in this category are shown in Table STRN-15. The 20 countries with the highest number of USPTO utility patents in this category are shown in Table STRN-16.

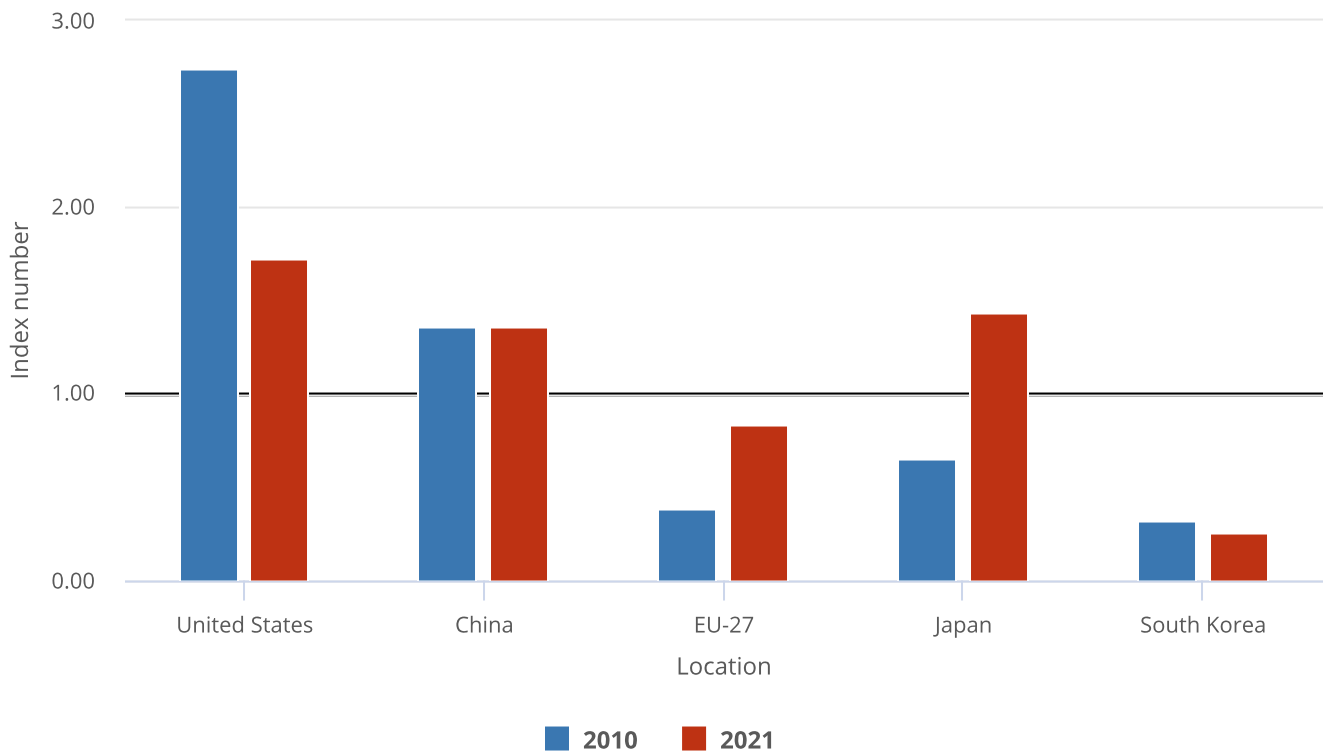
Source(s):

National Center for Science and Engineering Statistics; Science-Metrix (Elsevier); PATSTAT, spring 2025, accessed September 2025; PatentsView, USPTO, accessed March 2025.

Science and Engineering Indicators

The impact of AI priority patent families, as measured by citations in subsequent patents, was higher for both the EU-27 and Japan in 2021 compared with 2010. For both 2010 and 2021, the HCP share for U.S. inventors showed that while U.S.-attributed AI priority patent families continued to have outsized impact, the HCP share was lower in 2021 (1.73) compared to 2010 (2.74). The HCP share for inventors from China changed little when comparing those two time periods (Figure TRN-10; Table STRN-17).

Figure TRN-10. Highly cited patents granted in artificial intelligence, machine learning, autonomy, and related advances, by selected region, country, or economy: 2010 and 2021



EU-27 = European Union.

Note(s):

Highly cited patents (HCPs) refer to priority patents cited in subsequent priority patent documents. This figure shows the index number for citations within patent documents during all the years available following the reference year, including the reference year itself. For example, for 2010, citations in priority patents between 2010 and 2024, the last year with fully available data, are used in the calculation. The index number has been normalized for patent age, technology area, and patent office through the length of reference list from the citing priority patents. For information on the patent methodology, see <https://www.science-metrix.com/patent-and-trademark-indicators-for-the-science-and-engineering-indicators-2026-technical-documentation/>. This category is based on the 2025 classification of Key Technology Areas developed by the National Science Foundation's Technology Innovation Partnership program and shown in Table STRN-12. The relative HCP of the 20 countries with the most patents in 2024 are shown in Table STRN-17. China includes Hong Kong.

Source(s):

National Center for Science and Engineering Statistics; Science-Metrix (Elsevier); Worldwide Patent Statistical Database (PATSTAT), spring 2025, accessed September 2025.

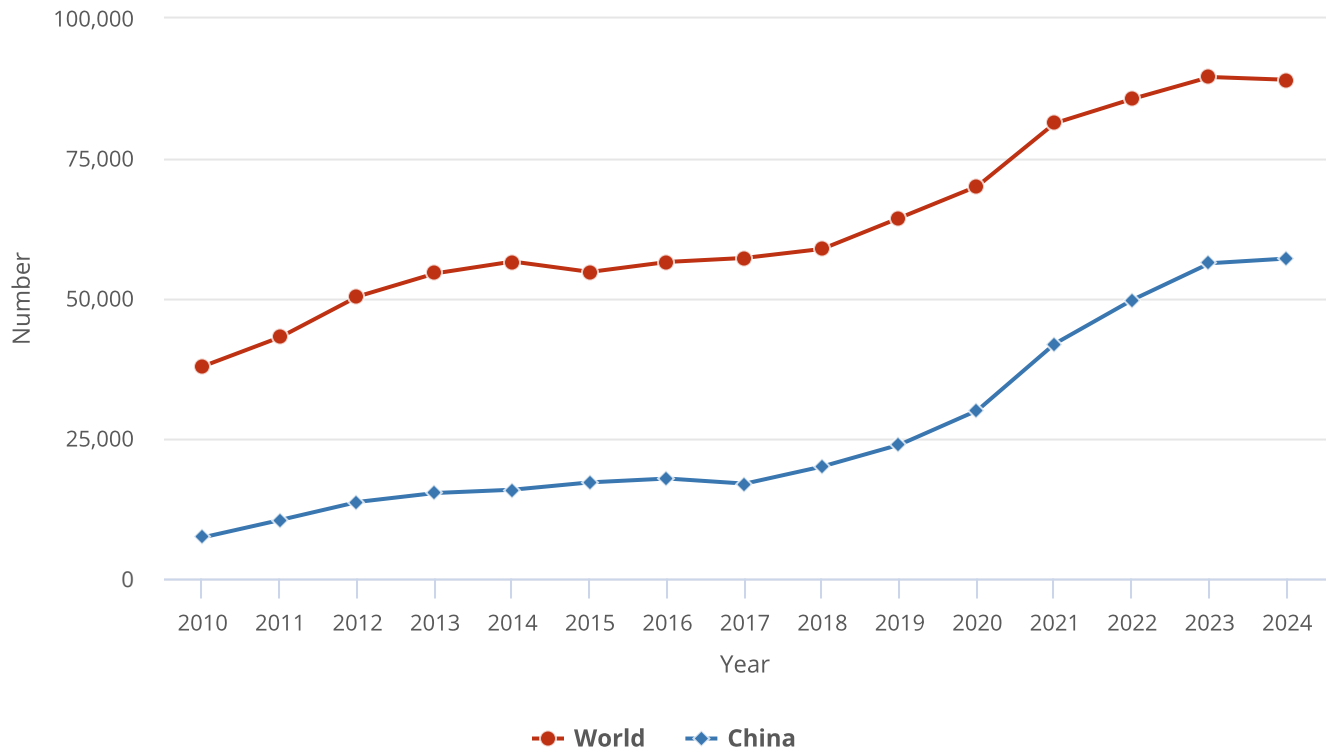
Science and Engineering Indicators

Biotechnology and Related Technologies

Biotechnology is an area of relatively high research activity for the United States and includes research into pharmaceuticals and medicines. Genetic code sequencing, RNA modification, and the development of disease-resistant crops are aspects of *biotechnology*, or the application of life sciences toward useful products and processes. Business R&D in the biotechnology focus area accounts for about 17% of total U.S. business R&D in 2022 (NCSES *BERD 2022*: Table 20). Citations to published research within USPTO patent documents show that academic authors in biological and biomedical sciences are cited more often than authors in any other S&E field in U.S.-granted patents (Figure TRN-6).

Inventors from China filed an increasing share of patents in the related categories of biotechnologies, medical technologies, genomics, and synthetic biology technologies, rising from 19% in 2010 (7,400) to 64% in 2024 (57,000) (Figure TRN-11; Table STRN-18). Patents with inventors from China are still a relatively small share of USPTO patents in 2024, about 4.6% (Figure TRN-12; Table STRN-19). Inventors from the United States were granted more than twice as many USPTO patents in 2024 as priority patent families. Also reflecting the role of the U.S. market, EU-27 inventors were granted 4,700 of this category's USPTO patents in 2024 compared with about 5,600 priority patent families (Figure TRN-12).

Figure TRN-11. Priority patent families granted in biotechnology, medical technology, genomics, and synthetic biology, by selected country or economy: 2010–24



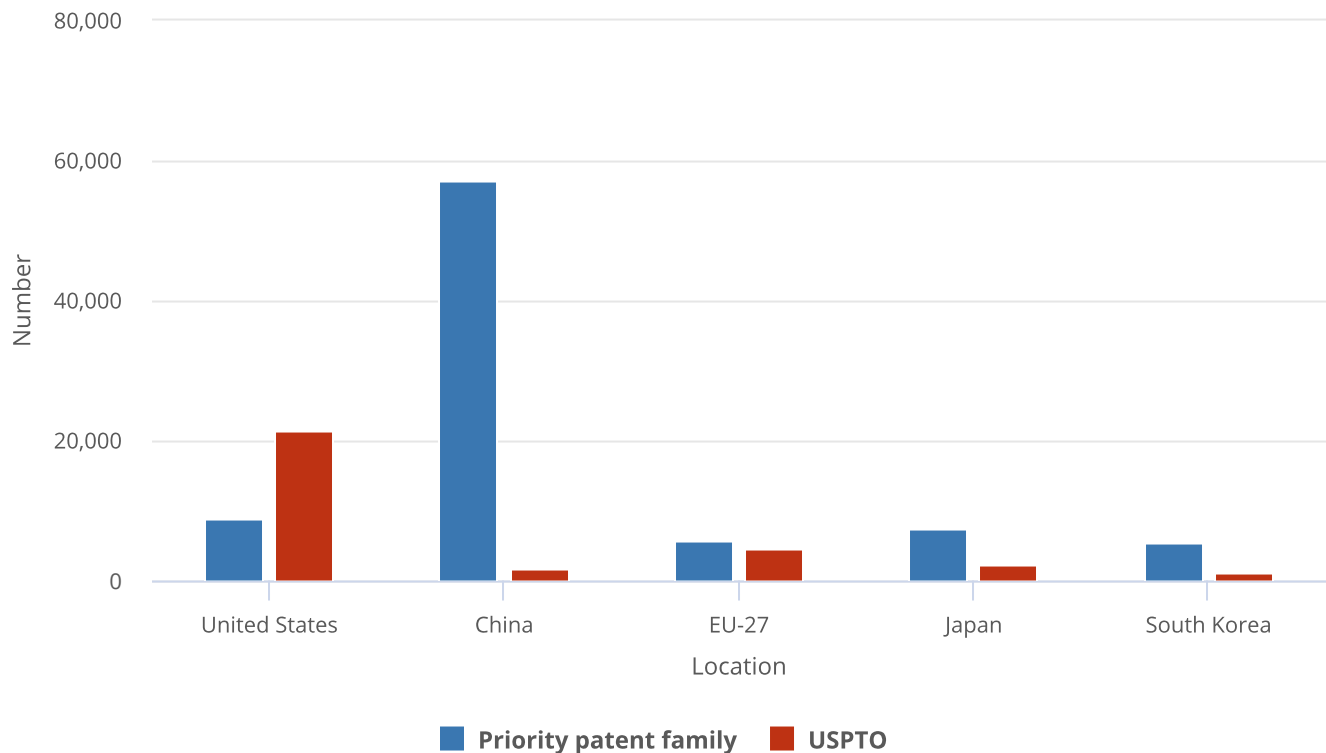
Note(s):

Priority patents are International Patent Documentation (INPADOC) patent families granted across all patent offices covered in the Worldwide Patent Statistical Database (PATSTAT). Locations are allocated according to patent inventorship information found on the priority patent of the INPADOC patent families and patents counted according to the year of the first granted patent in the patent family. This category is based on the 2025 classification of Key Technology Areas developed by the National Science Foundation's Technology Innovation Partnership program and shown in Table STRN-12. The 20 countries with the highest number of priority patents in this category are shown in Table STRN-18. China includes Hong Kong.

Source(s):

National Center for Science and Engineering Statistics; Science-Metrix (Elsevier); PATSTAT, spring 2025, accessed September 2025.

Figure TRN-12. Utility patents granted in biotechnology, medical technology, genomics, and synthetic biology, by selected country or economy: 2024



EU-27 = European Union; USPTO = Patent and Trademark Office.

Note(s):

Priority patents are International Patent Documentation (INPADOC) patent families granted across all patent offices covered in the Worldwide Patent Statistical Database (PATSTAT). Locations are allocated according to patent inventorship information found on the priority patent of the INPADOC patent families and patents counted according to the year of the first granted patent in the patent family. Utility patents are allocated to location based on the residence of the inventor. This category is based on the 2025 classification of Key Technology Areas developed by the National Science Foundation's Technology Innovation Partnership program and shown in Table STRN-12. The 20 countries with the highest number of priority patents in this category are shown in Table STRN-18. The 20 countries with the highest number of USPTO utility patents in this category are shown in Table STRN-19.

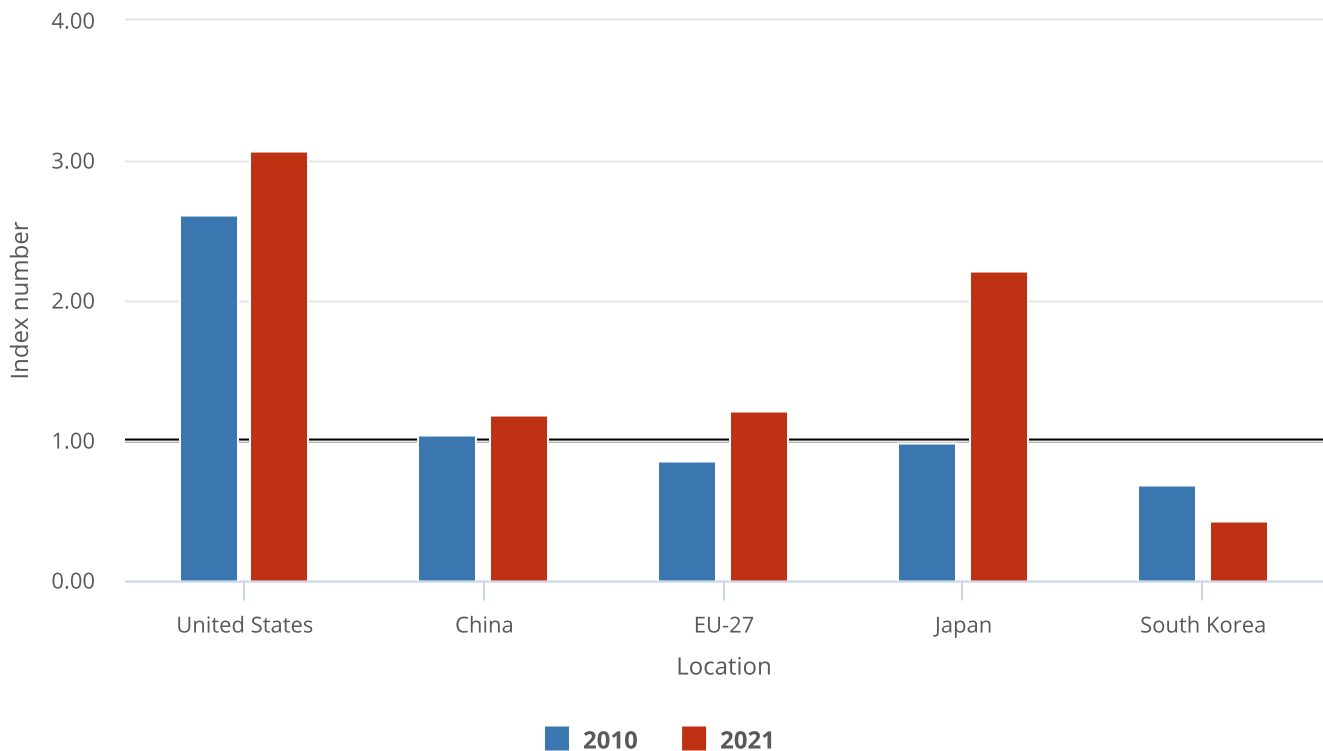
Source(s):

National Center for Science and Engineering Statistics; Science-Metrix (Elsevier); PATSTAT, spring 2025, accessed September 2025; PatentsView, USPTO, accessed March 2025.

Science and Engineering Indicators

Consistent with the importance of biotechnology-related academic research, biotechnology-related priority patent families granted to U.S. inventors have a particularly outsized impact on subsequent inventions, as reflected in its share of HCPs in the top 1% of similar patents. For patents awarded in 2021, those from U.S. inventors had an HCP share of 3.07, meaning more than 3% of these patents were in the top 1% of HCPs that year. However, the HCP shares of inventors from other regions, countries, or economies also increased between 2011 and 2021. Patents from inventors in Japan had a higher HCP share in 2021 (2.21) compared with 2010 (0.99). Patents from inventors in the EU-27 had a higher HCP share in 2021 (1.22) compared to 2010 (0.86). The HCP share of patents granted to inventors from China was slightly higher in 2021 (1.18) compared with 2010 (1.05) (Figure TRN-13; Table STRN-20).

Figure TRN-13. Highly cited patents granted in biotechnology, medical technology, genomics, and synthetic biology, by selected country or economy: 2010 and 2021



EU-27 = European Union.

Note(s):

Highly cited patents (HCPs) refer to priority patents cited in subsequent priority patent documents. This figure shows the index number for citations within patent documents during all the years available following the reference year, including the reference year itself. For example, for 2010, citations in priority patents between 2010 and 2024, the last year with fully available data, are used in the calculation. The index number has been normalized for patent age, technology area, and patent office through the length of reference list from the citing priority patents. For information on the patent methodology, see <https://www.science-matrix.com/patent-and-trademark-indicators-for-the-science-and-engineering-indicators-2026-technical-documentation/>. This category is based on the 2025 classification of Key Technology Areas developed by the National Science Foundation's Technology Innovation Partnership program and shown in Table STRN-12. The relative HCP of the 20 countries with the most patents in 2024 are shown in Table STRN-20. China includes Hong Kong.

Source(s):

National Center for Science and Engineering Statistics; Science-Matrix (Elsevier); Worldwide Patent Statistical Database (PATSTAT), spring 2025, accessed September 2025.

Science and Engineering Indicators

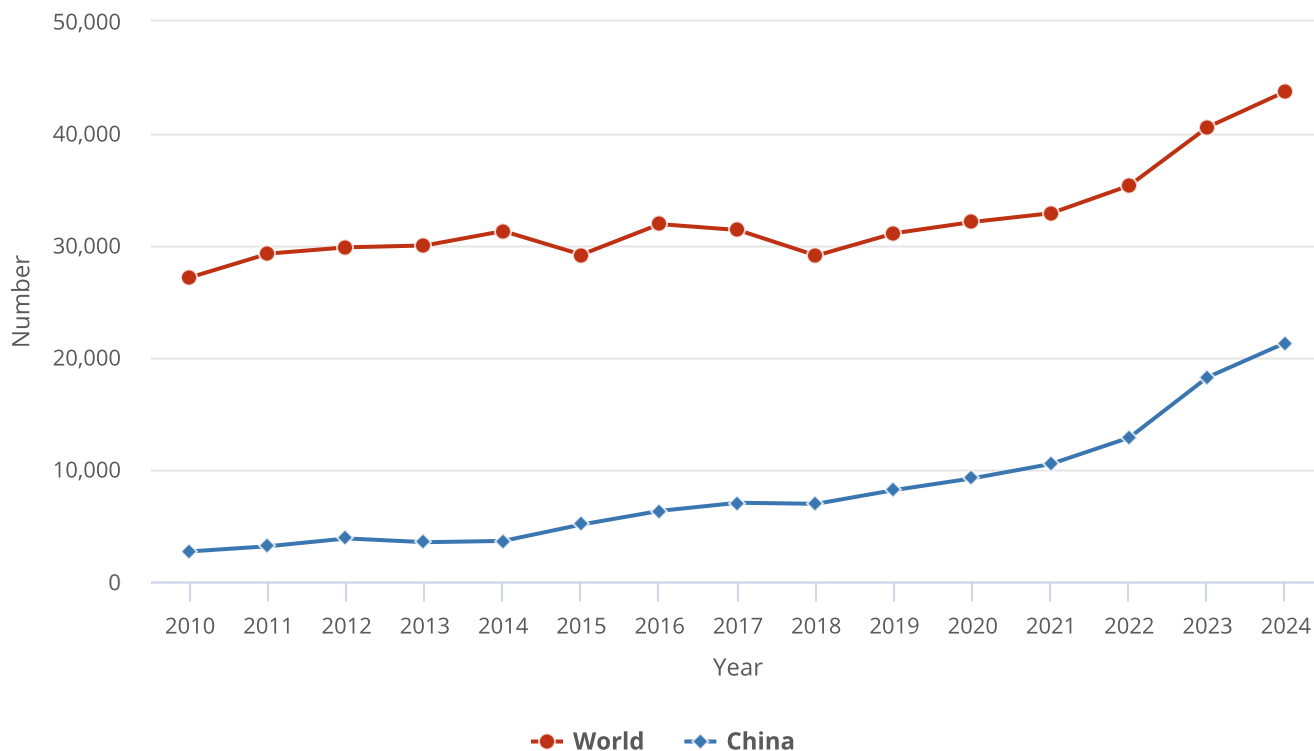
Semiconductors

Semiconductors are foundational components of electronic computing devices. Achieving international leadership in research, domestic manufacturing, and the development of a robust domestic technical workforce has been a goal of multiple recent presidential administrations as well as the focus of the 2022 CHIPS and Science Act (NSTC 2025). The semiconductor machinery and the semiconductor components manufacturing industries are R&D intensive, together accounting for about 8% of all U.S. business R&D in 2022 (NCSES 2024).

Globally, about 44,000 priority patent families were granted to inventors of semiconductor technology patents in 2024, and about half of these are from inventors in China (21,000) (Figure TRN-14). Inventors from South Korea and Japan were granted about 7,200 and 7,000, respectively, that year (Table STRN-21). Within the U.S. market, inventors in Japan and South Korea (shown in Figure TRN-15) and in Taiwan (Table STRN-22) accounted for more than half of USPTO semiconductor technology patents awarded in 2024. The HCP share for semiconductor priority patent families attributed to inventors from

the EU-27 and South Korea were higher in 2021 when compared to 2010. Conversely, the shares for the United States, China, and Japan were lower in 2021 when compared to 2010 (Figure TRN-16). Canada, Belgium, and Finland had HCP shares above 4.0 in 2021, reflecting a number of highly impactful priority patent families out of a smaller overall pool of patents driving high HCP shares (Table STRN-23).

Figure TRN-14. Priority patent families granted in semiconductors, by selected country or economy: 2010–24



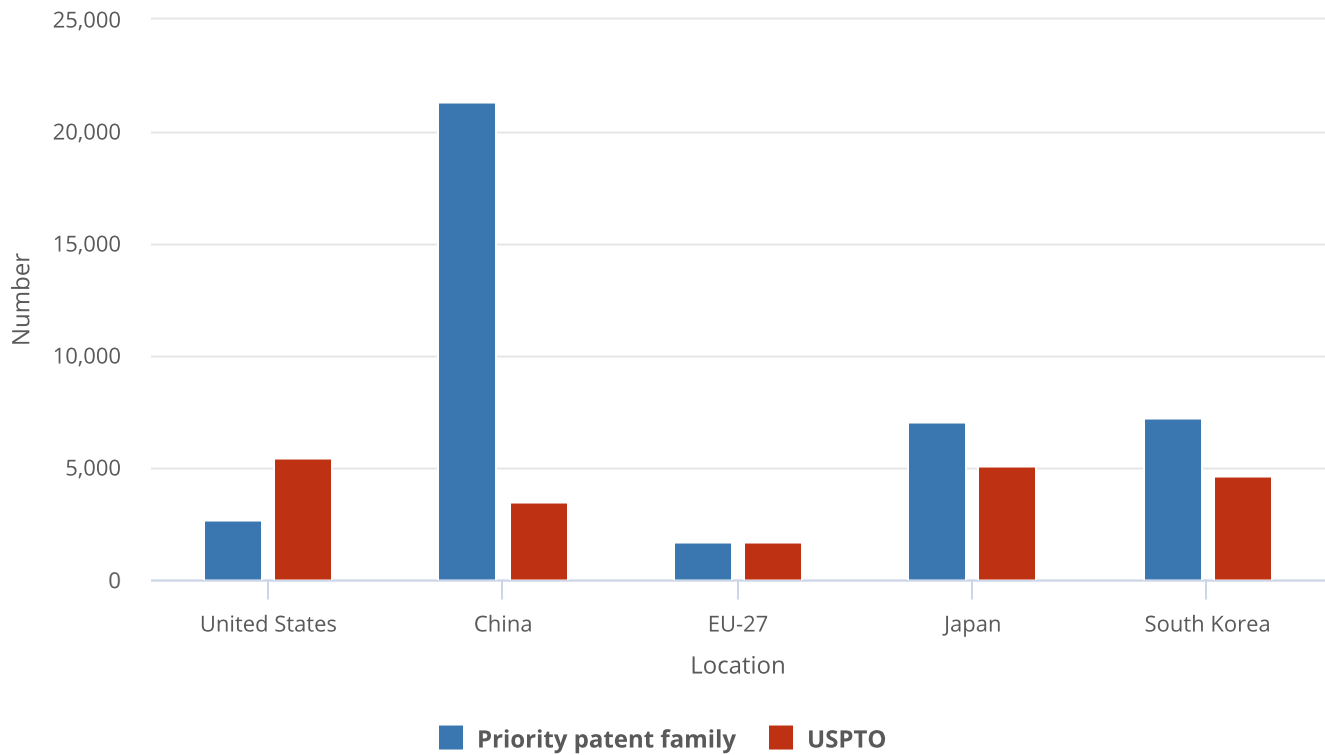
Note(s):

Priority patents are International Patent Documentation (INPADOC) patent families granted across all patent offices covered in the Worldwide Patent Statistical Database (PATSTAT). Locations are allocated according to patent inventorship information found on the priority patent of the INPADOC patent families and patents counted according to the year of the first granted patent in the patent family. This category is based on the 2025 classification of Key Technology Areas developed by the National Science Foundation's Technology Innovation Partnership program and shown in Table STRN-12. The 20 countries with the highest number of priority patents in this category are shown in Table STRN-21. China includes Hong Kong.

Source(s):

National Center for Science and Engineering Statistics; Science-Metrix (Elsevier); PATSTAT, spring 2025, accessed September 2025.

Science and Engineering Indicators

Figure TRN-15. Utility patents granted in semiconductors, by selected country or economy: 2024

EU-27 = European Union; USPTO = Patent and Trademark Office.

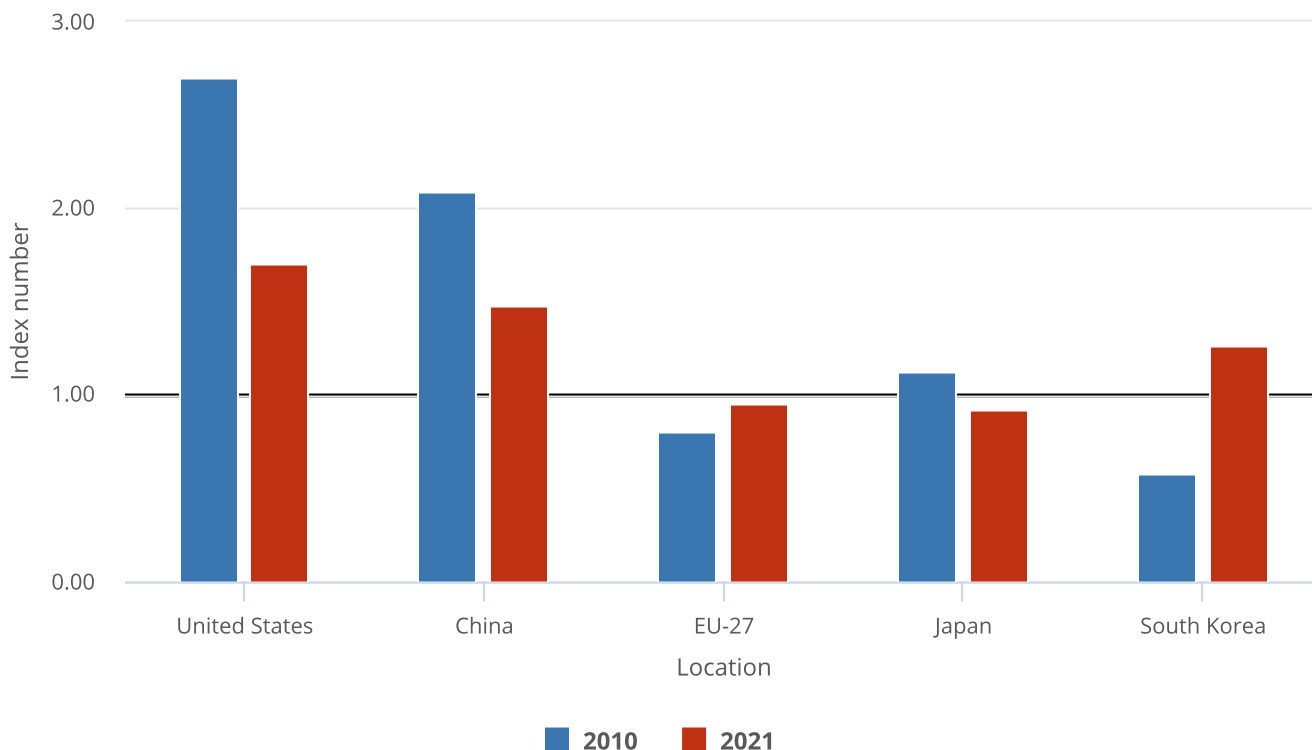
Note(s):

Priority patents are International Patent Documentation (INPADOC) patent families granted across all patent offices covered in the Worldwide Patent Statistical Database (PATSTAT). Locations are allocated according to patent inventorship information found on the priority patent of the INPADOC patent families and patents counted according to the year of the first granted patent in the patent family. Utility patents are allocated to location based on the residence of the inventor. This category is based on the 2025 classification of Key Technology Areas developed by the National Science Foundation's Technology Innovation Partnership program and shown in Table STRN-12. The 20 countries with the highest number of priority patents in this category are shown in Table STRN-21. The 20 countries with the highest number of USPTO utility patents in this category are shown in Table STRN-22.

Source(s):

National Center for Science and Engineering Statistics; Science-Metrix (Elsevier); PATSTAT, spring 2025, accessed September 2025; PatentsView, USPTO, accessed March 2025.

Science and Engineering Indicators

Figure TRN-16. Highly cited patents granted in semiconductors, by selected country or economy: 2010 and 2021

EU-27 = European Union.

Note(s):

Highly cited patents (HCPs) refer to priority patents cited in subsequent priority patent documents. This figure shows the index number for citations within patent documents during all the years available following the reference year, including the reference year itself. For example, for 2010, citations in priority patents between 2010 and 2024, the last year with fully available data, are used in the calculation. The index number has been normalized for patent age, technology area, and patent office through the length of reference list from the citing priority patents. For information on the patent methodology, see <https://www.science-metrix.com/patent-and-trademark-indicators-for-the-science-and-engineering-indicators-2026-technical-documentation/>. This category is based on the 2025 classification of Key Technology Areas developed by the National Science Foundation's Technology Innovation Partnership program and shown in Table STRN-12. The relative HCP of the 20 countries with the most patents in 2024 are shown in Table STRN-23. China includes Hong Kong.

Source(s):

National Center for Science and Engineering Statistics; Science-Metrix (Elsevier); Worldwide Patent Statistical Database (PATSTAT), spring 2025, accessed September 2025.

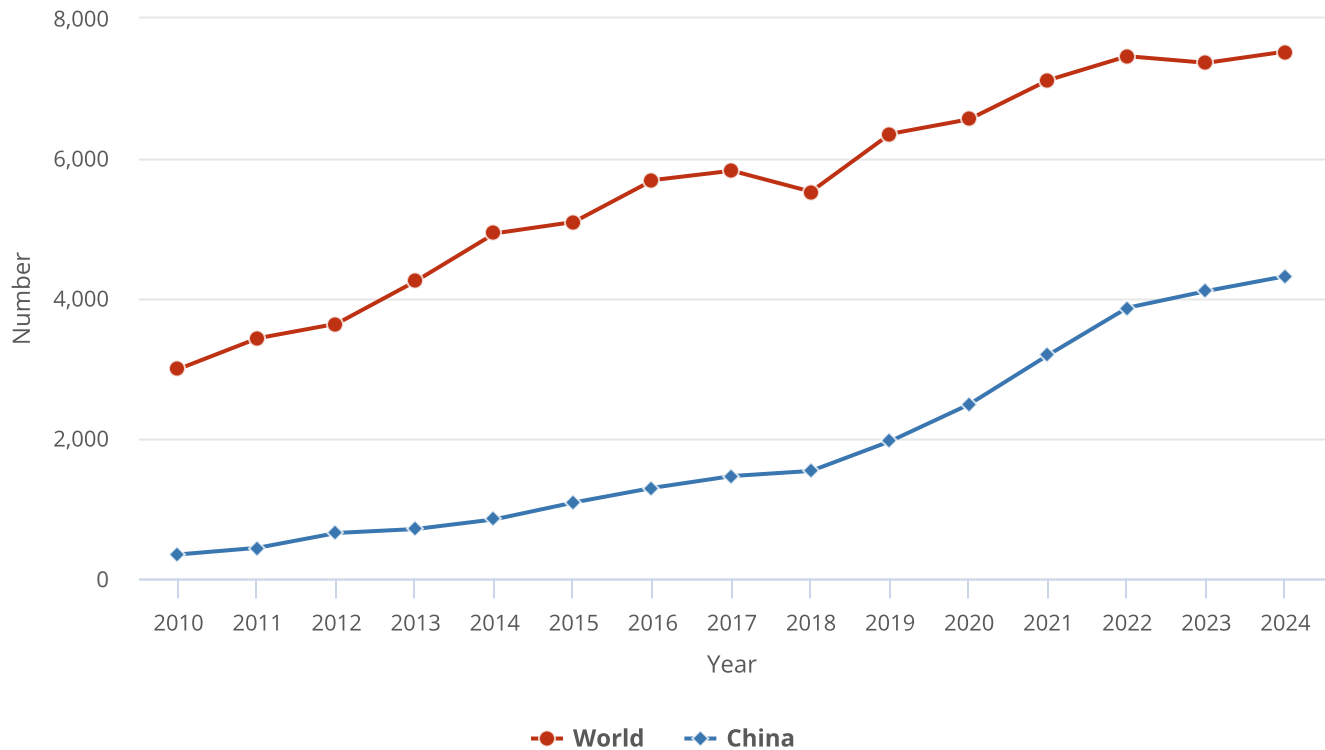
Science and Engineering Indicators

Quantum Information Science and Technology

QIST aims to use very small particles, or qubits, to develop computing, communication, and sensing systems to store, carry, and process information, leading to new technologies that can potentially solve problems that are currently unsolvable with available computation methods (for more discussion, see <https://www.nist.gov/quantum-information-science>). These problems include the encryption technologies used in economic and national security transactions, encouraging the race to be first to develop functional quantum computers (NASEM 2025). The United Kingdom and Australia are among the countries that have made large public investments to develop commercial quantum applications (Australian Government 2023; NQTP 2020). The U.S. government's National Quantum Initiative Act lays out a series of investments aimed at spurring innovation and protecting the security of these investments (NSTC 2024).

QIST inventors were granted about 7,500 priority patent families in 2024. Inventors from China were granted 4,300 of these (57%), increasing from about 300 (11%) in 2010 (Figure TRN-17). Inventors from Japan and the United States received the second- and third-highest number of priority patent families (900 and 800, respectively) that year (Figure TRN-18; Table STRN-24). Following the overall trend, inventors from the United States received more USPTO QIST patents than QIST priority patent families in 2024. While inventors from China are granted just a small fraction of USPTO QIST patents, that number has increased from about 1% of the world total in 2010 to 8% in 2024 (Table STRN-25).

Figure TRN-17. Priority patent families granted in quantum information science and technology, by selected country or economy: 2010–24



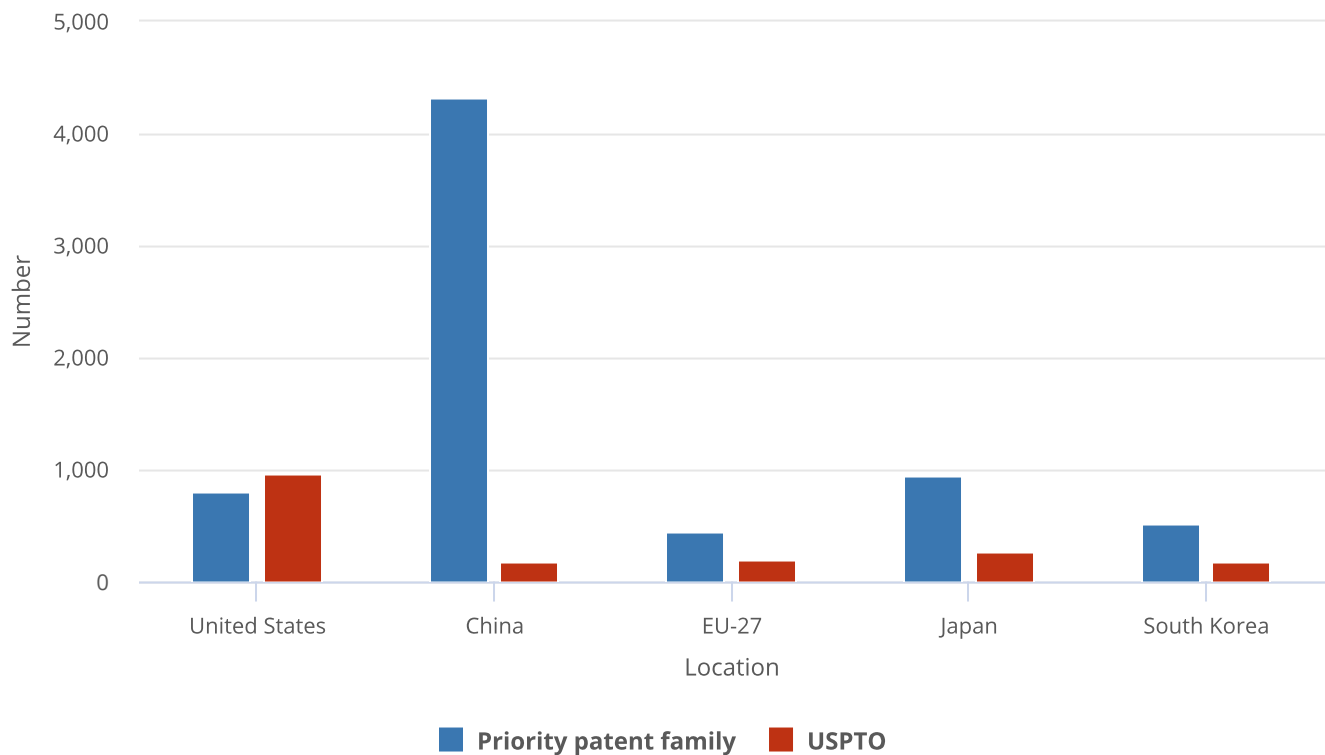
Note(s):

Priority patents are International Patent Documentation (INPADOC) patent families granted across all patent offices covered in the Worldwide Patent Statistical Database (PATSTAT). Locations are allocated according to patent inventorship information found on the priority patent of the INPADOC patent families and patents counted according to the year of the first granted patent in the patent family. This category is based on the 2025 classification of Key Technology Areas developed by the National Science Foundation's Technology Innovation Partnership program and shown in Table STRN-12. The 20 countries with the highest number of priority patents in this category are shown in Table STRN-24. China includes Hong Kong.

Source(s):

National Center for Science and Engineering Statistics; Science-Metrix (Elsevier); PATSTAT, spring 2025, accessed September 2025.

Science and Engineering Indicators

Figure TRN-18. Utility patents granted in quantum information science and technology, by selected country or economy: 2024

EU-27 = European Union; USPTO = Patent and Trademark Office.

Note(s):

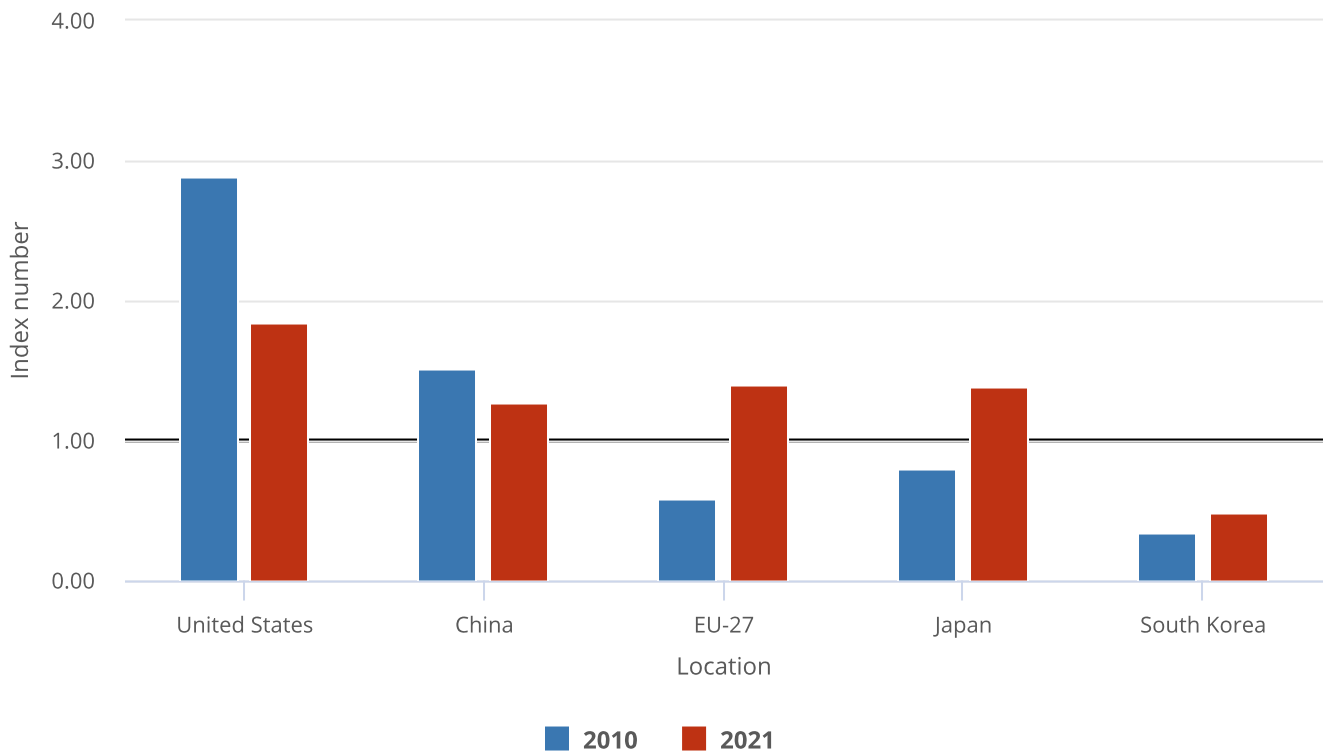
Priority patents are International Patent Documentation (INPADOC) patent families granted across all patent offices covered in the Worldwide Patent Statistical Database (PATSTAT). Locations are allocated according to patent inventorship information found on the priority patent of the INPADOC patent families and patents counted according to the year of the first granted patent in the patent family. Utility patents are allocated to location based on the residence of the inventor. This category is based on the 2025 classification of Key Technology Areas developed by the National Science Foundation's Technology Innovation Partnership program and shown in Table STRN-12. The 20 countries with the highest number of priority patents in this category are shown in Table STRN-24. The 20 countries with the highest number of USPTO utility patents in this category are shown in Table STRN-25.

Source(s):

National Center for Science and Engineering Statistics; Science-Metrix (Elsevier); PATSTAT, spring 2025, accessed September 2025; PatentsView, USPTO, accessed March 2025.

Science and Engineering Indicators

In both 2010 and 2021, inventors from the United States produced disproportionate shares of the top 1% of QIST HCPs. However, that advantage was smaller in 2021: the HCP share for QIST patents from U.S. inventors was 2.88 in 2010; by 2021, the share was 1.84. HCP shares for QIST patents from inventors in South Korea, the EU-27, and Japan increased between 2010 and 2021 (Figure TRN-19). Among other locations, patents granted in 2021 to inventors in Canada, Belgium, Finland, the United Kingdom, and Singapore had HCP shares above 3.00 (Table STRN-26).

Figure TRN-19. Highly cited patents granted in quantum information science and technology, by selected country or economy: 2010 and 2021

EU-27 = European Union.

Note(s):

Highly cited patents (HCPs) refer to priority patents cited in subsequent priority patent documents. This figure shows the index number for citations within patent documents during all the years available following the reference year, including the reference year itself. For example, for 2010, citations in priority patents between 2010 and 2024, the last year with fully available data, are used in the calculation. The index number has been normalized for patent age, technology area, and patent office through the length of reference list from the citing priority patents. For information on the patent methodology, see <https://www.science-metrix.com/patent-and-trademark-indicators-for-the-science-and-engineering-indicators-2026-technical-documentation/>. This category is based on the 2025 classification of Key Technology Areas developed by the National Science Foundation's Technology Innovation Partnership program and shown in Table STRN-12. The relative HCP of the 20 countries with the most patents in 2024 are shown in Table STRN-26. China includes Hong Kong.

Source(s):

National Center for Science and Engineering Statistics; Science-Metrix (Elsevier); Worldwide Patent Statistical Database (PATSTAT), spring 2025, accessed September 2025.

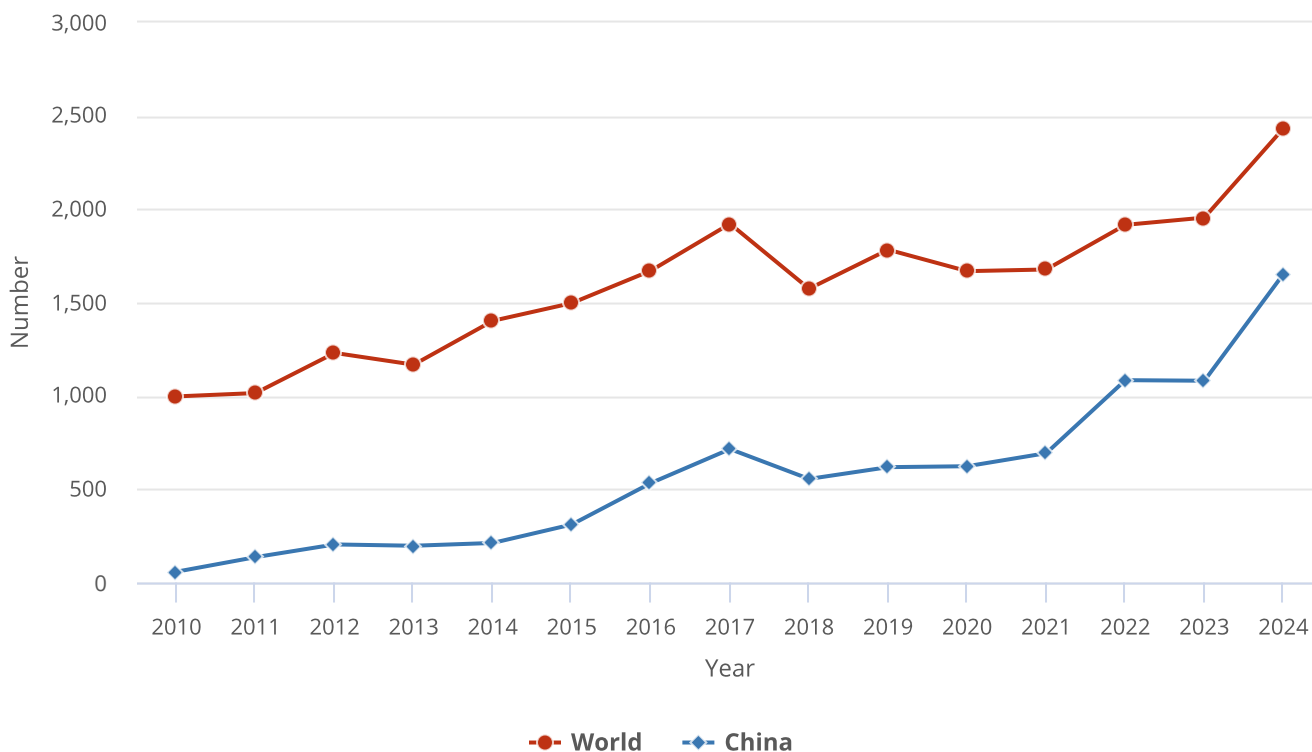
Science and Engineering Indicators

Nuclear Energy

The growth in the information sector of the U.S. economy has led to increased demand for electricity; by 2023, U.S. data centers accounted for 4.4% of total U.S. electricity consumption, and this share is expected to rise, according to a report by the Lawrence Berkeley National Laboratory (Shehabi, Smith, and Hubbard 2024). According to the International Energy Association (IEA), in recent years, nuclear market leadership has shifted toward China and Russia; half of all nuclear power plants under construction are currently in China (IEA 2025). In May 2025, the Trump administration announced executive orders to expand the use of nuclear power by streamlining regulations and adding capacity, aiming for 10 new large reactors to be under construction by 2030 (DOE 2025).

A relatively small number of patents are granted in advanced nuclear energy technologies relative to the other critical technologies described in this report. In 2024, only China, South Korea, Japan, and the United States received more than 100 priority patent families for advanced nuclear energy technologies (Table STRN-27). In keeping with the market leadership role attributed to China by IEA, inventors from China were awarded about two-thirds (1,700) of the 2,400 priority patent families awarded in advanced nuclear energy technologies in 2024 (Figure TRN-20). South Korea received about 240 patents and Japan received about 190 patents, followed by the United States with 140 patents. More than half of USPTO nuclear energy patents—90 of 140 patents—were awarded to U.S. inventors in 2024 (Table STRN-28). A relatively small number of advanced nuclear technologies USPTO patents were awarded to inventors from China in 2024, representing 8% of the total awarded (Figure TRN-21).

Figure TRN-20. Priority patent families granted in advanced nuclear technologies, by selected country or economy: 2010–24

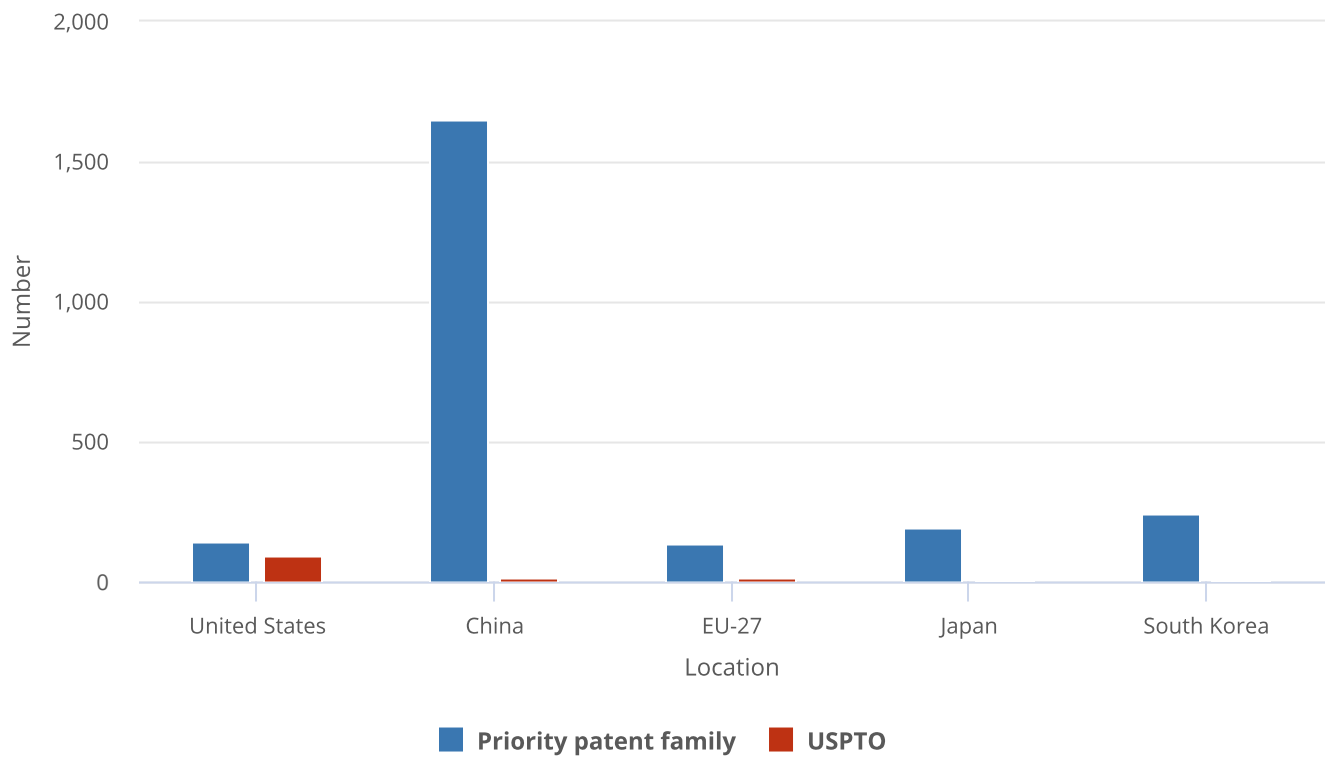


Note(s):

Priority patents are International Patent Documentation (INPADOC) patent families granted across all patent offices covered in the Worldwide Patent Statistical Database (PATSTAT). Locations are allocated according to patent inventorship information found on the priority patent of the INPADOC patent families and patents counted according to the year of the first granted patent in the patent family. This category is based on the 2025 classification of Key Technology Areas developed by the National Science Foundation's Technology Innovation Partnership program and shown in Table STRN-12. The 20 countries with the highest number of priority patents in this category are shown in Table STRN-27. China includes Hong Kong.

Source(s):

National Center for Science and Engineering Statistics; Science-Metrix (Elsevier); PATSTAT, spring 2025, accessed September 2025.

Figure TRN-21. Utility patents granted in advanced nuclear technologies, by selected country or economy: 2024

EU-27 = European Union; USPTO = Patent and Trademark Office.

Note(s):

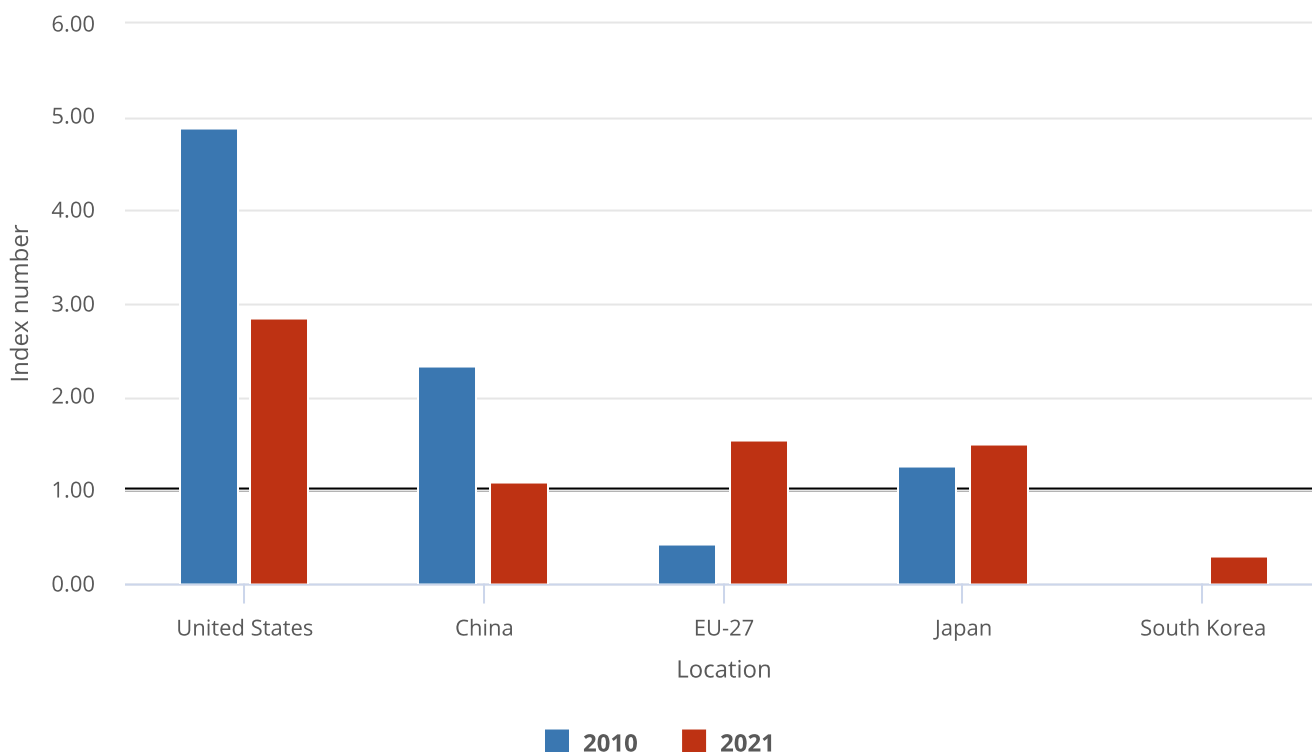
Priority patents are International Patent Documentation (INPADOC) patent families granted across all patent offices covered in the Worldwide Patent Statistical Database (PATSTAT). Locations are allocated according to patent inventorship information found on the priority patent of the INPADOC patent families and patents counted according to the year of the first granted patent in the patent family. Utility patents are allocated to location based on the residence of the inventor. This category is based on the 2025 classification of Key Technology Areas developed by the National Science Foundation's Technology Innovation Partnership program and shown in Table STRN-12. The 20 countries with the highest number of priority patents in this category are shown in Table STRN-27. The 20 countries with the highest number of USPTO utility patents in this category are shown in Table STRN-28.

Source(s):

National Center for Science and Engineering Statistics; Science-Metrix (Elsevier); PATSTAT, spring 2025, accessed September 2025; PatentsView, USPTO, accessed March 2025.

Science and Engineering Indicators

The relatively small number of patents granted in advanced nuclear technologies also affects HCP shares; several locations had zero patents in this category for the years calculated. The small number of patents in the category means that the index is more sensitive to a few HCPs. Only half of the top patenting locations in 2021 had any patents in the top 1% of HCPs, with patents from Denmark and Sweden ranking at 33.33 and 15.38, respectively (Table STRN-29). For patents awarded in 2021, those from U.S. inventors had an HCP share of 2.86, lower than the 4.89 value in 2010. Locations whose HCP shares were higher in 2021 compared with 2010 included the EU-27, Japan, and South Korea (Figure TRN-22).

Figure TRN-22. Highly cited patents granted in advanced nuclear technologies, by selected country or economy: 2010 and 2021

EU-27 = European Union.

Note(s):

Highly cited patents (HCPs) refer to priority patents cited in subsequent priority patent documents. This figure shows the index number for citations within patent documents during all the years available following the reference year, including the reference year itself. For example, for 2010, citations in priority patents between 2010 and 2024, the last year with fully available data, are used in the calculation. The index number has been normalized for patent age, technology area, and patent office through the length of reference list from the citing priority patents. For information on the patent methodology, see <https://www.science-metrix.com/patent-and-trademark-indicators-for-the-science-and-engineering-indicators-2026-technical-documentation/>. This category is based on the 2025 classification of Key Technology Areas developed by the National Science Foundation's Technology Innovation Partnership program and shown in Table STRN-12. The relative HCP of the 20 countries with the most patents in 2024 are shown in Table STRN-29. China includes Hong Kong.

Source(s):

National Center for Science and Engineering Statistics; Science-Metrix (Elsevier); Worldwide Patent Statistical Database (PATSTAT), spring 2025, accessed September 2025.

Science and Engineering Indicators

Patenting is not the only method by which inventors protect their inventions. The sidebar [Intellectual Property Measures in Context](#) describes both the utility and the limitations of patenting compared with other forms of IP protection.

SIDEBAR**Intellectual Property Measures in Context**

Inventors often have an economic motivation to keep the details of their inventions secret. The patenting system provides the legal right, for a limited time, to exclude others from making, using, offering for sale, or selling the invention, in exchange for public disclosure of the technical information in the granted patent. Extensive publicly available administrative data exist for patents and their inventors, and databases allow for systematic insights into these patents. In the absence of other comprehensive data on inventions, patent data provide unique and useful insights into the inventions deemed valuable enough to patent. However, analysis of these data requires caution.

While comprehensive data are scarce, available evidence shows that many patented inventions are never commercialized; a recent analysis of the Small Business Innovation Research program and the Department of Defense showed 21.5% of patents had evidence of commercialization (Bottai, de Rassenfosse, and Raiteri 2025). Conversely, many valuable inventions that are commercialized are not patented. Patent data are neither representative of all inventions, nor are they consistent measures of innovation. Companies choose a variety of strategies to protect their inventions and intellectual property (IP). For example, U.S. companies rate trade secrets higher than patents in their importance for protecting IP, which is true even for R&D-performing firms (NCSES 2024; NCSES 2025a: [Table 71](#); Shackelford and Kindlon 2021).

A small number of patents are issued with secrecy orders that restrict the release of information about the invention during the period of its patent protection for reasons that include national security and export control. The total number of USPTO patents with secrecy orders in effect at the end of FY 2024 was about 6,500 (FAS 2025).

In addition, patent protection may be sought for reasons other than intended commercialization. Patents may be obtained to block rivals and negotiate with competitors, to use in lawsuits, or to build “thickets” of patents to impede or raise others’ costs of R&D and innovation (Cohen, Nelson, and Walsh 2000). Research suggests that some organizations and countries pursue “strategic patenting” to block competitors and to monetize patents through licensing and other activities (Ernst 2015). New and emerging firms may seek patent protection to help obtain financing because investors may perceive patents as valuable assets and as indicators of future profitability. Finally, cross-country analysis indicates that international differences in taxes on corporate and patent income influence the choice of patent location for multinational firms (OECD 2016:3). However, considering these limitations, Patent and Trademark Office patent documents provide information as to when and in what technology areas inventors have decided to protect their IP with patent protection. This rich detail, which also includes the name and address of the inventor and assignee, justifies presentation of the patent documents.

There are marked differences in terms of the scale of economic resources directed toward patenting inventions across economic sectors; the private business sector expends significantly more resources than the federal government or higher education institutions. Even so, each of these sectors has evolved substantial capacities for identifying potentially patentable inventions and filing patent applications in the United States and worldwide. Differences also exist within and across these sectors in the perceived net benefit of choosing patenting as a principal means of pursuing the further development and commercialization of inventions.

Finally, patent protection is important for some technologies that have been identified as critical for the U.S. economy. Based on business survey data comparing other kinds of IP protection, 39% of firms that produce communication equipment and 34% of firms that produce pharmaceuticals and medicines consider utility patents very important (NCSES 2025a: [Table 72](#)).

Innovation

Innovation is the translation of knowledge arising from R&D activities into new or improved products, processes, or services with real-world applications. Innovation is measured through its incidence (survey measurement), activities (science, technology, engineering, and mathematics education and workforce), outputs (products and processes), outcomes (economic growth and societal benefits), and the creation of intangible capital (Aizcorbe, Moylan, and Robbins 2009). Like physical capital, the use of intangible capital provides future value; however, intangible capital has no separate physical existence, making it less costly to share. Computer software and R&D activities are two types of intangible capital included in measures of gross domestic product (GDP). Spending on software and R&D provides indicators of business investment in innovation activities (Corrado, Hulten, and Sichel 2009). R&D activity is described in depth in the *Indicators 2026* report “[Discovery: R&D Activity and Research Publications](#)” (NSB 2025). This section provides data on business registration of trademarks as well as business survey data on the introduction of new products and processes.

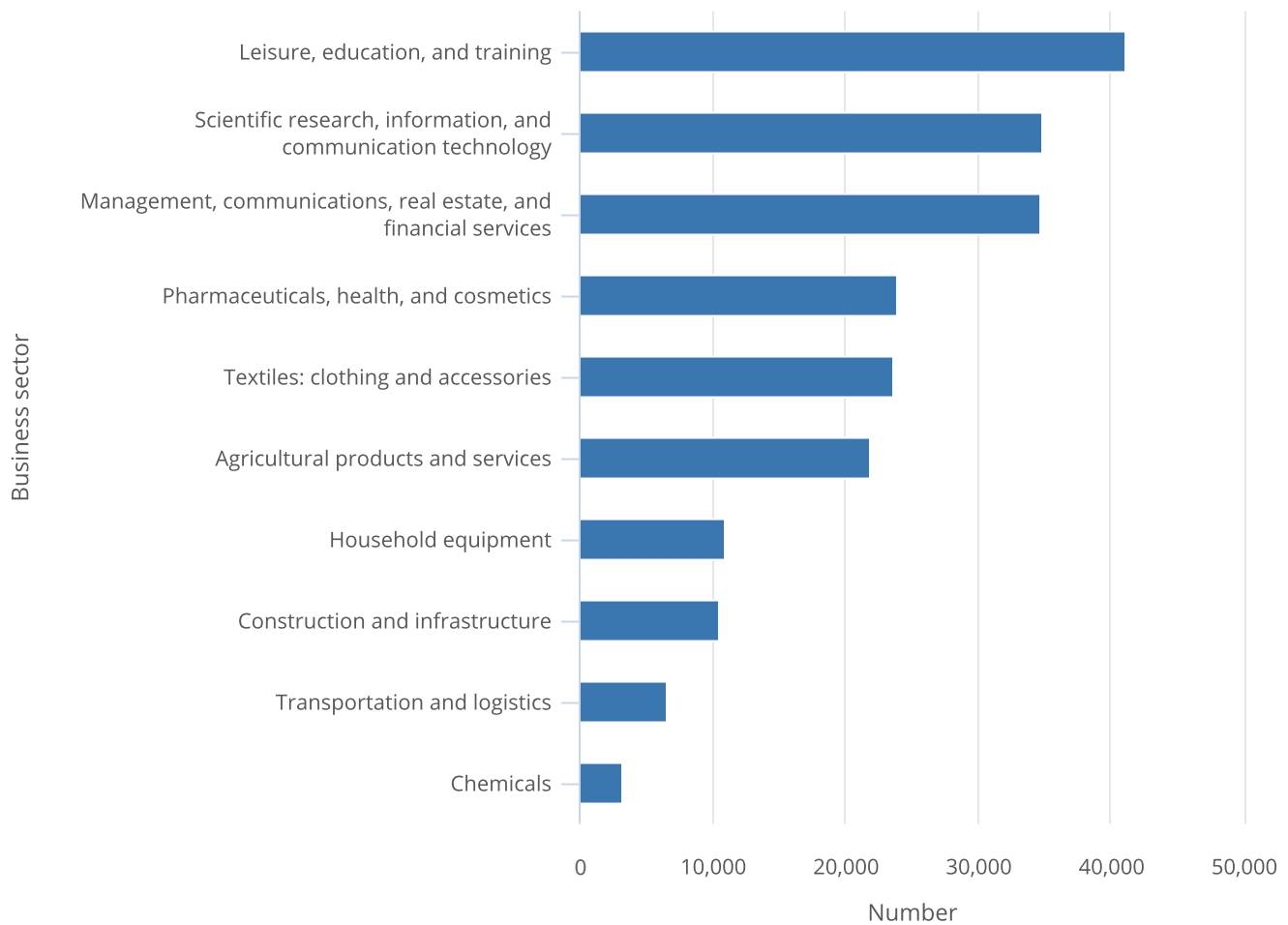
Other types of innovative activity are less well measured and, analogous to the unseen “dark matter” in the universe, have been referred to as “dark innovation” (Martin 2016). This unmeasured innovation can take place as products are used and freely shared, such as OSS. Data on open-source contributors and repositories show the growth and global reach of this software development activity.

Trademarks

Trademark data complement patent data as indicators of innovation activity. Trademark registrations from USPTO “capture the moment at which products or services are introduced into the market, turning inventions into innovations” (von Graevenitz, Graham, and Myers 2022:227–28). Academic studies in the last two decades have consistently found trademark activity to be correlated with innovation activity (Flikkema, Castaldi, and de Man 2025; Millot 2009). In 2024, USPTO registered about 378,000 trademarks to owners across the world, including about 212,000 registered to U.S. owners (Table STRN-30).

Trademarks are particularly valuable as innovation indicators for firms that produce services and firms that are knowledge or innovation intensive (Gotsch and Hipp 2014; Mendonça, Santos Pereira, and Godinho 2004). Trademark data can be analyzed by product type, based on 45 distinct classes that correspond to business sectors (Table STRN-31, Table STRN-32). For U.S.-registered trademarks in 2024, three service-industry categories had the highest numbers registered: the category that includes leisure, education, and training (41,000); the category that includes scientific research, information, and communication technology (35,000); and the category that includes management, communications, real estate, and financial services (35,000) (Figure TRN-23).

Figure TRN-23. U.S.-registered USPTO trademarks, by business sector: 2024



USPTO = Patent and Trademark Office.

Note(s):

Trademarks are allocated according to holder information and are fractionally allocated to regions, countries, or economies based on the proportion of residences of all named holders. Trademarks are classified under the Nice Classification of goods and services, which classifies trademarks under 34 categories of goods and 11 categories of services; see <https://www.wipo.int/classifications/nice/en/>. Fractional counts of trademarks were assigned to each category to assign the proper weight of a trademark to the corresponding category under the classification. Business sectors based on class groups are those defined by Edital. See Table STRN-31 for detail on the 10 aggregate business sectors and Table STRN-32 for detail by year and category.

Source(s):

National Center for Science and Engineering Statistics; Science-Matrix (Elsevier); USPTO data hosted by Reed Tech (LexisNexis), accessed March 2025.

Science and Engineering Indicators

Open-Source Software

As described in the sidebar [Intellectual Property Measures in Context](#), some inventions and knowledge products are created with the intention of being widely shared. Broadly defined, OSS is any software that is accessed, modified, and distributed freely. In this report, it refers to software with an Open Source Initiative–approved license. Linux, Apache, Python, and Kubernetes are examples. Economists have estimated a value of \$8.8 trillion for the OSS used by businesses for 2020 (Hoffman, Nagle, and Zhou 2024).

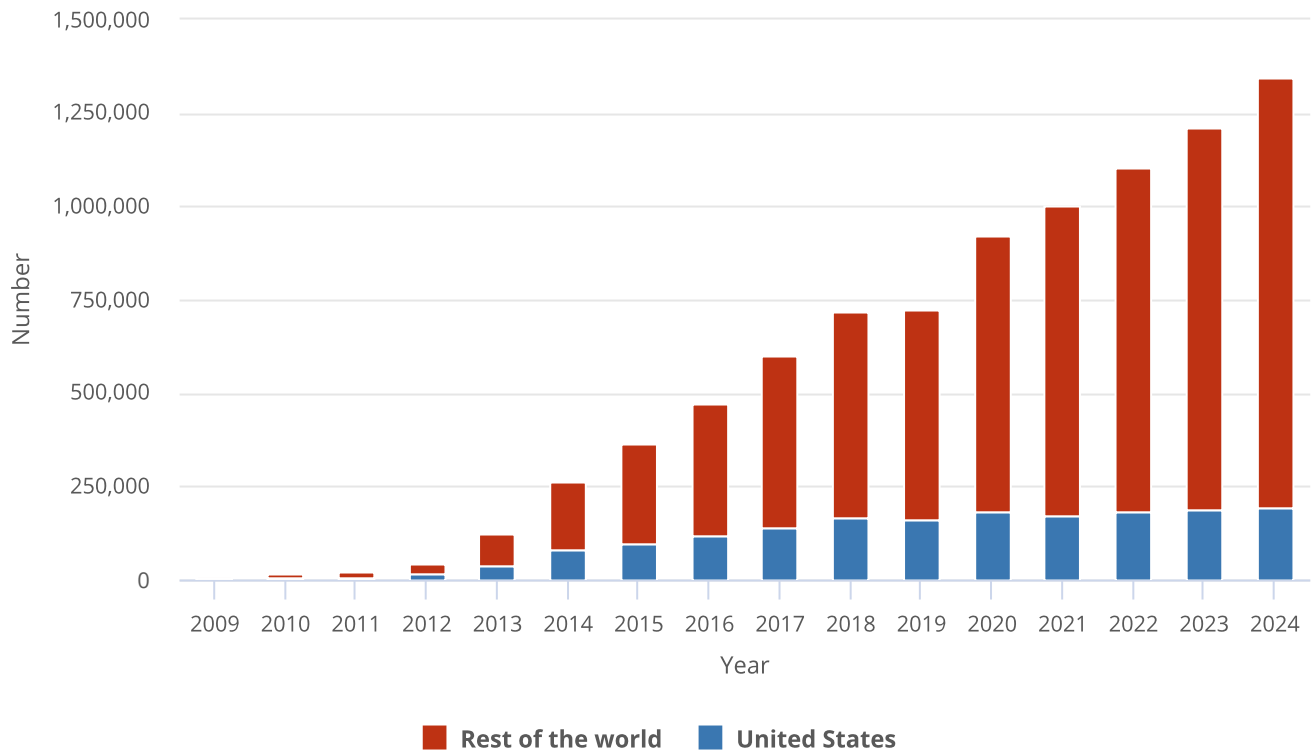
At the end of 2024, GitHub reported having almost 140 million developers contributing to open-source code in that year, increasing from 45.5 million developers at the beginning of 2020 (GitHub 2025). Although GitHub is the world's largest remote source code-hosting platform, it is not the only one. GitCode is an open-source hosting platform developed by the Chinese Software Developer Network and the company Huawei, reporting over 50 million users (GitCode 2025).

For the following analysis, data were collected for each GitHub repository with an open-source license. When available, information on the location and affiliation of each repository's developers was also collected. The location and employment affiliation are voluntarily supplied by GitHub users in their profiles; as a result, the location and sector are not complete for a notable share of developers (see the [Technical Appendix](#)). Furthermore, because only repositories with contributor location information are used in the analysis, location information was available for between 32% and 52% of the repositories in each year, with location information available for 36% of repositories in 2024 (Table STRN-33). This incomplete coverage may affect the reliability of location and sector analyses, which should be regarded as experimental at this time. The sidebar [Global Contributions and Collaborations in Open-Source Software](#) discusses the contributions of developers with known locations and the network formed by international collaborations.

SIDEBAR

Global Contributions and Collaborations in Open-Source Software

For new repositories created in 2010 with known locations, U.S. developers accounted for 38% of GitHub contributions ([Figure TRN-A](#)); by 2024, U.S. contributors with known locations accounted for 14.4% ([Figure TRN-B](#)). India, Brazil, China, and Germany join the United States in having some of the highest numbers of contributions to GitHub repositories (Table STRN-33). Seven countries accounted for over half of the known new GitHub contributions in 2024 ([Figure TRN-B](#)). The United States accounted for the largest share of known contributions to new GitHub repositories in 2024 (14.4%), followed by India (10.1%), Brazil (8.8%), and Germany (5.6%).

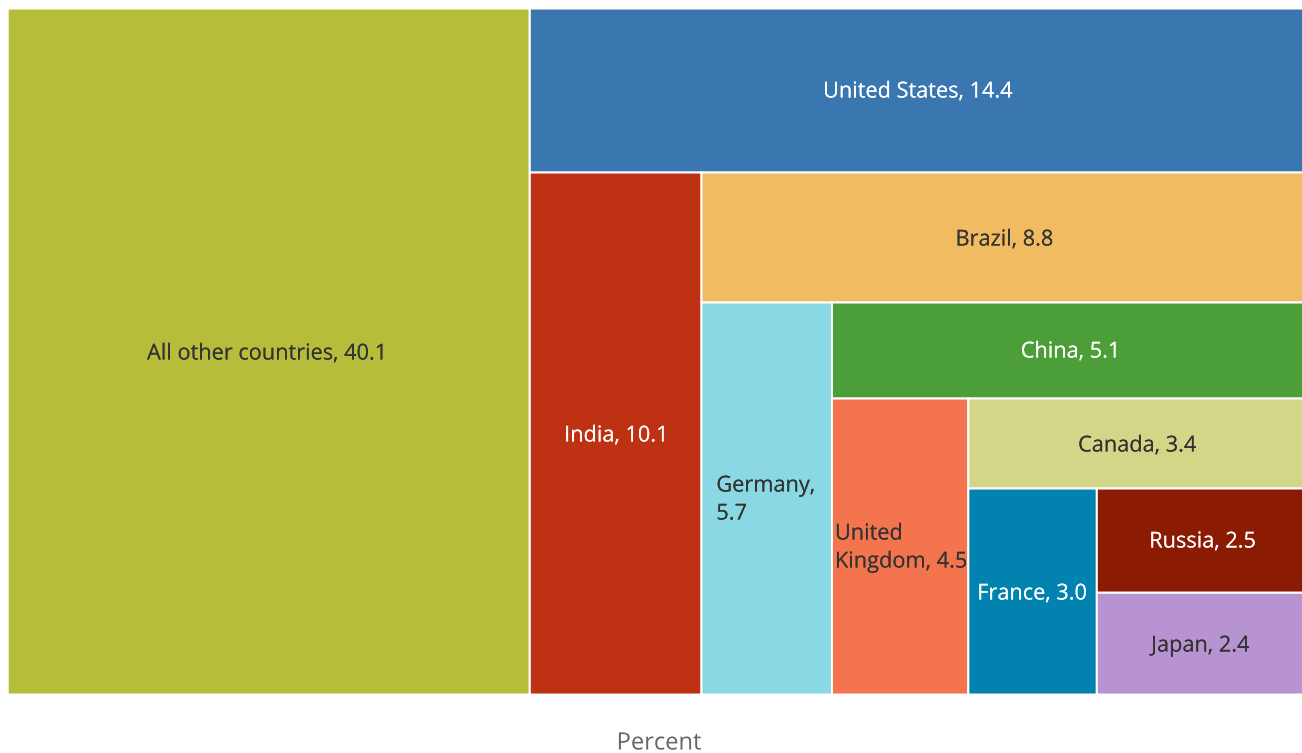
Figure TRN-A. New GitHub repositories contributed by the United States and the rest of the world: 2009–24**Note(s):**

Repositories are fractionally counted assigning equal credit to each developer within a repository and then distributed across associated countries. Repositories are attributed to the year of the earliest commit, and only developers who contributed in that earliest year receive credit, ensuring each repository is only counted once in time, even if contributions span multiple years. Repositories without location information are not shown.

Source(s):

Westat and National Center for Science and Engineering Statistics, tabulations of GitHub data, December 2025.

Science and Engineering Indicators

Figure TRN-B. Share of new GitHub repositories, by region, country, or economy of contributor: 2024**Note(s):**

This figure is based on the contributions to new GitHub repositories contributed to by each country per year using the fractional-counting method. Each new repository's credit is divided equally across its contributors, and each contributor's share is further divided across their associated countries. This ensures that the total sum of all countries' contributions matches the total number of unique repositories. See Table STRN-33.

Source(s):

Westat and National Center for Science and Engineering Statistics, tabulations of GitHub data, December 2025.

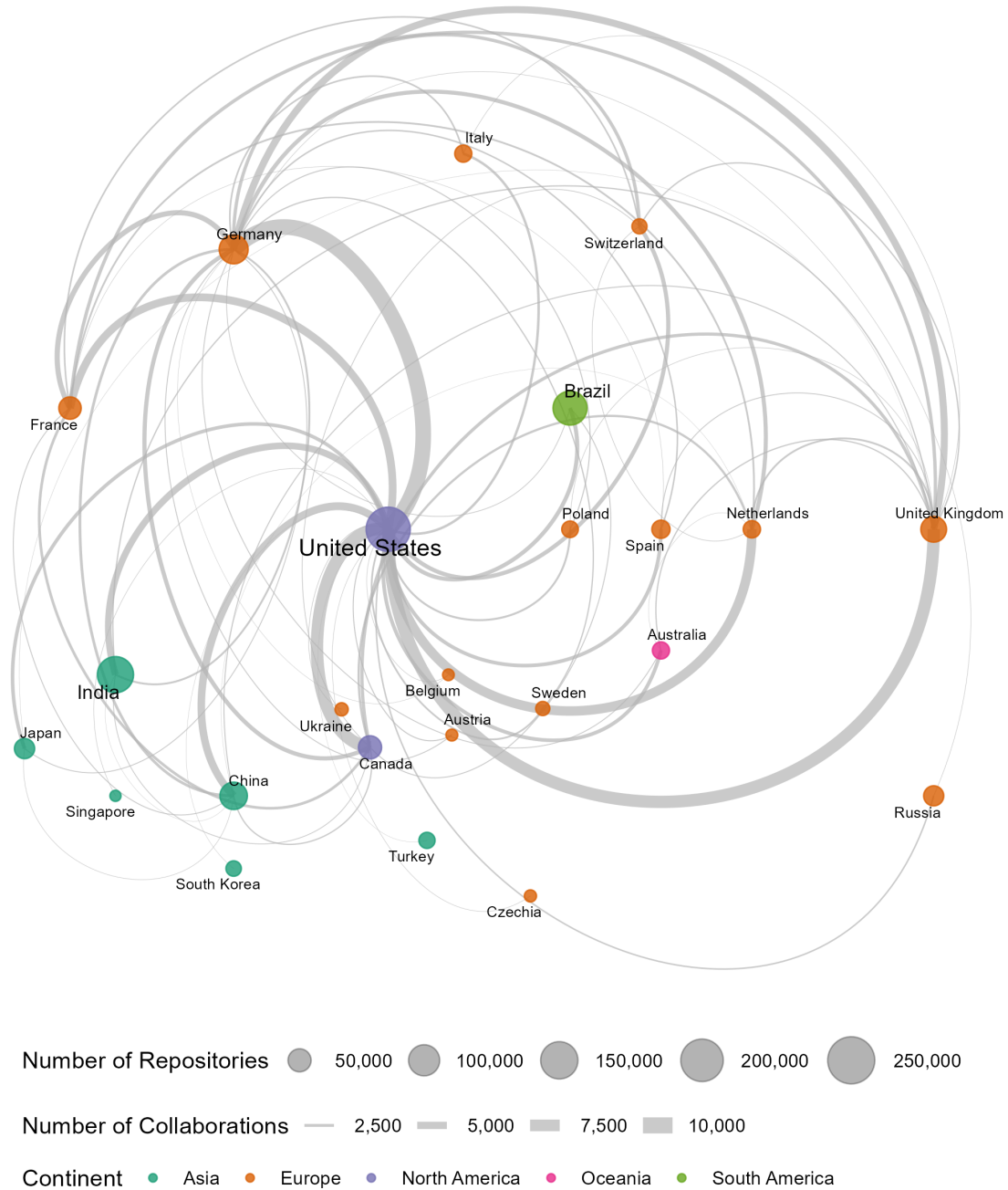
Science and Engineering Indicators

Seven of the top 10 private-sector companies that contributed to GitHub repositories between 2009 and 2024 are headquartered in the United States, with GitHub itself and Snyk, a cybersecurity company headquartered in Boston, accounting for the highest contributions. Chinese e-commerce company NetEase and the Russian Internet search and e-mail providers Yandex and VK round out the top 10. Of the top 10 global university contributors to GitHub during the same period, half are located in the United States. The Massachusetts Institute of Technology, Stanford University, Carnegie Mellon University, and the University of Washington Seattle Campus top the academic list; the University of California, Berkeley, is seventh. Foreign universities among the top contributors are Ecole pour l'Informatique et les Nouvelles Technologies (France), University of Toronto (Canada), Tsinghua University (China), Technische Universität München (Germany), and ETH Zurich (Switzerland) (Table STRN-34).

Developers throughout the world collaborate through the creation of open-source software (OSS). GitHub provides tools to collect user attribute and activity data that can be analyzed to assess OSS collaborations between countries. Collaboration is defined as pairs of individuals who contribute code to a common repository. Similar to the way in which research publication records show patterns of collaboration in the *Indicators 2026* report "[Discovery: R&D Activity and Research Publications](#)" (NSB 2025), OSS collaboration networks show international relationships in knowledge creation and transfer.

OSS collaborations occur across regions, countries, or economies, and network analysis can provide visualizations of these collaborative relationships, shown when a repository has contributions by developers from both countries. The most frequent collaboration pairing in 2024 was between Germany and the United States, appearing in almost 9,800 repositories, followed by Canada and the United States (7,900) (Figure TRN-C). Among collaborations not involving developers from the United States, the highest numbers of collaborations in 2024 were between Germany and the United Kingdom (4,800) and between Germany and France (3,800). For more details on collaboration pairs and contributions by country, see Table STRN-35. For the number of repositories attributed to each location, see Table STRN-36.

Figure TRN-C. Open-source software collaboration networks in GitHub, by region, country, or economy: 2024



Note(s):

This figure is based on the top country-to-country open-source software collaborations on GitHub in 2024, measured by the number of co-developed repositories that have more than 1,000 collaborations. A repository is counted as co-developed between two countries if it includes developers from both countries. All eligible country pairs are credited using a whole-counting method, meaning each country pair receives full credit for each shared repository. See Table STRN-35.

Source(s):

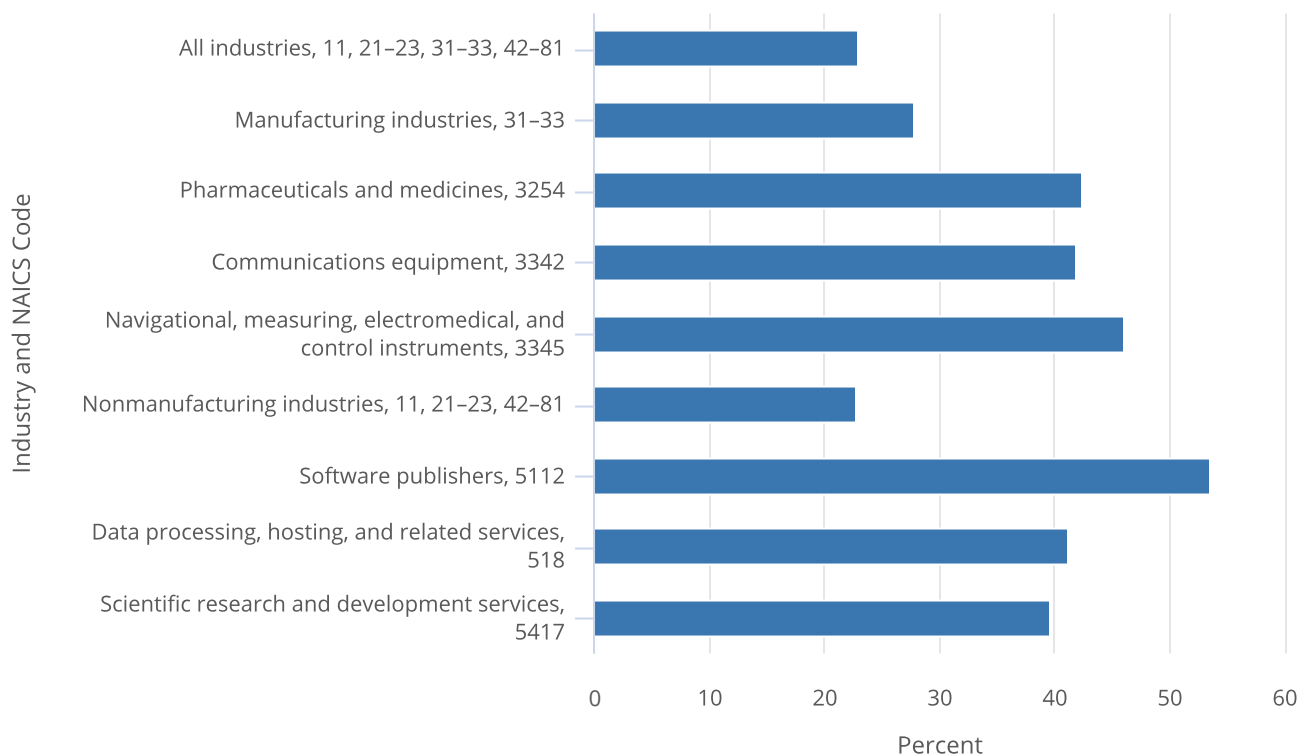
Westat and National Center for Science and Engineering Statistics, tabulations of GitHub data, December 2025.

Science and Engineering Indicators

Business-Reported Innovation

High rates of business-sector innovation are indicators of dynamic economic activity, whether at the local, regional, or national level (Hall and Jaffe 2018). A key indicator of business-sector innovation is the proportion of companies within an industry that introduce new or significantly improved products and processes. Business innovation activity, as an indicator provided in this report, is the proportion of companies within an industry in a given year that report introducing new or significantly improved products or processes within a 3-year period. In 2022, about 23% of U.S. companies reported introducing a product or process innovation in the 3-year period between 2020 and 2022. U.S. companies in the software publishing industry had the highest rates of reported innovation during this period; in 2022, 54% of companies reported introducing a product innovation (NCSES 2025a: [Table 30](#)). In the pharmaceutical and medicines industry, 42% of U.S. companies reported a product or process innovation over the same period ([Figure TRN-24](#)).

Figure TRN-24. Share of U.S. companies reporting product or business process innovation, by selected industry: 2020–22



Note(s):

Industry classification is based on dominant establishment payroll. Statistics are representative of companies located in the United States. Product-innovating companies are self-reporting, based on having introduced a new or improved product that differs significantly from the firm's previous products and that has also been introduced on the market or brought into use by the firm. These products may be goods or services.

Source(s):

National Center for Science and Engineering Statistics (NCSES), 2025, Annual Business Survey: 2023 (Data Year 2022), NSF 25-303, Table 30, available at <https://nces.nsf.gov/surveys/annual-business-survey/2023>.

Science and Engineering Indicators

These innovation rates are reported based on business survey data of U.S. firms, allowing for robust comparisons across industries. Although innovation rates and activities can also be compared across countries, they are affected by the limitations of cross-country comparisons. The sidebar [Comparing Innovation across Countries](#) describes efforts to make valid cross-country comparisons.

SIDEBAR

Comparing Innovation across Countries

As a driver of economic growth, innovation is an important aspect of overall national competitiveness, with implications for productivity, living standards, and national security. Relevant comparisons of innovation may include overall scale, intensity, and the rate and direction of change. There are different composite ways to look at innovations and competitiveness but limited agreement on standard definitions or methods. For reliable international comparisons, indicators developed from data collected in different national jurisdictions need to be standardized and harmonized. The standardization of measurement concepts across national surveys strengthens international comparisons. However, subjective elements in respondent identification of something “new or significantly improved” appear to vary across countries. Although the innovation activity described here takes place within private-sector firms, the impact of innovation is influenced by interrelated drivers such as social infrastructure and political institutions, monetary and fiscal policy, and microeconomic environment (Delgado et al. 2012).

The 38-member Organisation for Economic Co-operation and Development (OECD) provides integrated and harmonized data sets for R&D, scientific publications, intellectual property rights, and economy and workforce indicators for member countries and selected nonmember countries (OECD 2025a). OECD data cover most OECD members and data from Brazil, China, India, South Africa, and several other rapidly growing middle-income economies, where data are available. The *Science and Engineering Indicators 2026* report “[Discovery: R&D Activity and Research Publications](#)” includes international data from OECD’s Main Science and Technology Indicators and Analytical Business Enterprise Research and Development databases. Based on those data, R&D spending in 2022, adjusted for international prices, is highest in the United States, followed by China and then by Japan. However, the ratio of R&D to gross domestic product is highest for Israel, followed by South Korea, Taiwan, and the United States (NSB 2025).

The Community Innovation Survey is a business survey fielded since the early 1990s by members of the European Union and described in the *Oslo Manual*. This framework defines an innovation as a new or improved product or process (or combination thereof) that differs significantly from the unit’s previous products or processes and that has been made available to potential users (product) or brought into use by the unit (process) (OECD/Eurostat 2018). The OECD reports innovation data from 42 economies using this framework, including from Canada, the United States, South Korea, Japan, Australia, and countries from South America, but not from China, where the survey is not fielded. The definitions and measurement framework of the *Oslo Manual* are used for the comparison of business innovation by U.S. industries described in this report. By this measure, businesses in Canada had the highest percentage of total firms introducing an innovation over the most recently available 3-year (2018–20) reporting window (83%), followed by Israel (74%) and then by Greece (72%) (OECD 2023). To allow for causal analysis with microdata, this survey framework also collects information on innovation activities, including “all developmental, financial and commercial activities undertaken by a firm that are intended to result in an innovation for the firm” (OECD/Eurostat 2018:20).

The World Intellectual Property Organization’s (WIPO’s) Global Innovation Index (GII) provides a more curated set of indicators for a larger set of countries or economies in its annual report (WIPO 2024). Indicators are combined into seven pillars; five are identified as inputs: institutions, human capital and research, infrastructure, market sophistication, and business sophistication. Two pillars are identified as outputs: knowledge and technology outputs and creative outputs. The index equally weights the input sub-index and the output sub-index to develop a global ranking. Each year, the index is reevaluated, and components are added or subtracted. Based on the weighting scheme and choice of indicators in the 2024 GII, Switzerland is the most innovative economy (a position it has held for 14 consecutive years), Sweden is second, and the United States is third (WIPO 2024).

Unlike OECD data, WIPO's GII covers low- and middle-income countries and compares across regions. For example, the 2024 GII identifies the top three innovation economies in central and southern Asia as India, Iran, and Kazakhstan (WIPO 2024). Although most of the indicators are the same ones used in *Indicators* reports, such as S&E graduates, research publications, patents, and R&D spending, the GII indicators include subjective measures as well, including government effectiveness, regulatory quality, and rule of law. The inclusion of these factors is a recognition of the importance of institutions and infrastructure on innovative capacity. Due to different choices of indicators, use of subjective measures, and the reevaluation of weights for each cycle, users should be cautious comparing across cycles and understand the methods that WIPO uses for the development of the GII for each cycle.

Multifactor productivity (MFP), described in the sidebar [Measuring Short- and Long-Term Impacts of S&E Activity](#), provides an additional conceptually valid way of estimating the impact of innovation through its effect on productivity (Hall 2011). Practically, the effort involved in coordination of the data across countries means that updating the statistics takes place infrequently; the World Bank provides MFP data for over 160 countries, but the most recent data year available is 2018 (Dieppe, Celik, and Kindberg-Hanlon 2021). However, as a growth indicator, MFP is influenced by the size of the economic base; thus, low- and middle-income countries tend to display more rapid MFP growth compared with higher-income countries.

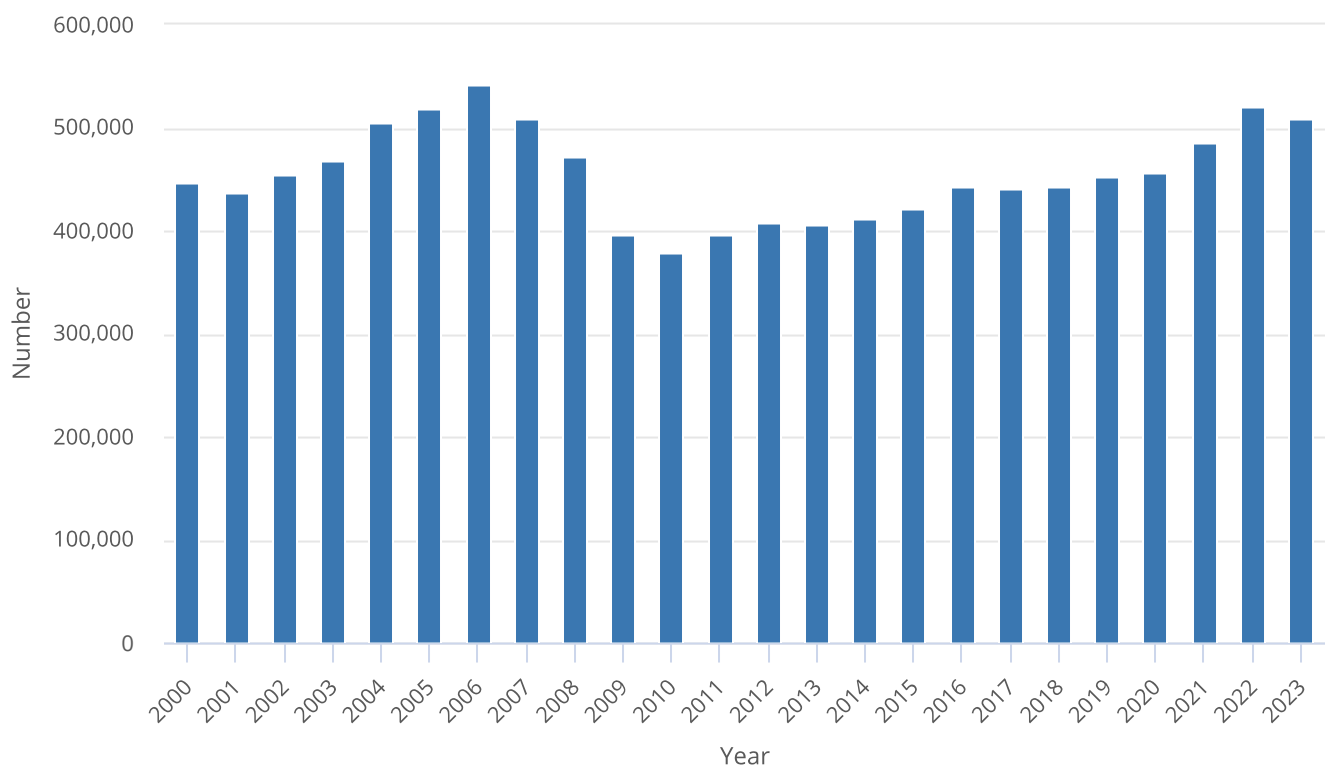
Business Dynamics and Investment

Startups and Small Business Innovation Research

Business Dynamics Statistics

Startups (firms less than 1 year old) are major drivers of job growth and innovation in the United States (Audretsch et al. 2020; Decker et al. 2014; Kane 2010; NASEM 2022). Figure TRN-25 presents the number of new firms created each year between 2000 and 2023. Firm creation peaked in 2006 at 541,000 and declined in subsequent years during the global financial crisis of 2007–09. Since 2010 and through the COVID-19 pandemic, firm creation has continued trending upward, reaching 521,000 in 2022 and declining slightly to 509,000 in 2023, both still short of the 2006 peak.

Figure TRN-25. Annual economywide business startups: 2000–23



Note(s):

Business startups are firms created within the last 12 months.

Source(s):

Census Bureau, Business Dynamics Statistics, firm age data through 2023, available at <https://www.census.gov/data/datasets/time-series/econ/bds/bds-datasets.html>, accessed February 2026.

Science and Engineering Indicators

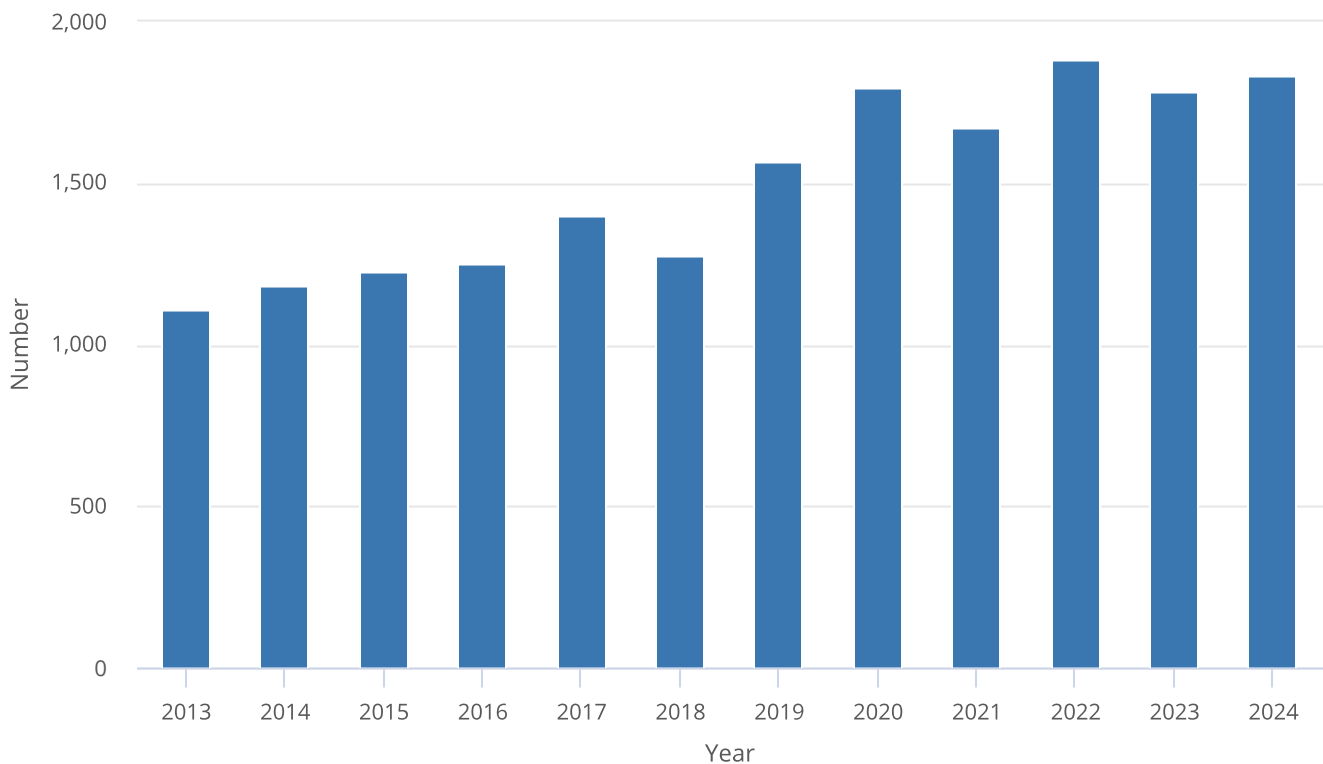
Small Business Innovation Research

The Small Business Innovation Research (SBIR) and the Small Business Technology Transfer (STTR) programs are long-standing federal programs designed to enhance small businesses' capacity to innovate and commercialize products. SBIR was created through the Small Business Innovation Development Act of 1982 (P.L. 97-219) and aims to "stimulate technological innovation in the U.S. economy through the investment of federal research and development (R&D) funds into innovative high-tech US small businesses" (SBA 2025a). STTR was created through the Small Business Research and

Development Enhancement Act of 1992 (P.L. 102-564) and serves a similar purpose but focuses its support on “small businesses that pursue technological innovation through cooperative research and development with nonprofit scientific and educational research institutions” (SBA 2025a). Both programs consist of three phases: Phase I provides funding for feasibility studies; Phase II provides additional funding for R&D; and Phase III focuses on commercialization and provides no SBIR or STTR funding, although participants can pursue outside funding (NASEM 2022).

Federal agencies with over \$100 million in R&D expenditures are required to spend 3.2% of their extramural research budget on their SBIR programs, and those with over \$1 billion in R&D spending per year must also operate an STTR program, with funding set at 0.45% of that agency’s extramural budget (SBA 2023).⁵ Currently, 11 agencies operate SBIR or STTR programs. In 2024, 1,835 firms received Phase II SBIR or STTR awards, a slight increase from 2023 and in line with the upward trend over the last decade (Figure TRN-26) (SBA 2025b). Since 2013, DOD has provided awards to the largest share of small businesses, followed by HHS (Figure TRN-27).

Figure TRN-26. Firms receiving Phase II SBIR or STTR awards: 2013–24



SBIR = Small Business Innovation Research; STTR = Small Business Technology Transfer.

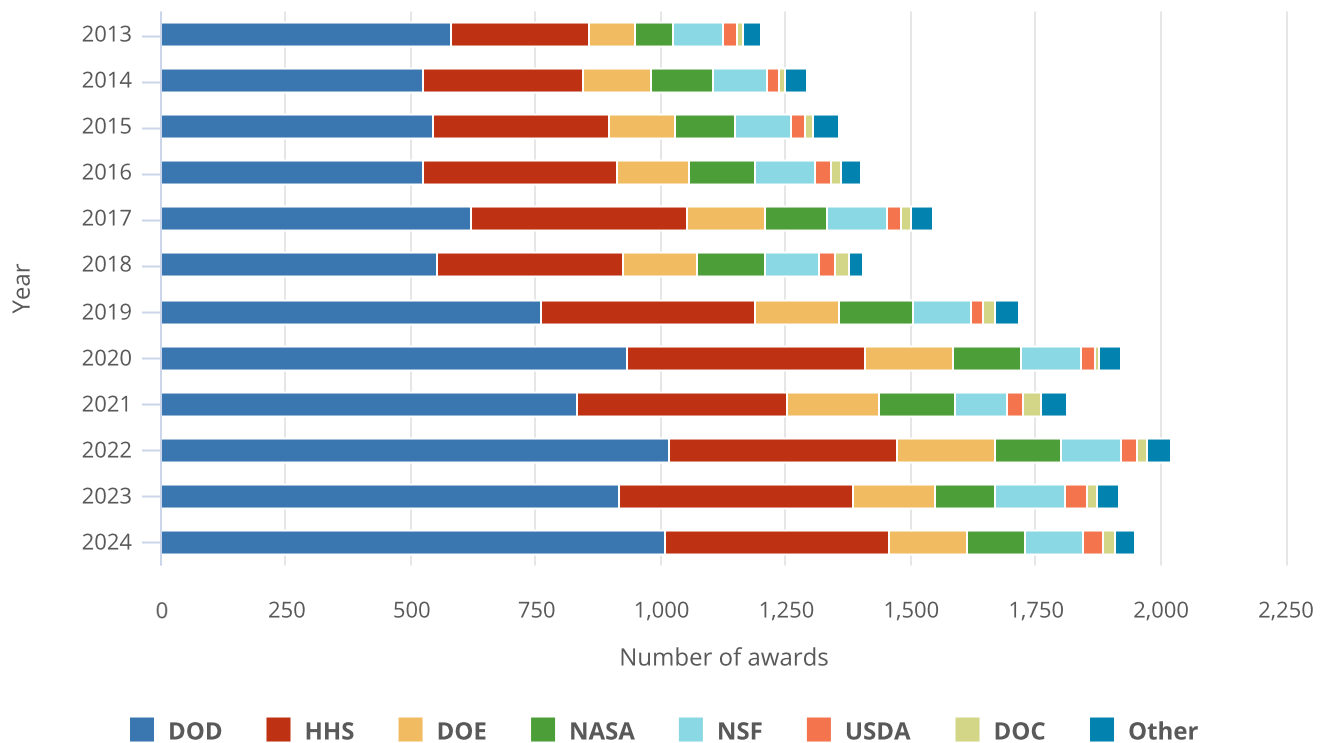
Note(s):

Firms receiving multiple SBIR or STTR Phase II awards in the same year are counted only once for that year.

Source(s):

Small Business Administration, SBIR/STTR Award database, accessed October 2025.

Figure TRN-27. Firms receiving Phase II SBIR or STTR awards, by awarding agency: 2013–24



DOC = Department of Commerce; DOD = Department of Defense; DOE = Department of Energy; HHS = Department of Health and Human Services; NASA = National Aeronautics and Space Administration; NSF = National Science Foundation; SBIR = Small Business Innovation Research; STTR = Small Business Technology Transfer; USDA = Department of Agriculture.

Note(s):

"Other" includes awards from the Department of Education, Department of Homeland Security, Department of Transportation, and Environmental Protection Agency.

Source(s):

Small Business Administration, SBIR/STTR Award database, accessed October 2025.

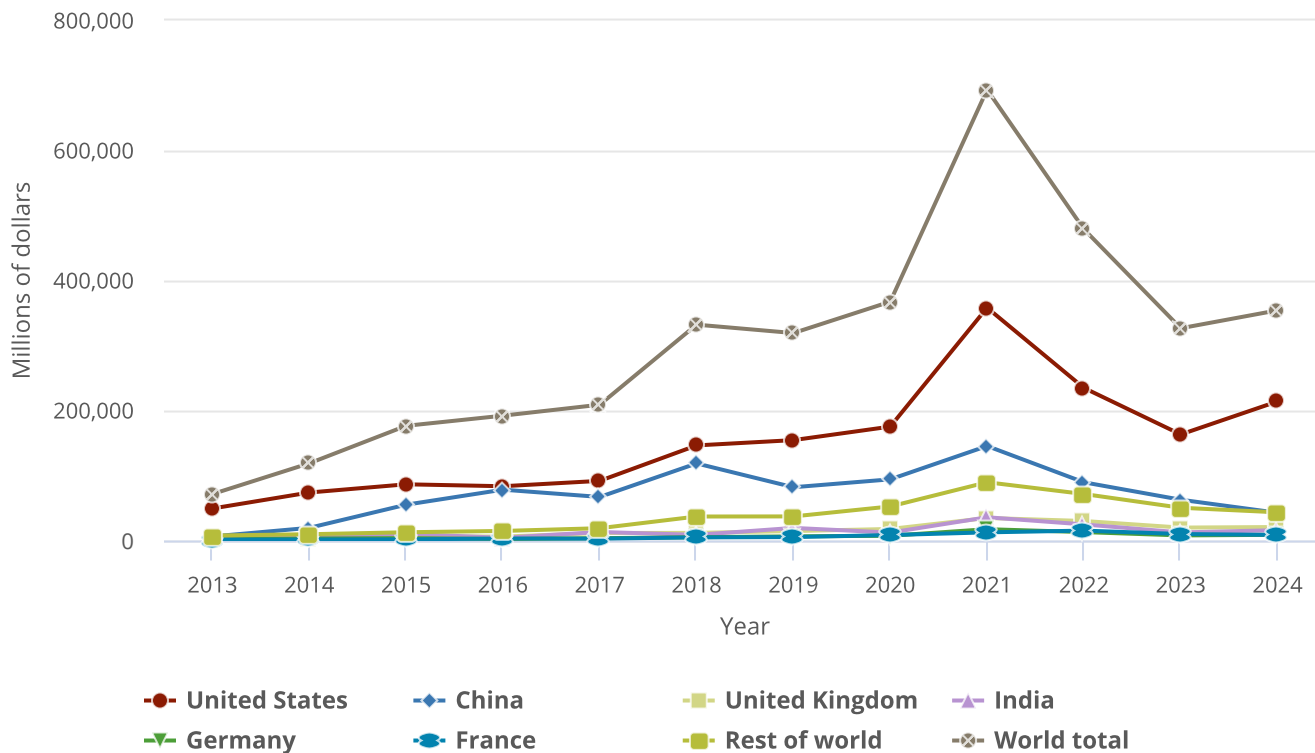
Science and Engineering Indicators

Venture Capital

Although VC funds only a small share of new private firms and provides a small share of overall funding compared with the overall U.S. private-sector investments, the size and number of investments are indicators of innovation activity because they fund a disproportionate number of pre-revenue companies that ultimately make public offerings (Lerner and Nanda 2020). Venture investors secure capital from large institutional investors, called *limited partners* (e.g., pension funds, university endowments, private equity funds, foundations), to invest in selected firms. VC-backed firms that become publicly traded are more likely to have recorded R&D expenditures compared with publicly traded firms that were not originally venture backed (Lerner and Nanda 2020).

Between 2013 and 2021, worldwide VC investments grew from \$71 billion to \$694 billion before decreasing (53%) over the next 2 years to \$327 billion in 2023. In 2024, worldwide VC investment increased to \$354 billion (Figure TRN-28; Table STRN-37). The countries with the largest VC investments that year—the United States, China, the United Kingdom, India, Germany—each received its highest level of VC investment in 2021. Similar reporting also finds a peak in U.S. VC investment in 2021 (NVCA 2025). Between 2013 and 2024, firms in the United States consistently received the largest amount of VC investment. At their highest value in 2021, U.S. firms (\$358 billion) received over twice the investment of firms headquartered in China (\$145 billion). For a discussion of PitchBook’s international coverage, see the [Technical Appendix](#).

Figure TRN-28. Venture capital investment received by firms headquartered in selected regions, countries, and economies: 2013–24



Note(s):

Data include capital from deals completed by access date, including investments at seed, early stage, and late stage. See Table STRN-37 for additional countries. China includes Hong Kong.

Source(s):

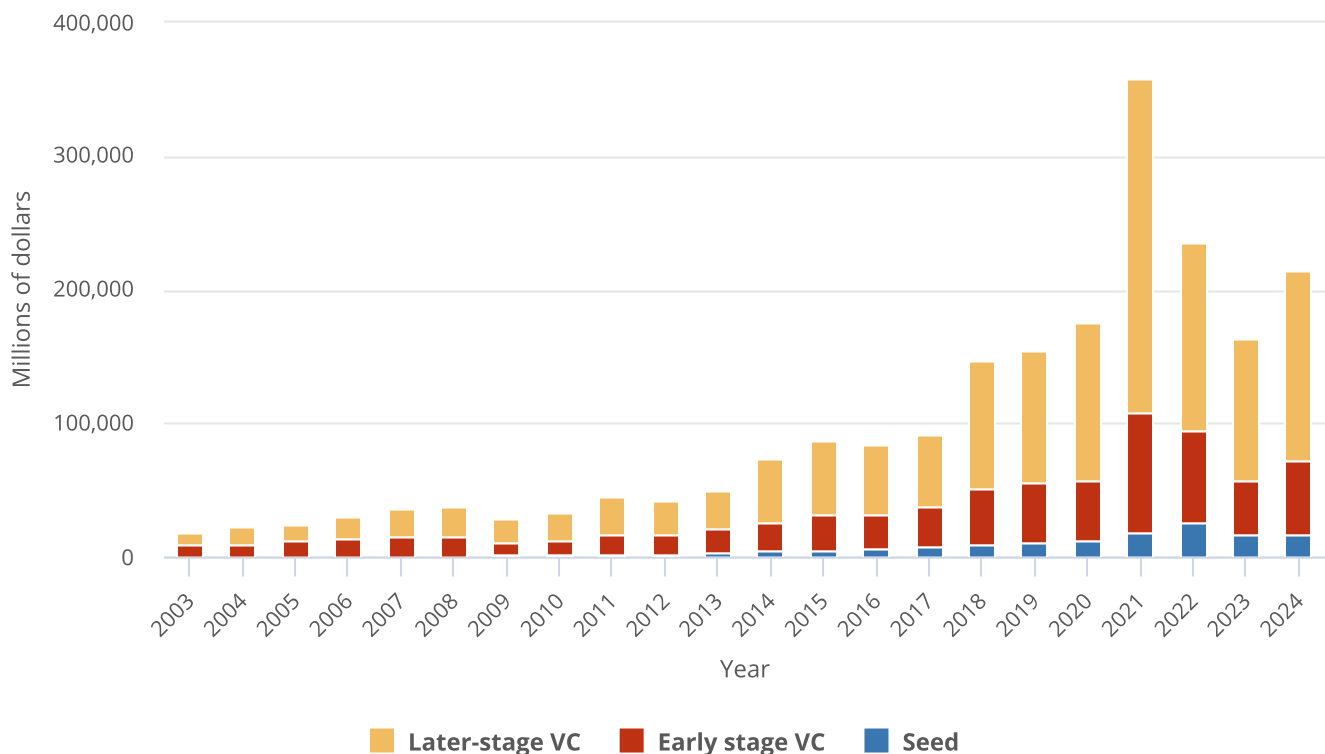
PitchBook, venture capital and private equity database, special tabulations, accessed May 2025.

Science and Engineering Indicators

VC funding generally consists of three stages of investment: seed stage, early stage, and later stage. Seed investment refers to the initial capital raised by a firm, often in exchange for equity in the company, from investors to support product development, staffing, and validation of a business model (Metrick and Yasuda 2021). In early stage investments, firms have typically entered development phases, with an existing product in testing, pilot production, or early release, and may be for 3 or fewer years (Metrick and Yasuda 2021). Later-stage VC generally invests in firms in their initial expansion or in a stable growth stage when they have an established product inventory and distribution system (Metrick and Yasuda 2021). Because seed-stage and early stage firms have a high rate of failure, venture investors deploy capital across a portfolio of these firms, expecting that one successful investment will compensate for those that yield no returns (Lerner and Nanda 2020).

Over half of VC investments in U.S. firms between 2003 and 2024 involved later-stage VC funding (Figure TRN-29). Early stage and later-stage VC funding followed a similar pattern to overall trends, growing from 2003 to a peak in 2021 before decreasing until 2024, while seed-stage VC peaked in 2022. Although seed-stage VC funding increased from \$11 billion to \$18 billion and early stage funding increased from \$45 billion to \$89 billion from 2020 to 2021, the peak in 2021 was driven by later-stage funding, which more than doubled from \$118 billion to \$251 billion and comprised 70% of VC investments that year. The share of early stage VC funding has gradually decreased, from 46% of VC funding in 2003 to 26% in 2024. The share of seed-stage VC funding has gradually increased from 0.5% in 2003 (\$95 million) to 11% and \$25 billion in 2022 before only a moderate decrease to 7% in 2024. However, the share of later-stage VC funding has also gradually expanded, from 53% in 2003 to 67% (\$142 billion) in 2024.

Figure TRN-29. Venture capital investment received by firms headquartered in the United States, by deal stage: 2003–24



VC = venture capital.

Note(s):

Deal stage is the stage as reported, based on the maturity of the firm receiving the venture investment. Data include capital from deals completed by access date. Definitions of deal stage are as follow. *Seed*: A deal is classified as seed if it is explicitly labeled so per a reliable source or when a company does not have prior VC rounds, does not have VC board members, and the round amount is between 1 million and 10 million U.S. dollars or euros. Pre-seed and pre-Series A deals are built as seed rounds when the company does not have prior VC backing. Otherwise, these deals will be built as early stage or later-stage rounds. *Early stage*: For a deal to be classified as early stage VC, the company must be founded fewer than 5 years by the time of the deal, and if a series is specified, it should be a Series A or Series B. *Later stage*: For a deal to be classified as later-stage VC, the company must be 5 years old or older regardless of series. Alternatively, if a series is specified, it should be a Series C or later regardless of time since founded. Angel investments and other pre-seed investments are omitted.

Source(s):

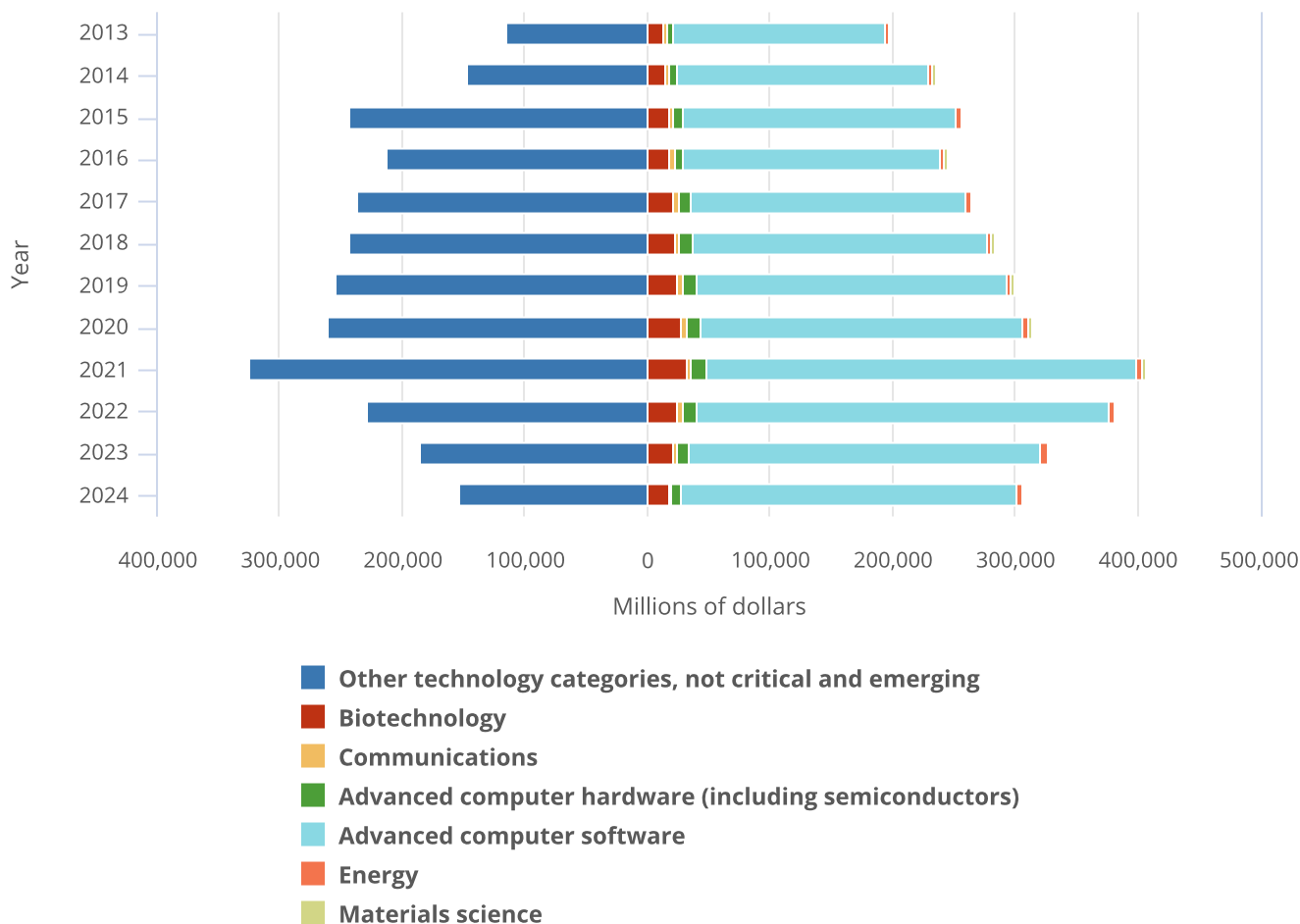
PitchBook, venture capital and private equity database, special tabulations, accessed May 2025.

Science and Engineering Indicators

VC investments can support firms developing CETs in the United States. The classification of CET areas developed by NSF TIP (see section [Technology Transfer Metrics](#)) was used to examine the share of VC investments funding these technologies in the United States (NSB 2024). Each year from 2013 to 2024, over half of all VC investments in the United States funded firms in CET areas, ranging between 52% and 67% (Figure TRN-30). (VC does fund a broader range of industries; see Table

STRN-38.) VC investments in U.S. firms developing computer software consistently accounted for the largest share among all CET areas between 2013 and 2024, receiving over 80% of VC funding in CET areas and between 44% and 59% of all U.S. VC funding each year (Figure TRN-30). VC tends to fund software publishing or other industries with “large uncertainty about an idea’s potential that can nonetheless be resolved quickly” (Lerner and Nanda 2020). This observation may contextualize the differences in the share of VC invested in software publishing in the United States and the share of software publishing within total KTI nonmanufacturing value added in the United States (see the section U.S. Industries).⁶ VC funding for U.S. companies developing computer software peaked at \$352 billion in 2021 and was \$274 billion in 2024.

Figure TRN-30. Firms headquartered in the United States receiving venture capital investment, by critical and emerging technologies: 2013–24



Note(s):

Critical and emerging technology categories are aggregates of PitchBook Primary Industry Codes based on the National Science Foundation Directorate for Technology, Innovation and Partnerships (TIP) classification of critical and emerging technologies (see <https://www.nsf.gov/tip/emerging-technology>), with the exception that Advanced computer hardware & software is split into Advanced computer hardware (including semiconductors) and Advanced computer software. See Table STRN-38 for capital marked critical and emerging technology and not relevant to critical and emerging technology and for capital sorted by industry.

Source(s):

PitchBook, venture capital and private equity database, special tabulations, accessed May 2025.

Biotechnology received the next-largest share of VC funding among CET areas, from 2013 to 2024, accounting for between 6% and 9% each year. VC funding for U.S. firms engaged in developing and producing biotechnology products and services peaked at \$32 billion in 2021 and was \$17 billion in 2024. VC investments in U.S. firms developing and producing computer hardware, a CET area that includes semiconductors, also reached their highest level in 2021 at \$12 billion and have since decreased to \$8 billion in 2024. [Table TRN-5](#) shows the 20 U.S.-based companies with the highest amount of VC raised in 2024. Many firms on this list strongly feature AI components in their offered products or services, including the top 5 firms: xAI, Databricks, Anthropic, OpenAI, and Waymo.

Table TRN-5. Top venture capital–funded firms headquartered in the United States: 2024

(Millions of dollars)

Entity	Capital invested
xAI	12,135
Databricks	10,230
Anthropic	8,000
OpenAI	6,600
Waymo	5,600
Juul Labs	1,984
Anduril Industries	1,500
Epic Games	1,500
CoreWeave	1,100
Cohesity	1,100
Safe Superintelligence	1,000
Wiz	1,000
Wonder Group	950
Pacific Fusion	900
Perplexity AI	885
Fervo Energy	743
Tenstorrent	700
Cyera	686
Groq	686
Crusoe	686

Note(s):

Data include capital from deals completed by access date, including investments at seed, early stage, and later stage.

Source(s):

PitchBook, accessed November 2025.

Science and Engineering Indicators

Production Patterns of Knowledge- and Technology-Intensive Industries

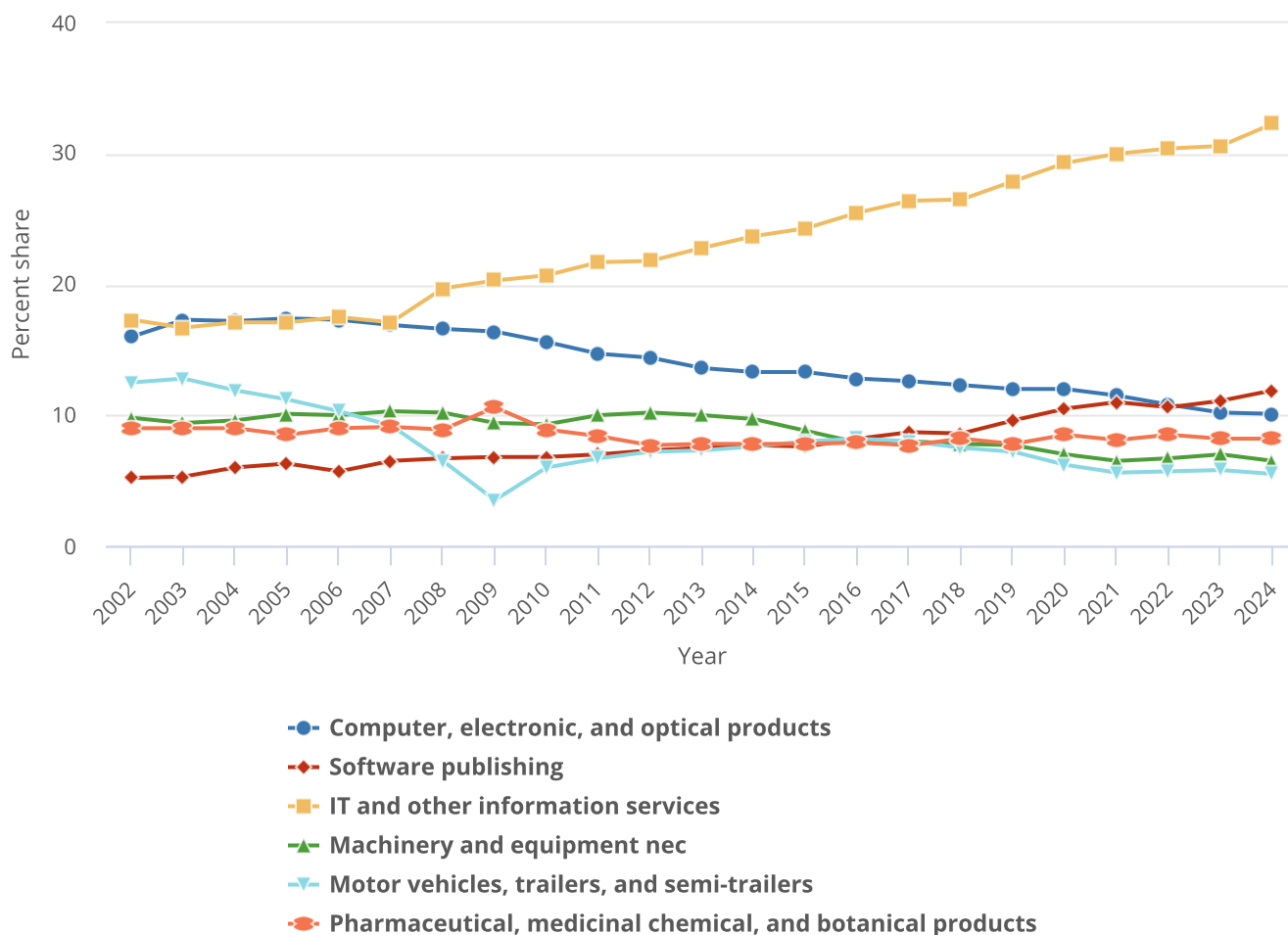
KTI industries are defined as those with high and medium-high R&D intensities based on an internationally comparable taxonomy developed by the OECD (2016) using the International Standard Industrial Classification of All Economic Activities (ISIC) (see the [Glossary](#) section for definitions). KTI industries include 10 industries in manufacturing and 3 industries in services (for a list of industries, see Table STRN-39).⁷ KTI industries compete globally, often in sectors characterized by technological disruption and complex supplier networks and supply chains, including those for critical minerals and materials, energy, technology, and labor (Baldwin and Freeman 2021; Bontadini et al. 2024; Cerdeiro et al. 2021; CRS 2022; Goldberg and Reed 2023; IMF 2025). KTI industries are important funders and performers of R&D, produce high-value products and services and intangible assets, and contribute to national economic competitiveness in global markets shaped by the macroeconomic and foreign affairs policies of national governments. Multinational enterprises and other firms in these industries participate in trade, investment, and other global value chain (GVC) activities that support and are influenced by national economic growth and innovation. This section covers trends in output and international trade by KTI industries. KTI output is measured as the value of goods and services (*gross output*) minus the cost of *intermediate inputs* (energy, materials, and purchased services)—henceforth, value added. KTI output and trade patterns illustrate some of the impacts of technology activities and related investments discussed earlier in this report and in other *Indicators 2026* reports.

U.S. Industries

The U.S. economy is service intensive; manufacturing makes up a relatively small share of GDP when compared to many international economies.⁸ Partly because of this, and because most KTI industries are in the manufacturing sector given their high R&D intensity, U.S. KTI manufacturing comprises a relatively small share of its GDP. In 2024, value added to goods and services within U.S. KTI industries totaled \$3.3 trillion in current U.S. dollars and accounted for 11% of U.S. GDP, a share little changed since 2002 (BEA 2025a) (see Table STRN-40, Table STRN-41).⁹

Notably, the share of KTI services industries that contribute to total U.S. KTI value added increased, from about 30% in 2002 to just over half in 2024, led by increases in information technology (IT) and other information services and in software publishing production (Figure TRN-31; Table STRN-40). The IT and other information services industry has been the largest U.S. KTI industry by value added in current dollars since 2006, growing from 17% in that year to 32% in 2024 (Figure TRN-31). Pharmaceutical, medicinal chemical, and botanical product manufacturing (including pharmaceutical biotechnology) has accounted for between 8% and 11% of total KTI value added, whereas motor vehicles, trailers, and semi-trailers manufacturing has steadily decreased as a share from 13% in 2002 to 5% in 2024. Computer and components manufacturing in a global context and trends in semiconductor production are discussed in the section [Sectoral and Industry Distributions](#) and the section [Global Semiconductor Production](#).

Figure TRN-31. Industry share of U.S. total KTI value added, by selected industries: 2002–24



IT = information technology; KTI = knowledge and technology intensive; nec = not elsewhere classified.

Note(s):

Value added is the value of goods and services (gross output) minus the cost of intermediate inputs (energy, materials, and purchased services). Industry value added is a measure of an industry's contribution to overall gross domestic product. KTI industries include high R&D intensive and medium-high R&D intensive industries based on a classification by the Organisation for Economic Co-operation and Development. The data have been crosswalked to the International Standard Industrial Classification of All Economic Activities, Revision 4.

Source(s):

S&P Global Market Intelligence, Comparative Industry Service special tabulations, April 2025.

Science and Engineering Indicators

Industries in the Global Economy

In 2024, KTI value-added manufacturing and services industries worldwide totaled \$11.7 trillion in current dollars, a 4.2% increase from 2023 (Table TRN-6); this change is similar to the 4.1% in current-dollar global GDP (IMF 2025). The country share of KTI value added to GDP (or KTI production intensity) has remained relatively stable for large global economies (Table STRN-42). Among these economies, South Korea has the highest KTI production intensity, about 20% of GDP since at least 2011, followed by China (between 15% and 16% since 2002), Germany (between 14% and 16% since 2010), and the

United States (about 10% from 2002 to 2019; 11% since 2020). Globally, KTI value added has accounted for between 10% and 11% of GDP, with 3%–4% from KTI services industries and 7%–8% from KTI manufacturing industries ([Table TRN-6](#)). Overall, services represent a larger share of global GDP compared with manufacturing; within KTI industries globally, however, services value added has a smaller share compared with manufacturing.

Table TRN-6. Global KTI industries, by value added and share of global GDP: 2018–24

(Billions of dollars, percent change, and share of global GDP)

Industry	ISIC, Rev.4, industry code	Billions of dollars							Percent change						Share of global GDP						
		2018	2019	2020	2021	2022	2023	2024	2019	2020	2021	2022	2023	2024	2018	2019	2020	2021	2022	2023	2024
GDP		86,497	87,772	85,519	97,403	101,409	105,685	110,065	1.5	-2.6	13.9	4.1	4.2	4.1	100.0	100.0	100.0	100.0	100.0	100.0	100.0
All manufacturing		13,908	13,753	13,413	15,926	16,576	16,787	16,941	-1.1	-2.5	18.7	4.1	1.3	0.9	16.1	15.7	15.7	16.4	16.3	15.9	15.4
Total private services		38,134	38,958	38,129	43,120	44,495	46,927	49,332	2.2	-2.1	13.1	3.2	5.5	5.1	44.1	44.4	44.6	44.3	43.9	44.4	44.8
All KTI industries		9,057	9,069	9,091	10,604	10,815	11,238	11,714	0.1	0.2	16.6	2.0	3.9	4.2	10.5	10.3	10.6	10.9	10.7	10.6	10.6
KTI manufacturing		6,457	6,319	6,286	7,379	7,480	7,634	7,783	-2.1	-0.5	17.4	1.4	2.1	2.0	7.5	7.2	7.3	7.6	7.4	7.2	7.1
Chemicals and chemical products	20	1,081	1,032	1,025	1,231	1,264	1,271	1,238	-4.5	-0.6	20.1	2.7	0.6	-2.6	1.2	1.2	1.2	1.3	1.2	1.2	1.1
Pharmaceutical, medicinal chemical, and botanical products	21	668	669	731	875	910	923	966	0.2	9.3	19.6	4.0	1.4	4.7	0.8	0.8	0.9	0.9	0.9	0.9	0.9
Weapons and ammunition	252	38	40	41	47	49	53	57	4.3	2.8	13.6	5.0	7.2	8.3	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Computer, electronic, and optical products	26	1,241	1,212	1,250	1,458	1,470	1,407	1,488	-2.4	3.2	16.6	0.8	-4.3	5.7	1.4	1.4	1.5	1.5	1.4	1.3	1.4
Electrical equipment	27	657	655	668	790	823	875	898	-0.3	2.0	18.2	4.1	6.3	2.6	0.8	0.7	0.8	0.8	0.8	0.8	0.8
Machinery and equipment nec	28	1,163	1,140	1,143	1,348	1,295	1,317	1,324	-2.0	0.2	18.0	-3.9	1.7	0.5	1.3	1.3	1.3	1.4	1.3	1.2	1.2
Motor vehicles, trailers, and semi-trailers	29	1,076	1,033	934	1,076	1,094	1,167	1,170	-4.0	-9.7	15.3	1.6	6.7	0.2	1.2	1.2	1.1	1.1	1.1	1.1	1.1
Air and spacecraft and related machinery	303	244	250	210	228	238	275	292	2.8	-16.1	8.6	4.4	15.6	5.9	0.3	0.3	0.2	0.2	0.2	0.3	0.3
Railroad, military vehicles, and transport equipment nec	30X	111	113	106	127	130	133	137	1.2	-5.6	19.7	1.8	2.5	3.4	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Medical and dental instruments and supplies	325	176	174	176	198	206	212	213	-0.8	1.3	12.4	3.9	2.8	0.7	0.2	0.2	0.2	0.2	0.2	0.2	0.2
KTI services		2,600	2,750	2,805	3,225	3,335	3,604	3,931	5.7	2.0	15.0	3.4	8.1	9.1	3.0	3.1	3.3	3.3	3.3	3.4	3.6
Software publishing	582	286	323	358	415	422	467	527	13.2	10.6	16.1	1.5	10.8	12.8	0.3	0.4	0.4	0.4	0.4	0.4	0.5
IT and other information services	62–63	1,585	1,673	1,721	1,974	2,055	2,230	2,446	5.6	2.9	14.7	4.1	8.5	9.7	1.8	1.9	2.0	2.0	2.0	2.1	2.2
Scientific R&D services	72	730	753	726	836	859	908	959	3.2	-3.6	15.1	2.7	5.6	5.7	0.8	0.9	0.8	0.9	0.8	0.9	0.9

GDP = gross domestic product; ISIC, Rev.4 = International Standard Industrial Classification of All Economic Activities, Revision 4; IT = information technology; KTI = knowledge and technology intensive; nec = not elsewhere classified.

Note(s):

Value added is the value of goods and services (gross output) minus the cost of intermediate inputs (energy, materials, and purchased services). KTI industries include high R&D intensive and medium-high R&D intensive industries based on a classification by the Organisation for Economic Co-operation and Development. Total private services corresponds to main services in ISIC, Rev.4.

Source(s):

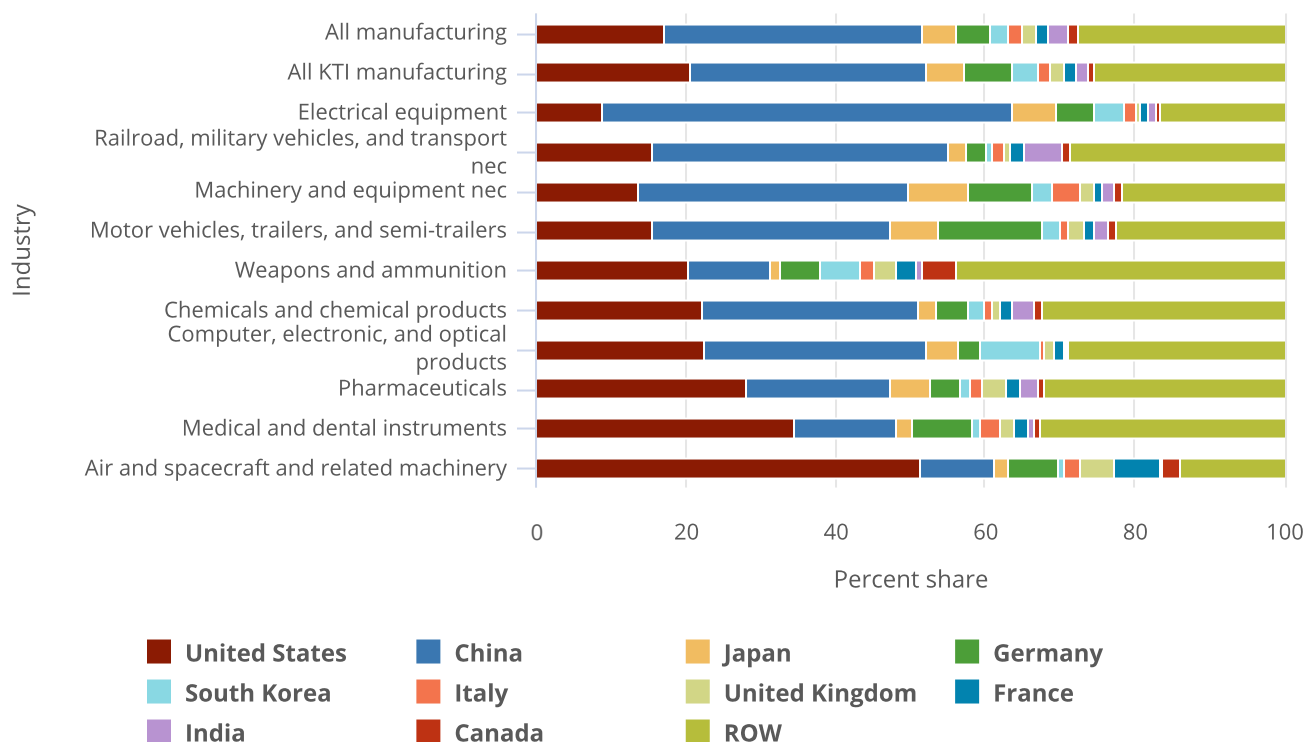
Value added data are from S&P Global Market Intelligence, Comparative Industry Service special tabulations, April 2025; GDP data are from International Monetary Fund World Economic Outlook, accessed April 2025 (available at <https://www.imf.org/en/Publications/WEO/weo-database/2023/October>), and Bureau of Economic Analysis, Industry Economic Accounts, accessed April 2025 (available at <https://www.bea.gov/itable/national-gdp-and-personal-income>).

Science and Engineering Indicators

The United States, China, the EU-27, Japan, and South Korea accounted for about 80% of global KTI value added in 2024 in current dollars (Table STRN-41, Table STRN-42). The United States and China were the top two producers of KTI output globally in 2024, with \$3.3 trillion (28%) and \$2.9 trillion (25%), respectively, followed by the EU-27, with \$2.1 trillion (18%). The EU-27 includes Germany, which accounted for about a third of the EU-27 share and 6% of global value added in 2024.

Global shares vary further by sector. China and the United States accounted for 31% and 21% of worldwide manufacturing KTI output in 2024, respectively (Figure TRN-32). These relative shares are consistent with the larger role of overall manufacturing in China’s value-added output compared with that of the United States. For KTI services output, the United States alone accounted for almost half (43%), followed by China (11%) (Figure TRN-33). South Korea had the highest KTI value added as a share of GDP in 2024 (21%).

Figure TRN-32. Country share of global KTI manufacturing value added, by KTI industry: 2024



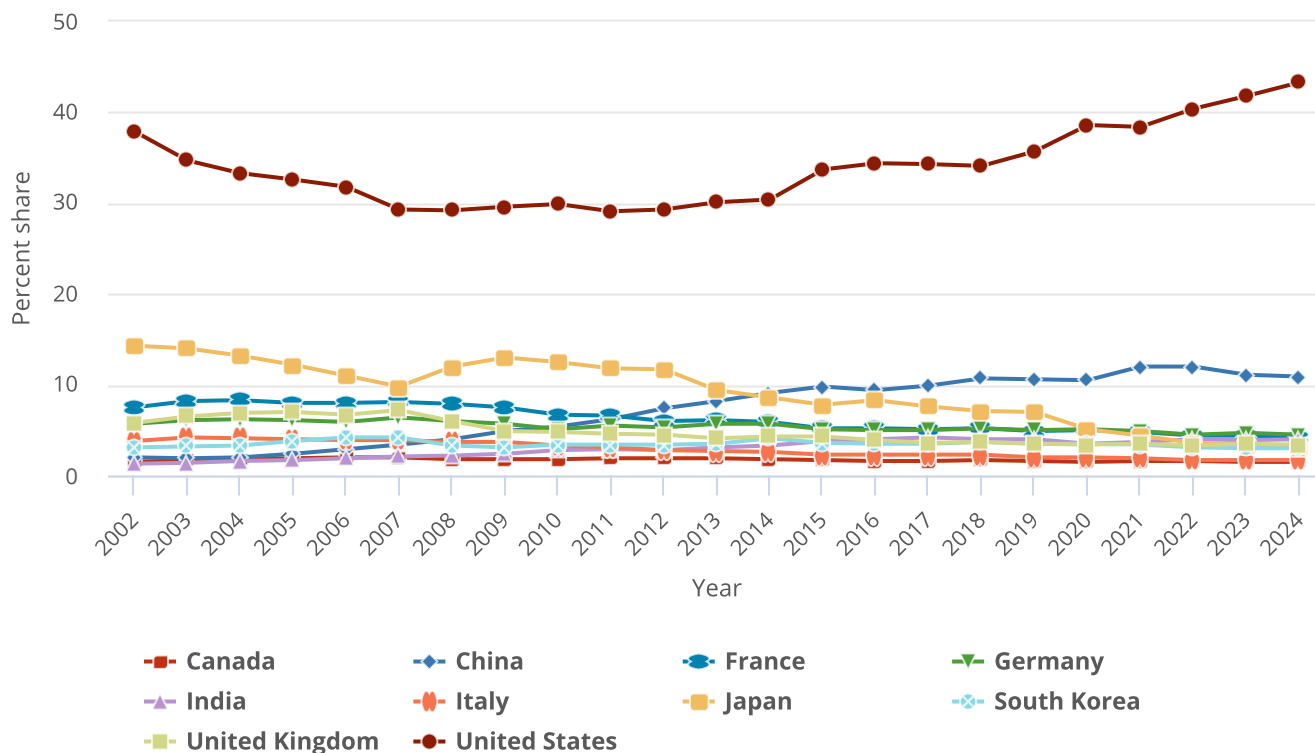
KTI = knowledge and technology intensive; nec = not elsewhere classified; ROW = rest of world.

Note(s):

Value added is the value of goods and services (gross output) minus the cost of intermediate inputs (energy, materials, and purchased services). KTI industries include high R&D intensive and medium-high R&D intensive industries based on a classification by the Organisation for Economic Co-operation and Development. Industry groups are at the top of the figure, and specific industries are sorted from smallest to largest based on the U.S. share. The United States is the first country listed, and the other countries are ordered from largest to smallest based on the share of all KTI manufacturing.

Source(s):

S&P Global Market Intelligence, Comparative Industry Service special tabulations, April 2025.

Figure TRN-33. Country share of global KTI services value added for selected regions, countries, or economies: 2002–24

KTI = knowledge and technology intensive.

Note(s):

Value added is the value of goods and services (gross output) minus the cost of intermediate inputs (energy, materials, and purchased services). KTI industries include high R&D intensive and medium-high R&D intensive industries based on a classification by the Organisation for Economic Co-operation and Development. KTI services industries include information technology and other information services, software publishing, and scientific R&D.

Source(s):

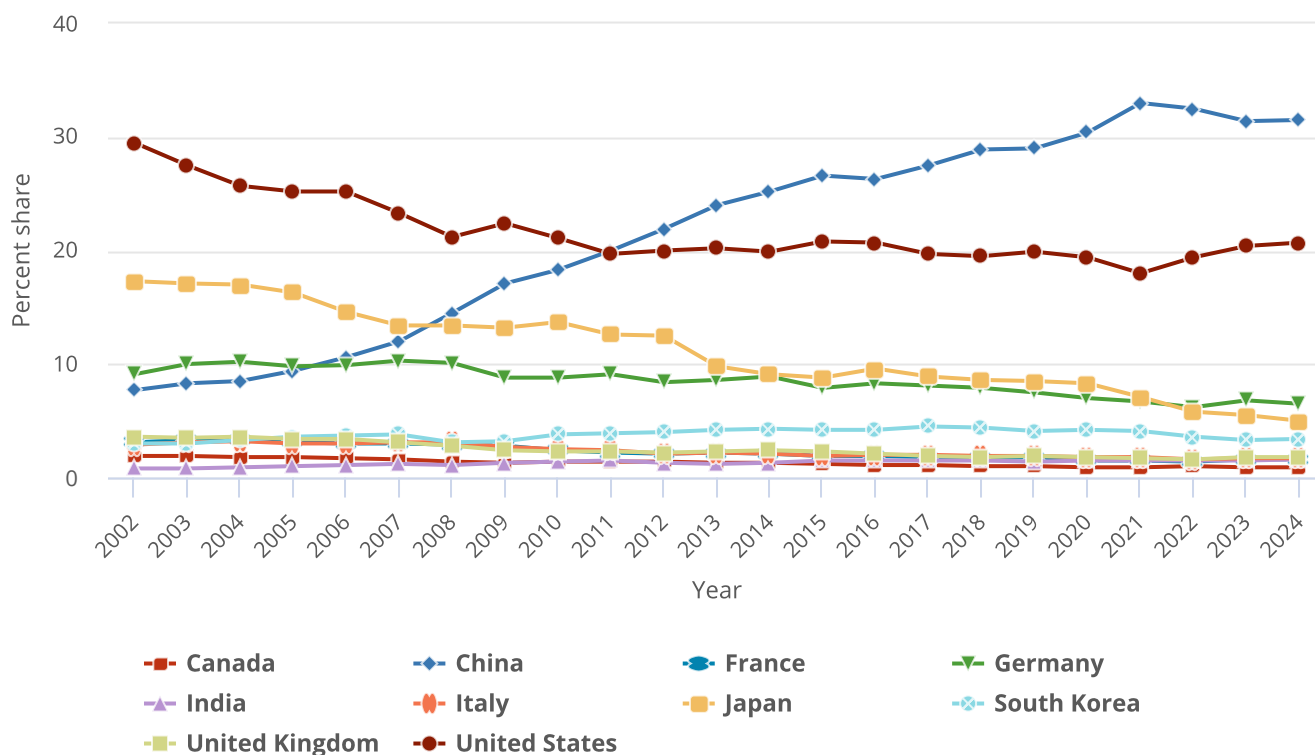
S&P Global Market Intelligence, Comparative Industry Service special tabulations, April 2025.

Science and Engineering Indicators

Sectoral and Industry Distributions

China has been the largest KTI manufacturer measured by value-added production since 2011 (31% share of the worldwide total in 2024) (Figure TRN-34), despite recent geopolitical and pandemic-related disruptions and ongoing global restructuring in trade and production supply chains (Alfaro and Chor 2023; IMF 2025:3–4, 8, 15, 18, 21). The long-term increase in China’s KTI manufacturing share was accompanied by declines in KTI manufacturing shares of the United States, Japan, and Germany (Figure TRN-34); see also Branstetter and Li (2022). Since 2011, the United States has accounted for around 20% of global manufacturing KTI value added (21% in 2024), compared with 25% in 2006 and about 30% in 2002. The shares of global manufacturing KTI value added for Japan and Germany also declined over this period; see also Baily, Bosworth, and Doshi (2020) and Baldwin (2024).

Figure TRN-34. Country share of global KTI manufacturing value added for selected regions, countries, or economies: 2002–24



KTI = knowledge and technology intensive.

Note(s):

Value added is the value of goods and services (gross output) minus the cost of intermediate inputs (energy, materials, and purchased services). KTI industries include high R&D intensive and medium-high R&D intensive industries based on a classification by the Organisation for Economic Co-operation and Development. KTI manufacturing industries include chemicals and chemical products; pharmaceuticals; weapons and ammunition; computer, electronic, and optical products; electrical equipment; machinery and equipment not elsewhere classified (nec); motor vehicles, trailers, and semi-trailers; air and spacecraft and related machinery; railroad, military vehicles, and transport nec; and medical and dental instruments.

Source(s):

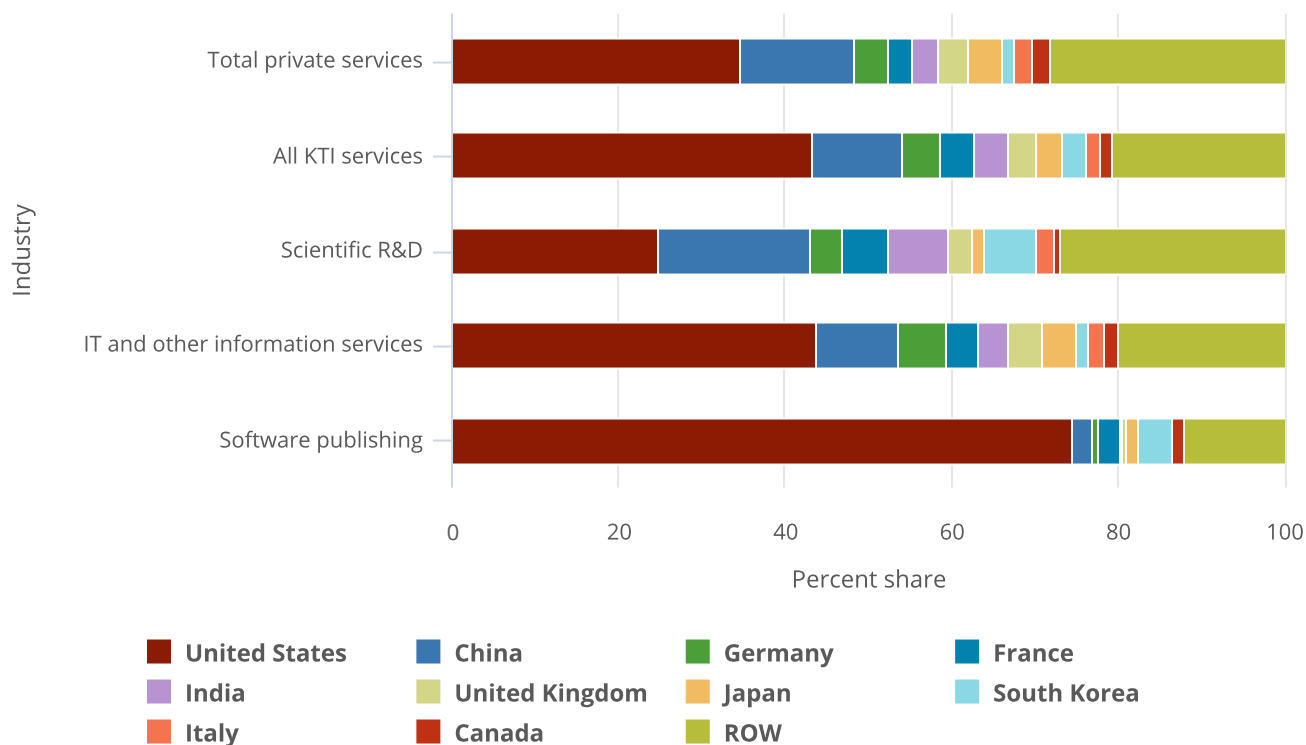
S&P Global Market Intelligence, Comparative Industry Service special tabulations, April 2025.

Science and Engineering Indicators

Even though China had the largest global share in total manufacturing and KTI manufacturing value added in 2024, the United States had the largest share in four KTI industries: air and spacecraft and related machinery (51%), medical and dental instruments (35%), pharmaceuticals (including pharmaceutical biotechnology) (28%), and weapons and ammunitions (20%) (Figure TRN-32). China accounted for the second-largest shares for all four industries. China continued to have the largest shares in the other six KTI manufacturing industries in 2024: electrical equipment (55%); railroad, military vehicles, and other transport equipment not elsewhere classified (nec), which includes military fighting vehicles (40%); machinery and equipment nec (36%); motor vehicles, trailers, and semi-trailers (which includes electric vehicles [EVs]) (32%); chemicals and chemical products (excluding pharmaceuticals) (29%); and computer, electronic, and optical products (including semiconductors) (30%).

The United States continues to be the top KTI services industries producer in 2024, with a 43% global share, with China second at 11% (Figure TRN-33). Within KTI services industries, the U.S. global share was largest for software publishing (75%), followed by IT and information services (44%) and then by scientific R&D services (25%) in 2024. For China, India, South Korea, and France, the largest global KTI services share was in scientific R&D services (18%, 7%, 6%, and 6%, respectively) (Figure TRN-35).

Figure TRN-35. Country share of global KTI services value added, by KTI industry: 2024



IT = information technology; KTI = knowledge and technology intensive; ROW = rest of world.

Note(s):

Value added is the value of goods and services (gross output) minus the cost of intermediate inputs (energy, materials, and purchased services). KTI industries include high R&D intensive and medium-high R&D intensive industries based on a classification by the Organisation for Economic Co-operation and Development. KTI services comprise scientific R&D, IT and other information services, and software publishing. Industry groups are at the top of the figure, and specific industries are sorted from smallest to largest based on the U.S. share. The United States is the first country listed, and the other countries are ordered from largest to smallest based on the share of all KTI services.

Source(s):

S&P Global Market Intelligence, Comparative Industry Service special tabulations, April 2025.

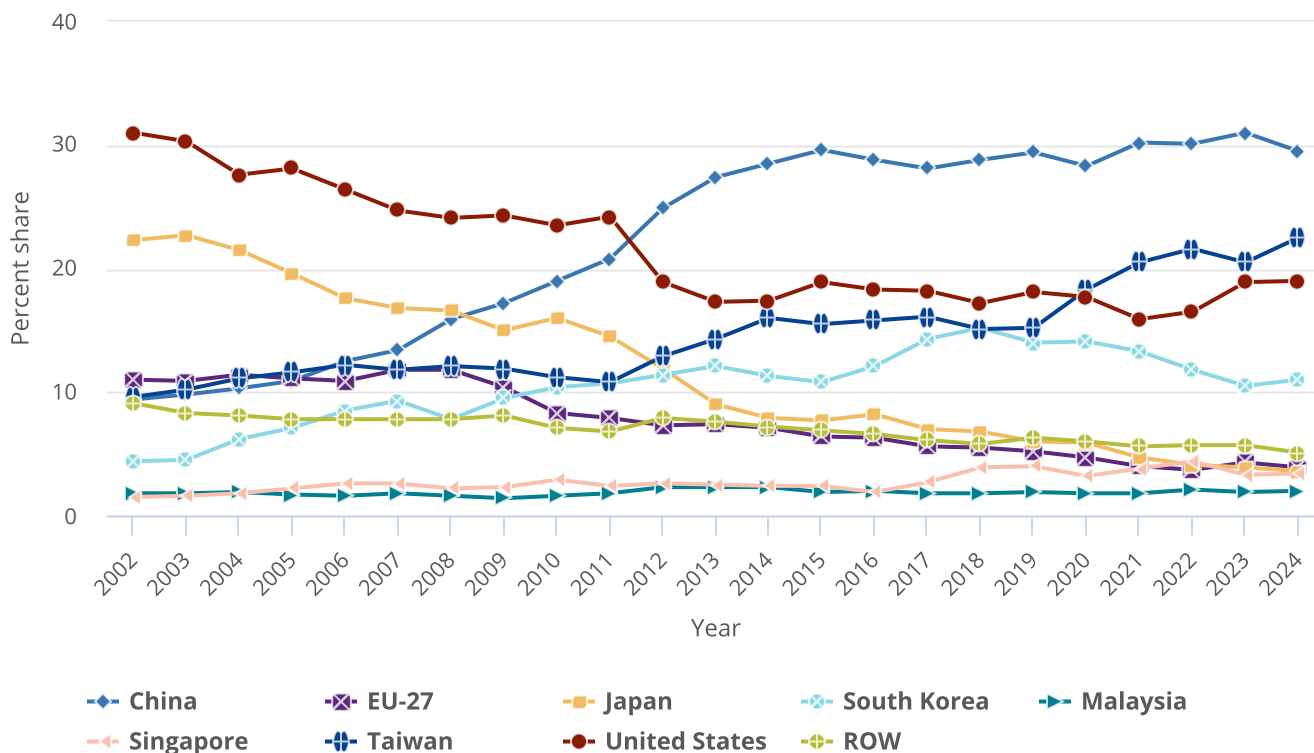
Science and Engineering Indicators

Global Semiconductor Production

Semiconductors (also called computer chips or microchips) are key enabling components of many CETs, such as AI, QIST, EVs, autonomous systems, robotics, advanced manufacturing, and defense and aerospace technologies, contributing to national and economic security (CRS 2020, 2023a; VerWey 2019). The CHIPS and Science Act of 2022 (NSTC 2025) appropriated \$52.7 billion to strengthen the U.S. semiconductor industry (CRS 2023a). Semiconductor production occurs along GVCs that include R&D, engineering, and design; fabrication; and assembly, testing, and packing stages (CRS 2023b). Modular production and cost advantages in Asia facilitated the separation of R&D and design and production stages starting in the late 1970s and early 1980s, with the emergence of semiconductor foundries in Taiwan and other Asian locations that had been established with foreign direct investment (CRS 2020; Yoffie 1993) or performing contract manufacturing for design-only companies (Kuan and West 2023). In 2002 and 2003, the United States and Japan together accounted for over half (53%) of value-added semiconductor production, with the EU-27 producing another 11% (Figure TRN-36). Since 2002,

China, Taiwan, and South Korea have substantially increased their shares of global value-added semiconductor production (Branstetter and Li 2023; CRS 2020; Torsekar and VerWey 2019). In 2024, just over half (52%) of global value-added semiconductor production occurred in China (30%) and Taiwan (22%), followed by the United States (19%) and South Korea (11%) (Figure TRN-36).

Figure TRN-36. Global share of value added for semiconductor manufacturing, by region, country, or economy: 2002–24



EU-27 = European Union; ROW = rest of world.

Note(s):

Value added is the value of goods and services (gross output) minus the cost of intermediate inputs (energy, materials, and purchased services). Semiconductor manufacturing refers to the industry Manufacture of electronic components and boards (International Standard Industrial Classification of All Economic Activities, Revision 4, 261), which includes the manufacture of semiconductors and other components for electronic applications.

Source(s):

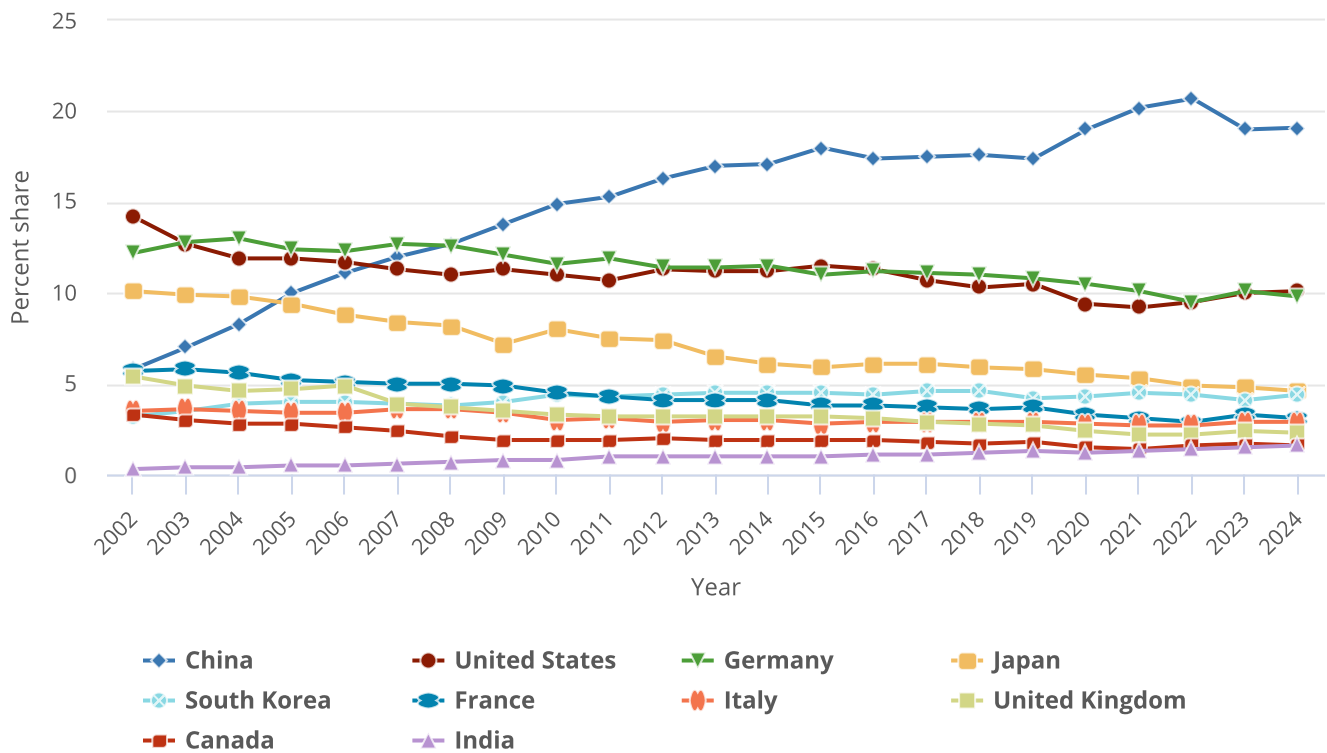
S&P Global Market Intelligence, Comparative Industry Service special tabulations, April 2025.

Global Trade by KTI Industries

International trade has long been recognized as a key conduit for knowledge and technology spillovers (Coe and Helpman 1995; Criscuolo, Haskel, and Slaughter 2010) as well as a factor in a country’s international competitiveness and productivity growth (Aghion and Howitt 2009; Baily, Bosworth, and Doshi 2020). Further, the trade patterns in KTI industries examined in this section reflect some of the output patterns examined in the previous section. Together, KTI output and trade patterns reflect and impact innovation activities in the business sector (Ambos et al. 2021; Autor et al. 2020; Ito et al. 2023; Jaax and Miroudot 2021).

Global goods exports rebounded by 2.2% in 2024, following a 3.7% decline in 2023. However, global KTI manufacturing goods exports were more resilient in 2023, declining by less than 1% and increasing by 3% in 2024 to \$11.7 trillion in current U.S. dollars (Table STRN-43). Since 2008, China has been the largest KTI manufacturing exporter globally, based on current U.S. dollars, with \$2.2 trillion and a global KTI goods share of 19.1% in 2024 (Figure TRN-37, Figure TRN-38). The United States and Germany were the next-largest KTI manufacturing exporters in 2024, with \$1.2 trillion and \$1.1 trillion in exports, respectively (Figure TRN-38; Table STRN-43). KTI manufacturing exports from China, Japan, and South Korea all declined in 2023 relative to exports in 2022, with India being the only major KTI manufacturing exporter in Asia to increase exports that year. In 2023, major KTI manufacturing exporters outside of Asia, including the United States, saw exports grow above 2022 levels.

Figure TRN-37. Country share of global KTI manufacturing exports for selected regions, countries, or economies: 2002–24



KTI = knowledge and technology intensive.

Note(s):

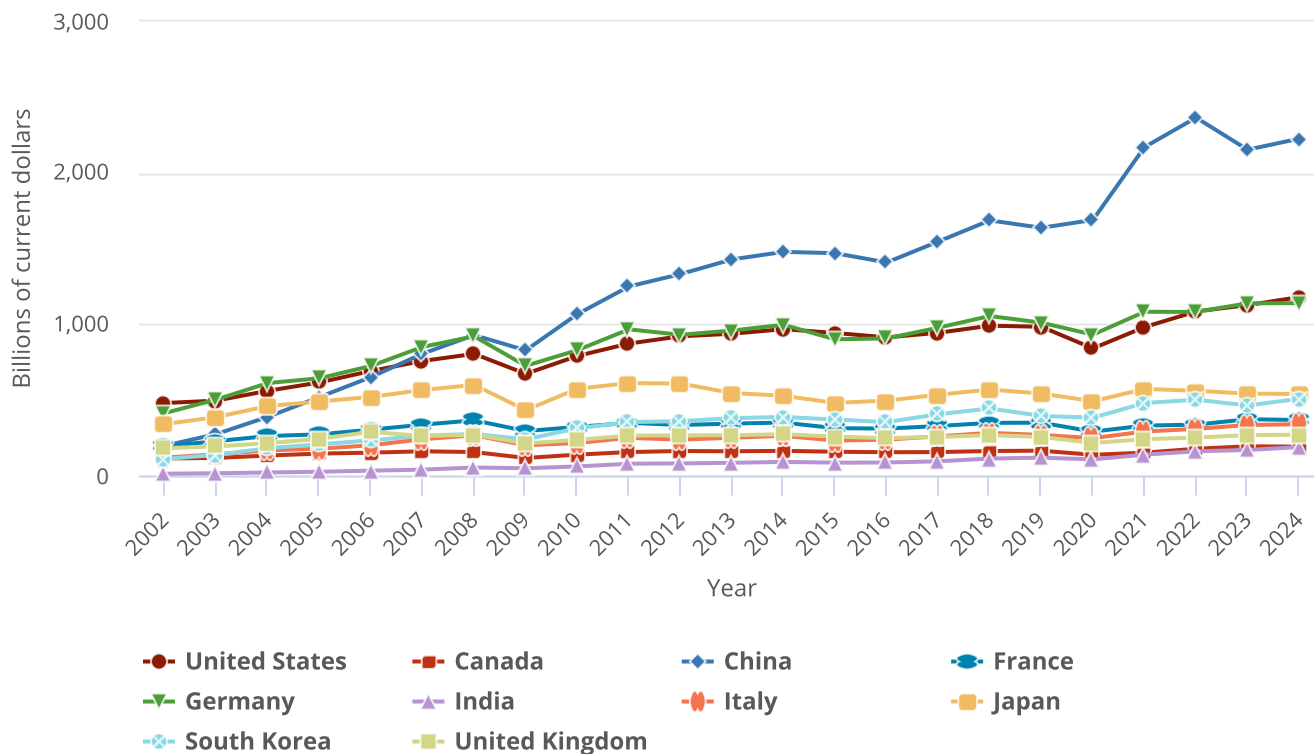
KTI manufacturing exports include exports from the following industries: chemicals and chemical products; pharmaceuticals; computer, electronic, and optical products; electrical equipment; machinery and equipment not elsewhere classified (nec); motor vehicles, trailers, and semi-trailers; air and spacecraft and related machinery; weapons and ammunition; and other transport equipment (the latter comprises railway locomotives and rolling stock manufacturing and transport equipment nec and military equipment manufacturing).

Source(s):

S&P Global Market Intelligence, Comparative Industry Service special tabulations, April 2025.

Science and Engineering Indicators

Figure TRN-38. Gross exports of KTI manufacturing industries for selected regions, countries, or economies: 2002–24



KTI = knowledge and technology intensive.

Note(s):

Data include trade for the following KTI industries: chemicals and chemical products; pharmaceuticals; computer, electronic, and optical products; electrical equipment; machinery and equipment not elsewhere classified (nec); motor vehicles, trailers, and semi-trailers; air and spacecraft and related machinery; weapons and ammunition; and other transport equipment (the latter comprises railway locomotives and rolling stock manufacturing and transport equipment nec and military equipment manufacturing).

Source(s):

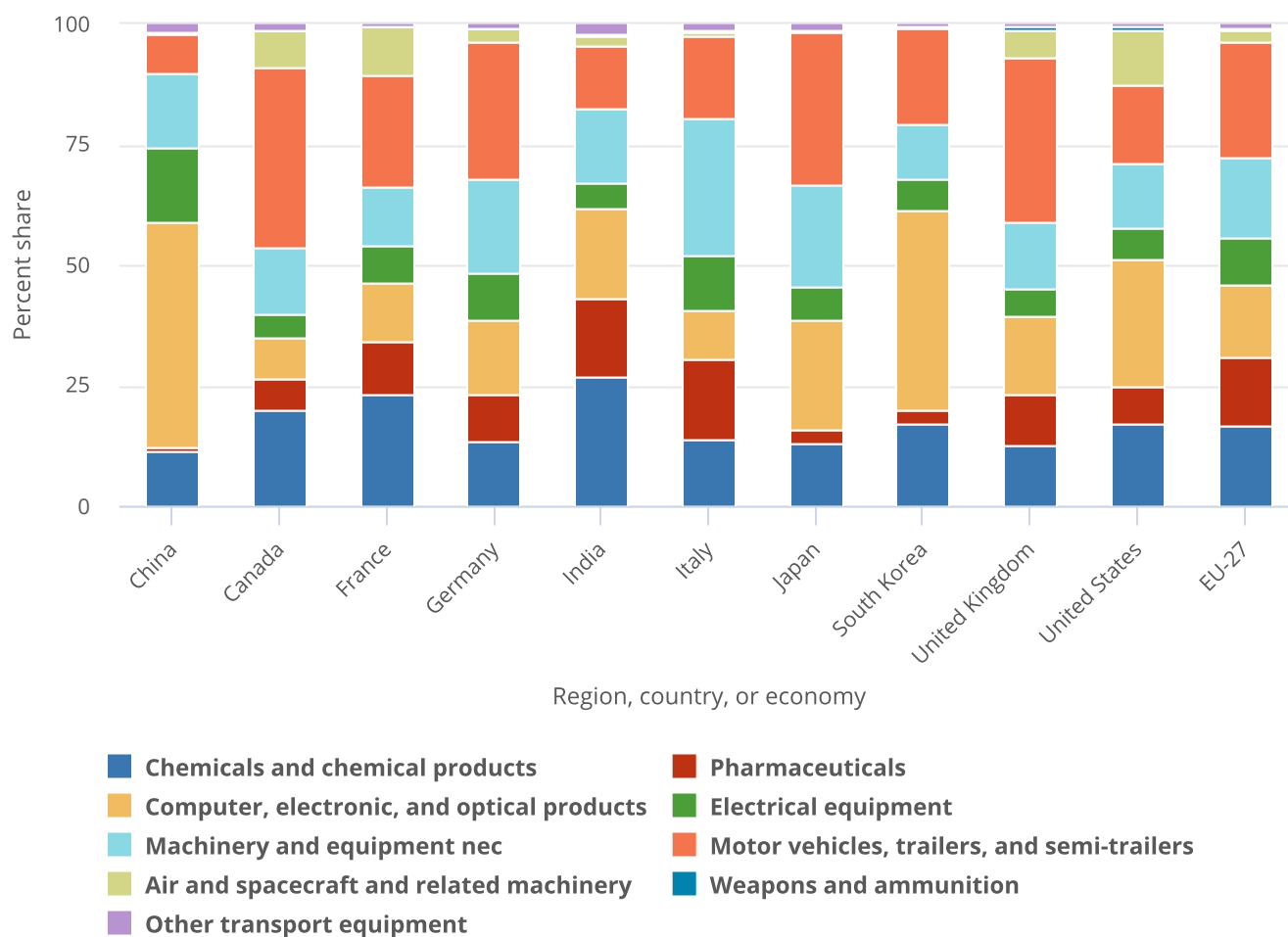
S&P Global Market Intelligence, Comparative Industry Service special tabulations, April 2025.

Science and Engineering Indicators

By 2024, all economies except China and Japan exceeded their 2022 KTI manufacturing exports in current U.S. dollars, and all economies except for China, Japan, and South Korea exceeded the average global growth rate during this period (Table STRN-43). Global KTI manufacturing exports have accounted for a majority (between 58% and 62%) of total global manufacturing exports since 2002 (Table STRN-43). In 2024, KTI manufacturing exports as a share of all national manufacturing exports exceeded 70% in Japan, South Korea, and Germany (73%, 73%, and 71%, respectively), followed by the United States (67%) and China (64%) (Table STRN-44).

The distribution of KTI manufacturing industries within global economies reflects specialization and participation in global supply and production chains (Bontadini et al. 2024). Computer, electronic, and optical products industry exports (which include computer chips or semiconductors) accounted for the largest shares of KTI manufacturing exports from China (47%), South Korea (42%), and the United States (26%) in 2024, based on current U.S. dollars (Figure TRN-39). The motor vehicles, trailers, and semi-trailers industry exports (including EVs) accounted for the largest share of KTI manufacturing exports from Canada (37%), the United Kingdom (34%), Japan (32%), Germany (28%), and France (23%). The machinery and equipment nec industry accounted for the largest share of KTI manufacturing exports from Italy (28%), and the chemicals and chemical products industry accounted for the largest share of KTI manufacturing exports from India (27%) (Figure TRN-39).

Figure TRN-39. Industry composition of KTI manufacturing exports for selected regions, countries, or economies: 2024



EU-27 = European Union; KTI = knowledge and technology intensive; nec = not elsewhere classified.

Note(s):

KTI manufacturing exports include exports from the following industries: chemicals and chemical products; pharmaceuticals; computer, electronic, and optical products; electrical equipment; machinery and equipment nec; motor vehicles, trailers, and semi-trailers; air and spacecraft and related machinery; weapons and ammunition; and other transport equipment (the latter comprises railway locomotives and rolling stock manufacturing and transport equipment nec and military equipment manufacturing).

Source(s):

S&P Global Market Intelligence, Comparative Industry Service special tabulations, April 2025.

In 2024, the United States had a KTI manufacturing goods trade deficit of \$794 billion in current U.S. dollars (Table STRN-45). Across all goods, the U.S. trade deficit was \$1.2 trillion in 2024, compared with a deficit of \$1.1 trillion in 2023 (BEA 2025b, Exhibit 5). China has had trade surpluses above \$1 trillion in KTI goods since 2021, including \$1.4 trillion in 2024 in current U.S. dollars, based on S&P Global data (Table STRN-45).

Conclusion

This report examined the science, technology, and innovation activities of businesses, government agencies, and academic institutions that support the translation of scientific discoveries and provide societal and economic impact through the development of new goods and services. Public and private S&E research and innovation have driven the development of critical and emerging technologies, such as AI, biotechnology, semiconductors, QIST, and nuclear technology. U.S. federal agencies perform R&D and support translation through research funding to academia and businesses and by funding or providing technical support to private technology transfer activities. Academic technology transfer activities include technology licensing to external firms and to startup companies formed specifically to develop university research and innovation for commercial purposes.

Of peer-reviewed publications that acknowledged federal funding, nine agencies were cited in more than 20,000 articles from 2002 to 2022, and these articles had high scientific impact as measured using citation analysis. Further, employees of federal agencies are involved with publishing research, acquiring patents for innovation, and contributing to OSS.

Granted patents provide a window into the technologies under development, and the location of inventors demonstrates where resources are being expended for research and the development of new products and processes. USPTO patenting is driven by the search for protection in the U.S. market; international patent data provide a broader view of international competition. Although patent quality standards and incentives differ across countries, priority patent family trends in critical technologies show the scale and strength of patenting in China and Asia in AI, biotechnology, semiconductors, QIST, and nuclear technology. At the same time, U.S. inventors still have an outsized impact through HCPs, including priority patent families. This is particularly true for patents in biotechnology and related technologies, an area of U.S. research strength.

Businesses are large drivers of innovation activity in the United States; in 2022, 23% of businesses reported having introduced a new or an improved product or process to market in 2020–22. The innovation incidence rate is much higher for businesses in KTI industries, such as software (54%) and pharmaceutical manufacturing (42%), compared with the national average for all businesses (23%).

In addition, the translation of scientific discovery and invention gives rise to new products and services that support the creation and growth of new and existing companies and industries. The economic effects of translation activity are seen over time in the shifting composition of the United States' and other economies' industry base and the organization of trade among countries. Several of the critical and emerging technology areas of national-level policy focus examined in this report (AI, biotechnology, semiconductors, and QIST) are characterized by relatively high levels of business R&D spending and the use of patenting to protect IP.

Indicators of discovery, technology transfer, innovation, and KTI economic activity point to strengths and weaknesses across countries and over time in different critical and emerging technologies and industry sectors. South Korea, China, Germany, and Japan each have had a higher KTI production intensity than the United States since 2002. China has had the largest KTI manufacturing sector globally since 2011 and has been the largest single exporter of KTI manufactured goods since 2008, while the United States has been the largest KTI services producer for over two decades.

Glossary

Definitions

Air and spacecraft and related machinery, manufacture of: Includes the manufacture of airplanes for the transport of goods or passengers, defense forces, or other purposes; helicopters; gliders and hang gliders; dirigibles and hot air balloons; parts and accessories of the aircraft of this class; ground-flying trainers; spacecraft and launch vehicles, satellites, planetary probes, orbital stations, and shuttles; intercontinental ballistic missiles; overhaul and conversion of aircraft or aircraft engines; and aircraft seats.

Artificial intelligence (AI): Computer systems that can perform tasks such as reasoning, decision-making, and creating normally done by humans (NASA 2025).

AUTM: An organization of technology transfer professionals working in universities, hospitals, and other research institutions. Among other advocacy activities, AUTM conducts a yearly survey of its members to compile information on licensing activity and other indicators of technology transfer (AUTM 2025).

Chemicals and chemical products, manufacture of: This industry includes the transformation of organic and inorganic raw materials by a chemical process and the formation of products.

Computer, electronic, and optical products, manufacture of: Includes the manufacture of computers, computer peripherals, communications equipment, and similar electronic products, as well as components such as electronic components and boards. The latter include resistors, microprocessors, and semiconductors. Also includes consumer electronics; measuring, testing, navigating, and control equipment; irradiation, electromedical, and electrotherapeutic equipment; optical instruments and equipment; and magnetic and optical media.

Early stage venture capital: Private equity investment in a nascent company before the generation of revenue.

Economic sectors: Economic activity is organized in national economic accounts into four sectors: business, government, nonprofits serving households, and households. This organization has also been recommended for innovation statistics (OECD/Eurostat 2018). In the statistical data in this report, public universities and private nonprofit universities are shown together as *academic* institutions. The term *individuals* refers to the *household* economic sector.

Electrical equipment, manufacture of: This industry includes the manufacture of products that generate, distribute, and use electrical power, as well as electrical lighting, signaling equipment, and electric household appliances.

European Union (EU-27): The EU comprises 27 member nations: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, and Sweden. The United Kingdom withdrew from the EU on 1 February 2020. Unless otherwise noted, data on the EU include all 27 member countries.

General-purpose technology (GPT): GPTs are technologies that are widely used, are capable of ongoing technical improvement, and enable applications in other sectors (Bresnahan 2010).

GitHub: A Web-based platform serving as a tool for software developers to implement the Git distributed version control system for software backup, sharing, and modification.

Global value chain (GVC): A chain of activities to produce goods and services that may extend across firms or countries. These activities include design, production, marketing and sales, logistics, and maintenance.

Gross domestic product (GDP): The market value of all final goods and services produced within a country in a given period.

Highly cited patent (HCP): HCPs are patents that have received enough citations in subsequent patent documents such that they are in top 1% of cited patents in that category and year. The HCP share represents the share of an entity's patents that are in the top 1% of all cited patents. For example, if 1% of artificial intelligence (AI) patents from the United States are in the top 1% of AI patents globally, then the HCP share for the United States is 1.0. If the HCP share for a location is 2.0, then 2% of that location's patents are in the top 1% globally, implying higher impact patents.

Information sector: As defined by the North American Industry Classification System (NAICS), this industry sector engaged in (1) producing and distributing information and cultural products, (2) providing the means to transmit or distribute these products as well as data or communications, and (3) processing data.

Information technology (IT) and other information services: This industry is the composite of International Standard Industrial Classification of All Economic Activities (ISIC) sectors 62 (computer programming, consultancy, and related activities) and 63 (information service activities). ISIC 62 includes providing expertise in information technologies: writing, modifying, testing, and supporting software; planning and designing computer systems that integrate computer hardware, software, and communication technologies; and on-site management and operation of clients' computer systems or data processing facilities. ISIC 63 includes Web search portals and data processing and hosting activities.

Innovation: A new or improved product or process (or combination thereof) that differs significantly from the unit's previous products or processes and that has been made available to potential users (*product*) or brought into use by the unit (*process*). The *unit* is a generic term to describe the actor responsible for innovations. It refers to any institutional unit in any sector, including households and their individual members, according to the *Oslo Manual 2018* (OECD/Eurostat 2018).

Intangible or intellectual property product (IPP): IPPs are the result of R&D or innovation leading to knowledge that the developers can market or use to their own benefit in production because use of the knowledge is restricted by means of legal or other protection. They include R&D; mineral exploration and evaluation; computer software and databases; and entertainment, literary and artistic originals, and other IPPs.

Intellectual property (IP): Creations of the mind including inventions; literary and artistic works; and symbols, names, images, and designs used in commerce. Industrial IP includes patents, utility models, trademarks, and industrial designs. IP covered by copyright includes literary, artistic, and musical works (WIPO 2020).

Invention: Any new and useful process, machine, manufacture, or composition of matter or any new and useful improvement thereof (USPTO 2020).

Knowledge- and technology-intensive (KTI) industries: Industries classified by the Organisation for Economic Co-operation and Development (OECD) as high and medium-high R&D-intensive industries. OECD defines industry R&D intensity as the ratio of an industry's business R&D expenditures to its value added (OECD 2016).

Knowledge transfer: The process by which technology or knowledge developed in one place or for one purpose is applied and used in another place for the same or a different purpose. This transfer can occur freely or through exchange and be deliberate or unintentional. Technology transfer represents a specific case of knowledge transfer that involves the transfer of knowledge embedded in technology.

Machinery and equipment not elsewhere classified (nec), manufacture of: This industry includes the manufacture of machinery and equipment that act independently on materials either mechanically or thermally or perform operations on materials (such as handling, spraying, weighing, or packing). Includes the manufacture of fixed and mobile or handheld devices, regardless of whether they are designed for industrial, building, and civil engineering; agricultural; or home use. Also included is the manufacture of special equipment for passenger or freight transport within demarcated premises.

Medical and dental instruments and supplies, manufacture of: Includes manufacture of laboratory apparatus, surgical and medical instruments, surgical appliances and supplies, dental equipment and supplies, orthodontic goods, and dentures and orthodontic appliances.

Motor vehicles, trailers, and semi-trailers, manufacture of: This industry includes the manufacture of motor vehicles for transporting passengers or freight. Also included is the manufacture of parts and accessories and of trailers and semi-trailers.

Organisation for Economic Co-operation and Development (OECD): An international organization of 38 countries headquartered in Paris, France. The member countries are Australia, Austria, Belgium, Canada, Chile, Colombia, Costa Rica, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Latvia, Lithuania, Luxembourg, Mexico, the Netherlands, New Zealand, Norway, Poland, Portugal, Slovakia, Slovenia, South Korea, Spain, Sweden, Switzerland, Türkiye, the United Kingdom, and the United States. Among its many activities, OECD compiles social, economic, and science and technology statistics for all member and selected nonmember countries.

Patent and Trademark Office (USPTO) patent: As defined by USPTO, a property right granted by the U.S. government to an inventor “to exclude others from making, using, offering for sale, or selling the invention throughout the United States or importing the invention into the United States” for a limited time in exchange for public disclosure of the invention when the patent is granted (USPTO 2025a).

Patenting intensity: Number of patents per population in a geographic location.

PatentsView: Patent database of USPTO patents used in this report.

PATSTAT: Patent database from the European Patent Office that is the source of the priority patent family data in this report.

Pharmaceuticals (manufacture of basic pharmaceutical products and pharmaceutical preparations): This industry includes the manufacture of basic pharmaceutical products, pharmaceutical preparations, and medicinal chemical and botanical products.

Priority patent: The first patent filed in a family of subsequent patents. Counting priority patent families allows each patented innovation to be counted once, based on the first filing. The original filing may be domestic or from another jurisdiction.

Priority patent families: These are original patents that have been issued by any international jurisdiction, adjusted to count only the first issuance of a series or family of related patents. The unit of measurement is a patent family that shares a single original invention in common. All subsequent patents in a family refer to the first patent filed, or *priority patent*, and the indicator provides an unduplicated count of original or priority patents in any individual jurisdiction. The data used in this report are from the European Patent Office’s PATSTAT database.

Quantum information science and technology (QIST): A set of technologies based on the principles of “quantum physics for the storage, transmission, manipulation, computing, or measurement of information,” according to the National Quantum Initiative Act (P.L. 115-368). QIST can perform certain operations faster than conventional computers and may have application in areas such as cryptography, modeling, and simulation.

Railroad, military vehicles, and transport not elsewhere classified (nec), manufacture of: This manufacturing industry is the composite of International Standard Industrial Classification of All Economic Activities (ISIC) 302 (railway locomotives and rolling stock), ISIC 304 (military fighting vehicles), and ISIC 309 (transport equipment nec).

Repository: In GitHub, a repository is a virtual storage space where computer code and files are stored, along with the history of commits, or changes to the file.

Scientific research and development (R&D) services: This industry includes the activities of three types of R&D: (1) basic research, (2) applied research, and (3) experimental development.

Semiconductors: This industry refers to the manufacture of electronic components and boards (International Standard Industrial Classification of All Economic Activities 261), which includes semiconductors and other components for electronic applications.

Software publishing: This industry includes publication of ready-made (noncustomized) software: operating systems, business and other applications, and computer games for all platforms.

Technical field in patents: *Chemistry:* Biotechnology, pharmaceuticals, organic fine chemistry, microstructural and nanotechnology, chemical engineering, macromolecular chemistry and polymers, basic materials chemistry, materials, metallurgy, surface technology, coating, environmental technology, food chemistry. *Electrical engineering:* Computer technology, electrical machinery, apparatus and energy, semiconductors, digital communication, telecommunications, audio-visual technology, basic communication processes, information technology methods for management. *Mechanical engineering:* Other special machines, engines, pumps, and turbines; transport; mechanical elements; machine tools; textile and paper machines; thermal processes and apparatus; handling. *Instruments:* Medical technology, measurement, analysis of biological materials, optics, control. *Other categories:* Civil engineering, other consumer goods, furniture, games.

Technology transfer: The process by which technology or knowledge developed in one place or for one purpose is applied and exploited in another place or for another purpose. In the federal setting, technology transfer is the process by which existing knowledge, facilities, or capabilities developed under federal research and development funding are used to fulfill public and private needs.

Total private services: Aggregate of the following International Standard Industrial Classification of All Economic Activities (ISIC) industries (ISIC Revision 4): wholesale and retail trade and repair of motor vehicles and motorcycles; transportation and storage; accommodation and food service activities; information and communication; financial and insurance activities; real estate activities; professional, scientific, technical activities; and administrative and support service activities. This aggregate corresponds to Business Sector Services (ISIC aggregate "D45T82") in economic and R&D data from the Organisation for Economic Co-operation and Development (OECD 2025b).

Trade secret: Information that fulfills all the following requirements, as defined by the Patent and Trademark Office: "Either actual or potential independent economic value by virtue of not being generally known, has value to others who cannot legitimately obtain the information, and is subject to reasonable efforts to maintain its secrecy" (USPTO 2025c).

Trademark: A word, phrase, symbol, or design, or a combination thereof, that identifies and distinguishes the source of the goods of one party from those of others. In this report, trademark refers to both goods and services.

Utility patent: Intellectual property protection for a potentially useful, previously unknown, and nonobvious invention.

Value added: Value added is a net measure of output; it is the difference between the value of goods and services (gross output) and the cost of intermediate inputs that were used in production, including energy, materials, and services. Industry value added is a measure of an industry's contribution to overall GDP.

Weapons and ammunition, manufacture of: This industry includes the manufacture of heavy weapons (such as artillery, mobile guns, and rocket launchers), small arms (revolvers, shotguns, light machine guns), ammunition, and explosive devices, as well as hunting and sporting firearms. Excludes the manufacture of space vehicles and tanks or other fighting vehicles (included in other industries).

Key to Acronyms and Abbreviations

ABS: Annual Business Survey

AI: artificial intelligence

BEA: Bureau of Economic Analysis

BLS: Bureau of Labor Statistics

COVID-19: coronavirus disease 2019

CRADA: cooperative research and development agreement

DOC: Department of Commerce

DOD: Department of Defense

DOE: Department of Energy

EPO: European Patent Office

EU-27: European Union

EV: electric vehicle

GDP: gross domestic product

GII: Global Innovation Index

GPT: general-purpose technologies

GVC: global value chain

HCA: highly cited article

HHS: Department of Health and Human Services

IEA: International Energy Association

IMF: International Monetary Fund

IP: intellectual property

IPP: intellectual property product

ISIC: International Standard Industrial Classification of All Economic Activities

IT: information technology

KTI: knowledge and technology intensive

MFP: multifactor productivity

NAICS: North American Industry Classification System

NASA: National Aeronautics and Space Administration

NCSES: National Center for Science and Engineering Statistics

nec: not elsewhere classified

NIST: National Institute of Standards and Technology

NSF: U.S. National Science Foundation

OECD: Organisation for Economic Co-operation and Development

OSS: open-source software

PCT: Patent Cooperation Treaty

QIST: quantum information science and technology

R&D: research and development

S&E: science and engineering

SBIR: Small Business Innovation Research

STTR: Small Business Technology Transfer

TFP: total factor productivity

TIP: Directorate for Technology, Innovation and Partnerships

USDA: Department of Agriculture

USPTO: Patent and Trademark Office

VA: Department of Veterans Affairs

VC: venture capital

WIPO: World Intellectual Property Organization

References

- Acemoglu D, Johnson S. 2023. *Power and Progress: Our Thousand-Year Struggle over Technology and Prosperity*. London, UK: Basic Books.
- Aghion P, Howitt P. 2009. *The Economics of Growth*. Cambridge, MA: MIT Press.
- Aizcorbe AM, Moylan CE, Robbins CA. 2009. Toward Better Measurement of Innovation and Intangibles. Survey of Current Business. *BEA Briefing* June:10–23. Washington, DC: Bureau of Economic Analysis, Department of Commerce.
- Alfaro L, Chor D. 2023. *Global Supply Chains: The Looming “Great Reallocation.”* Working Paper No. 31661. Cambridge, MA: National Bureau of Economic Research.
- Ambos B, Brandl K, Perri A, Scalera VG, Van Assche A. 2021. The Nature of Innovation in Global Value Chains. *Journal of World Business* 56(4):101221. Available at <https://doi.org/10.1016/j.jwb.2021.101221>. Accessed 27 August 2025.
- Audretsch D, Colombelli A, Grilli L, Minola T, Rasmussen E. 2020. Innovative Start-Ups and Policy Initiatives. *Research Policy* 49(10):104027. Available at <https://doi.org/10.1016/j.respol.2020.104027>. Accessed 29 September 2025.
- Australian Government. 2023. *National Quantum Strategy*. Department of Industry, Science, and Resources. Available at <https://www.industry.gov.au/sites/default/files/2023-05/national-quantum-strategy.pdf>. Accessed June 2025.
- AUTM. 2025. *Who We Are*. Available at <https://autm.net/about-autm/who-we-are/>. Accessed 22 September 2025.
- Autor D, Dorn D, Hanson GH, Pisano G, Shu P. 2020. Foreign Competition and Domestic Innovation: Evidence from U.S. Patents. *AER: Insights* 2(3):357–74. Available at <https://doi.org/10.1257/aeri.20180481>. Accessed 27 August 2025.
- Baily MN, Bosworth B, Doshi S. 2020. *Productivity Comparisons: Lessons from Japan, the United States, and Germany*. Washington, DC: Brookings Institution. Available at <https://www.brookings.edu/wp-content/uploads/2020/01/es-1.30.20-bailybosworthdoshi.pdf>. Accessed 27 August 2025.
- Baldwin R. 2024. *China Is the World’s Sole Manufacturing Superpower: A Line Sketch of the Rise*. Available at <https://cepr.org/voxeu/columns/china-worlds-sole-manufacturing-superpower-line-sketch-rise>. Accessed 13 May 2025.
- Baldwin R, Freeman R. 2021. *Risks and Global Supply Chains: What We Know and What We Need to Know*. Working Paper 29444. Cambridge, MA: National Bureau of Economic Research. Available at <https://www.nber.org/papers/w29444>. Accessed 27 August 2025.
- Biden J. 2022. *Executive Order on Advancing Biotechnology and Biomanufacturing Innovation for a Sustainable, Safe, and Secure American Bioeconomy* 12 September. Available at <https://bidenwhitehouse.archives.gov/briefing-room/presidential-actions/2022/09/12/executive-order-on-advancing-biotechnology-and-biomanufacturing-innovation-for-a-sustainable-safe-and-secure-american-bioeconomy/>. Accessed 27 August 2025.
- Bontadini F, Evangelista R, Meliciani V, Savona M. 2024. Technology, Global Value Chains and Functional Specialisation in Europe. *Research Policy* 53(2):104908. Available at <https://doi.org/10.1016/j.respol.2023.104908>. Accessed 18 May 2025.
- Bottai C, de Rassenfosse G, Raiteri E. 2025. A New Approach to Measuring Invention Commercialization: An Application to the SBIR Program. *Research Policy* 54(9):105302. Available at <https://doi.org/10.1016/j.respol.2025.105302>. Accessed 31 January 2026.
- Branstetter LG, Li G. 2022. *Does “Made in China 2025” Work for China? Evidence from Chinese Listed Firms*. Working Paper 30676. Cambridge, MA: National Bureau of Economic Research. Available at <https://www.nber.org/papers/w30676>. Accessed 27 August 2025.

- Branstetter LG, Li G. 2023. Picking Winners or Propping Up Losers? The Challenges of Chinese Industrial Policy. In Jones B, Lerner J, editors, *Entrepreneurship and Innovation Policy and the Economy, Volume 3*. Cambridge, MA: National Bureau of Economic Research. Available at <https://www.nber.org/books-and-chapters/entrepreneurship-and-innovation-policy-and-economy-volume-3/challenges-chinese-industrial-policy>. Accessed 27 August 2025.
- Bresnahan T. 2010. General Purpose Technologies. In Hall B, Rosenberg N, editors, *Economics of Innovation*, Vol. 2, pp. 761–91. Elsevier.
- Bresnahan T, Trajtenberg M. 1992. *General Purpose Technologies “Engines of Growth”?* Working Paper No. 4148. Cambridge, MA: National Bureau of Economic Research. Available at <https://doi.org/10.3386/w4148>. Accessed 26 November 2025.
- Brocal F, Sebastián MA, González C. 2019. Advanced Manufacturing Processes and Technologies. In Roig B, Weiss K, Thireau V, editors, *Management of Emerging Public Health Issues and Risks*, pp. 31–64. Cambridge, MA: Academic Press. Available at <https://doi.org/10.1016/B978-0-12-813290-6.00002-0>. Accessed 27 August 2025.
- Bruneel J, Clarysse B, Bobelyn A, Wright M. 2020. Liquidity Events and VC-Backed Academic Spin-Offs: The Role of Search Alliances. *Research Policy* 49(10):104035. <https://doi.org/10.1016/j.respol.2020.104035>. Accessed 8 October 2025.
- Brynjolfsson E, McAfee A. 2016. *The Second Machine Age: Work, Progress, and Prosperity in Time of Brilliant Technologies*. New York, NY: W. W. Norton and Company.
- Bureau of Economic Analysis (BEA). 2025a. *GDP by Industry*. Available at <https://www.bea.gov/data/gdp/gdp-industry>. Accessed 27 August 2025.
- Bureau of Economic Analysis (BEA). 2025b. *International Trade in Goods and Services*. Available at <https://www.bea.gov/data/intl-trade-investment/international-trade-goods-and-services>. Accessed 18 May 2025.
- Business Council of Australia (BCA). 2025. *Business Council Unveils Australian AI Report to Secure Leadership by 2028*. Available at https://www.bca.com.au/business_council_unveils_australian_ai_report_to_secure_leadership_by_2028. Accessed 2 June 2025.
- Census Bureau. 2022. *Business Dynamics Statistics*. Available at <https://www.census.gov/programs-surveys/bds.html>. Accessed 27 August 2025.
- Cardeiro DA, Eugster J, Mano RC, Muir D, Peiris SJ. 2021. *Sizing Up the Effects of Technological Decoupling*. Working Paper No. 2021/069. Washington, DC: International Monetary Fund. Available at <https://www.imf.org/en/Publications/WP/Issues/2021/03/12/Sizing-Up-the-Effects-of-Technological-Decoupling-50125>. Accessed 27 August 2025.
- Chatterji A, Murray F. 2025. *How Geopolitics Is Changing the Economics of Innovation*. Working Paper c15160. Cambridge, MA: National Bureau of Economic Research. Available at <https://www.nber.org/system/files/chapters/c15160/c15160.pdf>. Accessed June 2025.
- Coe D, Helpman E. 1995. International R&D Spillovers. *European Economic Review* 39:859–87.
- Cohen WM, Nelson RR, Walsh JP. 2000. *Protecting Their Intellectual Assets: Appropriability Conditions and Why U.S. Manufacturing Firms Patent (or Not)*. Working Paper 7552. Cambridge, MA: National Bureau of Economic Research. Available at <https://www.nber.org/papers/w7552>. Accessed 29 September 2025.
- Compagnucci L, Spigarelli F. 2020. The Third Mission of the University: A Systematic Literature Review on Potentials and Constraints. *Technological Forecasting and Social Change* 161:120284. Available at <https://doi.org/10.1016/j.techfore.2020.120284>. Accessed 14 January 2026.
- Congress.gov. 2022. CHIPS and Science Act. Available at <https://www.congress.gov/bill/117th-congress/house-bill/4346>. Accessed 27 August 2025.

- Congressional Research Service (CRS). 2020. *Semiconductors: U.S. Industry, Global Competition, and Federal Policy*. Washington, DC: CRS.
- Congressional Research Service (CRS). 2022. *Critical Minerals in EV Batteries*. Washington, DC: CRS.
- Congressional Research Service (CRS). 2023a. *Semiconductors and the CHIPS Act: The Global Context*. Washington, DC: CRS. Available at https://www.congress.gov/crs_external_products/R/PDF/R47558/R47558.5.pdf. Accessed 2 February 2026.
- Congressional Research Service (CRS). 2023b. *Semiconductors and the Semiconductor Industry*. Washington, DC: CRS.
- Corrado C, Hulten C, Sichel D. 2009. Intangible Capital and U.S. Economic Growth. *Review of Income and Wealth* 55(3):661–85. Available at <https://doi.org/10.1111/j.1475-4991.2009.00343.x>. Accessed 27 August 2025.
- Criscuolo C, Haskel JE, Slaughter MJ. 2010. Global Engagement and the Innovation Activities of Firms. *International Journal of Industrial Organization* 28(2):191–202.
- Decker R, Haltiwanger J, Jarmin R, Miranda J. 2014. The Role of Entrepreneurship in US Job Creation and Economic Dynamism. *Journal of Economic Perspectives* 28(3):3–24. Available at <https://doi.org/10.1257/jep.28.3.3>. Accessed 29 September 2025.
- Delgado M, Ketels C, Porter M, Stern S. 2012. *The Determinants of National Competitiveness*. Working Paper 18249. Cambridge, MA: National Bureau of Economic Research. Available at https://www.nber.org/system/files/working_papers/w18249/w18249.pdf. Accessed 27 August 2025.
- Department of Energy (DOE), Office of Nuclear Energy. 2025. *9 Key Takeaways from President Trump's Executive Orders on Nuclear Energy*. Available at <https://www.energy.gov/ne/articles/9-key-takeaways-president-trumps-executive-orders-nuclear-energy>. Accessed June 2025.
- Dieppe A, Celik SK, Kindberg-Hanlon G. 2021. Global Productivity Trends. In Dieppe A, editor, *Global Productivity: Trends, Drivers, and Policies*, pp. 49–80. Washington, DC: World Bank.
- Elsevier. 2023. *Scopus Abstract and Citation Database* (tabulated by Science-Metrix). Available at <https://www.elsevier.com/solutions/scopus>. Accessed 27 August 2025.
- Ernst D. 2015. *Global Strategic Patenting and the Distribution of Innovation Gains*. Honolulu, HI: East-West Center. Available at <https://www.hks.harvard.edu/sites/default/files/centers/mrcbg/files/patent/Ernst+Think+Ernst%20Piece+Global+Strategic+Patenting+and+the+Distribution+of+Innovation+Gains+01+27+15.pdf>.
- European Patent Office (EPO). 2025. *PATSTAT Database*. Available at <https://data.epo.org/expert-services/>. Accessed 30 September 2025.
- Federation of American Scientists (FAS). 2025. *Invention Secrecy Activity*. Available at <https://sgp.fas.org/othergov/invention/stats.html>. Accessed 26 January 2026.
- Flikkema M, Castaldi C, de Man AP. 2025. On Trademarks and Innovation: A Retrospective, 10 Years Later. *Industry and Innovation*, 1–6. Available at <https://doi.org/10.1080/13662716.2025.2538842>. Accessed 27 August 2025.
- GitCode. 2025. *Product Introduction*. Available at <https://docs.gitcode.com/en/docs/start/>. Accessed 27 August 2025.
- GitHub. 2025. *Developer Metrics*. Available at <https://innovationgraph.github.com/global-metrics/developers>. Accessed August 2025.
- Goldberg PK, Reed T. 2023. *Is the Global Economy Deglobalizing? And If So, Why? And What Is Next?* Working Paper 31115. Cambridge, MA: National Bureau of Economic Research. Available at <https://www.nber.org/papers/w31115>. Accessed 27 August 2025.

- Gordon R. 2017. *The Rise and Fall of American Growth: The U.S. Standard of Living since the Civil War*. Princeton, NJ: Princeton University Press.
- Gotsch M, Hipp C. 2014. Using Trademarks to Measure Innovation in Knowledge-Intensive Business Services. *Technology Innovation Management Review* 4(5):18–30.
- Green E, Parker O. 2026. China's 15th Five-Year Plan. *IJSS* 23 March. Available at <https://www.iiss.org/online-analysis/online-analysis/2026/03/chinas-15th-five-year-plan/>. Accessed 27 March 2026.
- Griliches, Z. 1991. *The Search for R&D Spillovers*. Working Paper 3768. Cambridge, MA: National Bureau of Economic Research. Available at https://www.nber.org/system/files/working_papers/w3768/w3768.pdf. Accessed June 2025.
- Gullo T, Page B, Weiner D, Williams HL. 2025. *Estimating the Economic and Budgetary Effects of Research Investments*. Working Paper 33402. Cambridge, MA: National Bureau of Economic Research. Available at https://www.nber.org/system/files/working_papers/w33402/w33402.pdf. Accessed 30 September 2025.
- Hall B. 2011. *Using Productivity Growth as an Innovation Indicator*. Working Paper. Available at https://eml.berkeley.edu/~bhall/papers/BHH11_EC_DGR_prod_innov_Oct.pdf. Accessed 27 August 2025.
- Hall B, Jaffe A. 2018. Measuring Science, Technology, and Innovation: A Review. *Annals of Science and Technology Policy* 2(1):1–74.
- Hall B, Jaffe A, Trajtenberg M. 2002. The NBER Patent-Citations Data File: Lessons, Insights, and Methodological Tools. In Jaffe AB, Trajtenberg M, editors, *Patents, Citations, and Innovations: A Window on the Knowledge Economy*, pp. 403–60. Cambridge, MA: MIT Press.
- Heaven WD. 2023. The Inside Story of How ChatGPT Was Built from the People Who Made It. *MIT Technology Review* 3 March. Available at <https://www.technologyreview.com/2023/03/03/1069311/inside-story-oral-history-how-chatgpt-built-openai/>. Accessed 27 August 2025.
- Hoffman M, Nagle F, Zhou Y. 2024. The Value of Open Source Software. Harvard Business School Working Paper 24-038. Available at https://www.hbs.edu/ris/Publication%20Files/24-038_51f8444f-502c-4139-8bf2-56eb4b65c58a.pdf. Accessed February 2026.
- Institute of Defense Analysis (IDA). 2012. *Emerging Global Trends in Advanced Manufacturing*. IDA Paper P-4603. Washington, DC: IDA.
- Instituto Danneman Siemens (IDS). 2024. *Brazil's Federal Government Launches the Brazilian Artificial Intelligence Plan 2024–2028*. Rio de Janeiro, Brazil: IDS. Available at <https://ids.org.br/en/news-post/brazils-federal-government-launches-the-brazilian-artificial-intelligence-plan-2024-2028/>. Accessed 27 August 2025.
- International Energy Agency (IEA). 2025. *The Path to a New Era for Nuclear Energy*. Paris, France: IEA. Available at <https://www.iea.org/reports/the-path-to-a-new-era-for-nuclear-energy>. Accessed 27 August 2025.
- International Monetary Fund (IMF). 2025. *World Economic Outlook*. Washington, DC: IMF. Available at <https://www.imf.org/en/Publications/WEO/Issues/2025/04/22/world-economic-outlook-april-2025>. Accessed 15 May 2025.
- Ito K, Ikeuchi K, Criscuolo C, Timmis J, Bergeaud A. 2023. Global Value Chains and Domestic Innovation. *Research Policy* 52(3):104699. Available at <https://doi.org/10.1016/j.respol.2022.104699>. Accessed 27 August 2025.
- Jaax A, Miroudot S. 2021. Capturing Value in GVCs through Intangible Assets: The Role of the Trade-Investment–Intellectual Property Nexus. *Journal of International Business Policy* 4(3):433–52.

- Jones B, Summers L. 2020. *A Calculation of the Social Returns to Innovation*. Working Paper 27863. Cambridge, MA: National Bureau of Economic Research. Available at <https://www.nber.org/papers/w27863>. Accessed May 2025.
- Jorgenson D. 2001. Information Technology and the U.S. Economy. *American Economic Review* 91(1):1–32.
- Kane T. 2010. *The Importance of Startups in Job Creation and Job Destruction*. Kansas City, MO: Kauffman Foundation. Available at <https://www.kauffman.org/reports/firm-formation-and-growth-series/the-importance-of-startups-in-job-creation-and-job-destruction/>. Accessed 29 September 2025.
- Kratsios M. 2025. *ICYMI: President Trump Outlines OSTP's Goals and Priorities*. Available at <https://www.whitehouse.gov/articles/2025/03/icymi-president-trump-outlines-ostps-goals-and-priorities/>. Accessed 27 August 2025.
- Kuan J, West J. 2023. Interfaces, Modularity and Ecosystem Emergence: How DARPA Modularized the Semiconductor Ecosystem. *Research Policy* 52(8):104789. Available at <https://doi.org/10.1016/j.respol.2023.104789>. Accessed 27 August 2025.
- Lerner J, Nanda R. 2020. *Venture Capital's Role in Financing Innovation: What We Know and How Much We Still Need to Learn*. Working Paper 27492. Cambridge, MA: National Bureau of Economic Research. Available at <https://www.nber.org/papers/w27492>. Accessed 27 August 2025.
- Lifshitz-Assaf H, Nagle F. 2021. The Digital Economy Runs on Open Source. Here's How To Protect It. *Harvard Business Review* 2 September. Available at <https://hbr.org/2021/09/the-digital-economy-runs-on-open-source-heres-how-to-protect-it>. Accessed 30 September 2025.
- Link A, Scott J. 2012. *The Theory and Practice of Public-Sector R&D Economic Analysis*. Planning Report 11-1. Gaithersburg, MD: National Institute of Standards and Technology. Available at <https://www.nist.gov/system/files/documents/2017/04/28/report11-1.pdf>. Accessed 30 September 2025.
- Martin BR. 2016. Twenty Challenges for Innovation Studies. *Science and Public Policy* 43(3):432–50. Available at <https://doi.org/10.1093/scipol/scv077>. Accessed 30 September 2025.
- Mendonça S, Santos Pereira T, Godinho M. 2004. Trademarks as an Indicator of Innovation and Industrial Change. *Research Policy* 33(9):1385–1404.
- Metrick A, Yasuda A. 2021. *Venture Capital and the Finance of Innovation*. 3rd ed. Hoboken, NJ: Wiley.
- Millot V. 2009. *Trademarks as an Indicator of Product and Marketing Innovations*. OECD Science, Technology, and Industry Working Papers 2009/06. Paris, France: OECD Publishing. Available at <https://doi.org/10.1787/224428874418>. Accessed 30 September 2025.
- Moore G. 1965. Cramming More Components onto Integrated Circuits. *Electronics* 38(8):114–17. Available at <https://www.cs.utexas.edu/~fussell/courses/cs352h/papers/moore.pdf>. Accessed 28 November 2025.
- National Academies of Sciences, Engineering, and Medicine (NASEM). 2022. *Assessment of the SBIR and STTR Programs at the National Institutes of Health*. Washington, DC: National Academies Press. Available at <https://doi.org/10.17226/26376>. Accessed May 2025.
- National Academies of Sciences, Engineering, and Medicine (NASEM). 2025. *Artificial Intelligence and the Future of Work*. Washington, DC: National Academies Press. Available at <https://doi.org/10.17226/27644>. Accessed June 2025.
- National Aeronautics and Space Administration (NASA). 2025. *What Is Artificial Intelligence?* Available at <https://www.nasa.gov/what-is-artificial-intelligence/>. Washington, DC: NASA. Accessed 30 September 2025.

- National Center for Science and Engineering Statistics (NCSES). 2020. *Business Research and Development: 2018*. NSF 21-312. Alexandria, VA: U.S. National Science Foundation. Available at <https://ncses.nsf.gov/pubs/nsf21312>.
- National Center for Science and Engineering Statistics (NCSES). 2023. *Product Innovation Trends 2016–18 to 2018–20: Findings from the Annual Business Survey*. Alexandria, VA: U.S. National Science Foundation. Available at <https://ncses.nsf.gov/pubs/nsf23331>.
- National Center for Science and Engineering Statistics (NCSES). 2024. *Business Enterprise Research and Development: 2022 (BERD 2022)*. NSF 24-335. Alexandria, VA: U.S. National Science Foundation. Available at <https://ncses.nsf.gov/surveys/business-enterprise-research-development/2022>.
- National Center for Science and Engineering Statistics (NCSES). 2025a. *Annual Business Survey: 2023 (Data Year 2022)*. NSF 25-303. Alexandria, VA: U.S. National Science Foundation. Available at <https://ncses.nsf.gov/surveys/annual-business-survey/2023>.
- National Center for Science and Engineering Statistics (NCSES). 2025b. *Federal R&D Obligations Declined 2.1% in FY 2023; Estimated to Increase in FY 2024*. NSF 25-329. Alexandria, VA: U.S. National Science Foundation. Available at <https://ncses.nsf.gov/pubs/nsf25329>.
- National Institute of Standards and Technology (NIST), U.S. Department of Commerce. 2022. *Federal Laboratory Technology Transfer, Fiscal Year 2020: Summary Report to the President and the Congress*. Available at <https://www.nist.gov/tpo/federal-laboratory-interagency-technology-transfer-summary-reports>. Accessed May 2025.
- National Science and Technology Council (NSTC). 2024. *National Quantum Initiative Supplement to the President's FY 2025 Budget*. Washington, DC: NSTC, Office of Science and Technology Policy. Available at <https://www.quantum.gov/wp-content/uploads/2024/12/NQI-Annual-Report-FY2025.pdf>. Accessed August 2025.
- National Science and Technology Council (NSTC). 2025. *National Strategy on Microelectronics Research*. Washington, DC: NSTC, Office of Science and Technology Policy. Available at <https://www.whitehouse.gov/wp-content/uploads/2025/03/Amended-National-Strategy-on-Microelectronics-Research.pdf>. Accessed 25 September 2025.
- National Science Board (NSB), National Science Foundation. 2024. Invention, Knowledge Transfer, and Innovation. *Science and Engineering Indicators 2024 (Indicators 2024)*. NSB-2024-1. Alexandria, VA. Available at <https://ncses.nsf.gov/pubs/nsb20241/>.
- National Science Board (NSB), National Science Foundation. 2025. Discovery: R&D Activity and Research Publications. *Science and Engineering Indicators 2026 (Indicators 2026)*. NSB-2025-7. Alexandria, VA. Available at <https://ncses.nsf.gov/pubs/nsb20257/>.
- National Science Board (NSB), National Science Foundation. 2026. STEM Talent: Education, Training, and Workforce. *Science and Engineering Indicators 2026 (Indicators 2026)*. NSB-2026-1. Alexandria, VA. Available at <https://ncses.nsf.gov/pubs/nsb20261/>.
- National Science Foundation, Technology, Innovation and Partnerships (NSF/TIP). 2025. *TIP Key Technology Areas/Technology Foci Key Terms, Version 2024*. White Paper. Alexandria, VA.
- National Venture Capital Association (NVCA). 2025. *NVCA 2025 Yearbook*. Available at <https://nvca.org/document/nvca-2025-yearbook/>. Accessed 31 July 2025.
- Organisation for Economic Co-operation and Development (OECD). 2016. *OECD Taxonomy of Economic Activities Based on R&D Intensity*. Paris, France: OECD Publishing. Available at <https://doi.org/10.1787/5jlv73sqqp8r-en>. Accessed 1 June 2023.

Organisation for Economic Co-operation and Development (OECD). 2023. *Business Innovation Statistics and Indicators*. Paris, France: OECD Publishing. Available at <https://www.oecd.org/en/data/datasets/business-innovation-statistics-and-indicators.html>. Accessed 20 June 2025.

Organisation for Economic Co-operation and Development (OECD). 2025a. *Science, Technology and Innovation Scoreboard*. Paris, France: OECD Publishing. Available at <https://www.oecd.org/en/data/datasets/science-technology-and-innovation-scoreboard.html>. Accessed May 2025.

Organisation for Economic Co-operation and Development (OECD). 2025b. *Structural Analysis Database*. Paris, France: OECD Publishing. Available at <https://www.oecd.org/en/data/datasets/structural-analysis-database.html>. Accessed May 2025.

Organisation for Economic Co-operation and Development (OECD), Eurostat. 2018. *Oslo Manual: Guidelines for Collecting, Reporting and Using Data on Innovation*, 4th ed. Paris, France: OECD Publishing. Available at <https://doi.org/10.1787/9789264304604-en>. Accessed May 2025.

Patent and Trademark Office (USPTO). 2020. *2104 Requirements of 35 U.S.C. 101* [R-10.2019]. Available at <https://www.uspto.gov/web/offices/pac/mpep/s2104.html>. Accessed May 2025.

Patent and Trademark Office (USPTO). 2025a. *Glossary*. Available at <https://www.uspto.gov/learning-and-resources/glossary>. Accessed August 2025.

Patent and Trademark Office (USPTO). 2025b. *PatentsView* (tabulated by Science-Metrix). Available at <https://patentsview.org/>. Accessed January 2025.

Patent and Trademark Office (USPTO). 2025c. *Trade Secrets/Regulatory Data Protection*. Available at <https://www.uspto.gov/ip-policy/trade-secret-policy>. Accessed August 2025.

Patent and Trademark Office (USPTO). 2026. *Section 120 Secrecy Orders*. Available at <https://www.uspto.gov/web/offices/pac/mpep/s120.html>. Accessed 27 March 2026.

PCI Productions. 2024. *NASA Economic Impact Study 2023*. Huntsville, AL: PCI Productions. Available at <https://www.nasa.gov/fy-2023-economic-impact-report/>. Accessed May 2025.

Perkmann M, Tartari V, McKelvey M, Autio E, Broström A, D'Este P, Fini R, Geuna A, Grimaldi R, Hughes A, Krabel S, Kitson M, Llerena P, Lissoni F, Salter A, Sobrero M. 2013. Academic Engagement and Commercialisation: A Review of the Literature on University-Industry Relations. *Research Policy* 42(2):423–42. Available at <https://doi.org/10.1016/j.respol.2012.09.007>. Accessed 28 January 2026.

PitchBook Data, Inc. 2025. *Venture Capital and Private Equity Database*. Available at <https://pitchbook.com/>. Accessed May 2025.

President's Council of Advisors on Science and Technology (PCAST). 2020. *Recommendations for Strengthening American Leadership in Industries of the Future: A Report to the President of the United States of America*. Washington, DC: Executive Office of the President of the United States. Available at <https://digitalcollections.rice.edu/documents/detail/266531>. Accessed 27 August 2025.

S&P Global Market Intelligence. 2025. *Comparative Industry Service Special Tabulations*. Accessed 2 April 2025.

Sansone G, Battaglia D, Landoni P, Paolucci E. 2021. Academic Spinoffs: The Role of Entrepreneurship Education. *International Entrepreneurship and Management Journal* 17(1):369–99. Available at <https://doi.org/10.1007/s11365-019-00601-9>. Accessed 23 December 2025.

Science-Metrix. 2024. *Patent and Trademark Indicators for the Science and Engineering Indicators 2024: Technical Documentation*. Available at <https://www.science-metrix.com/reports/>. Accessed February 2024.

- Shackelford B, Kindlon A. 2021. *Nondisclosure Agreements, Trade Secrets, and Trademarks Considered Very Important to More U.S. Businesses than Were Patents or Copyrights in 2017*. NSF 22-305. Alexandria, VA: U.S. National Science Foundation. Available at <https://nces.nsf.gov/pubs/nsf22305>.
- Shehabi A, Smith S, Hubbard A. 2024. *2024 United States Data Center Energy Usage Report*. Lawrence Berkeley National Laboratory LBL Publications. Available at <https://escholarship.org/uc/item/32d6m0d1>. Accessed June 2025.
- Small Business Administration (SBA). 2023. *Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) Program*. Policy Directive. Available at https://www.sbir.gov/sites/default/files/SBA%20SBIR_STTR_POLICY_DIRECTIVE_May2023.pdf. Accessed June 2023.
- Small Business Administration (SBA). 2025a. *Office of Investment and Innovation*. Available at <https://www.sba.gov/about-sba/sba-locations/headquarters-offices/office-investment-innovation>. Accessed May 2025.
- Small Business Administration (SBA). 2025b. *SBIR-STTR Award Analytic Dashboard*. Available at <https://www.sbir.gov/>. Accessed May 2025.
- Solow RM. 1956. A Contribution to the Theory of Economic Growth. *Quarterly Journal of Economics* 70(1):65–94. Available at <https://doi.org/10.2307/1884513>. Accessed 30 September 2025.
- Stephan PE. 2012. *How Economics Shapes Science*. Cambridge, MA: Harvard University Press.
- Swamidass PM. 2013. University Startups as a Commercialization Alternative: Lessons from Three Contrasting Case Studies. *Journal of Technology Transfer* 38(6):788–808. Available at <https://doi.org/10.1007/s10961-012-9267-6>. Accessed 8 January 2026
- Thomas D. 2026. *Annual Report on the U.S. Manufacturing Economy: 2025*. National Institute of Standards and Technology Advanced Manufacturing Series (NIST AMS) 100-76. Gaithersburg, MD: NIST. Available at <https://doi.org/10.6028/NIST.AMS.100-76>. Accessed 27 March 2026.
- Torsekar MP, VerWey J. 2019. East Asia-Pacific's Participation in the Global Value Chain for Electronic Products. *Journal of International Commerce and Economics* March. Available at https://www.usitc.gov/staff_publications. Accessed 31 July 2023.
- Trajtenberg M. 2002. A Penny for Your Quotes: Patent Citations and the Value of Innovations. In Jaffe AB, Trajtenberg M, editors *Patents, Citations, & Innovations: A Window on the Knowledge Economy*. Cambridge, MA: MIT Press.
- Trajtenberg M. 2018. *AI as the Next GPT: A Political-Economy Perspective*. Working Paper 24245. Cambridge, MA: National Bureau of Economic Research.
- Trump D. 2025. A Letter to Michael Kratsios, Director of the White House Office of Science and Technology Policy. *Briefings & Statements* 26 March. Available at <https://www.whitehouse.gov/briefings-statements/2025/03/a-letter-to-michael-kratsios-director-of-the-white-house-office-of-science-and-technology-policy/>. Accessed June 2025.
- United Kingdom National Quantum Technologies Programme (NQTP). 2020. *Strategic Intent*. Available at <https://uknqt.ukri.org/wp-content/uploads/2021/10/UKNQT-Strategic-Intent-2020.pdf>. Accessed June 2025.
- VerWey J. 2019. Chinese Semiconductor Industrial Policy: Prospects for Future Success. *Journal of International Commerce and Economics* August. Available at https://www.usitc.gov/journals/jice_home.htm. Accessed 31 July 2023.
- von Graevenitz G, Graham SJH, Myers AF. 2021. Distance (Still) Hampers Diffusion of Innovations. *Regional Studies* 56(2):227–41. Available at <https://doi.org/10.1080/00343404.2021.1918334>. Accessed 29 September 2025.

Vought RT, Kratsios MJ. 2025. *Fiscal Year (FY) 2027 Administration Research and Development Budget Priorities and Cross-Cutting Actions*. M-25-34/NSTM-2. Washington, DC: Executive Office of the President. Available at <https://www.whitehouse.gov/wp-content/uploads/2025/09/M-25-34-NSTM-2-Fiscal-Year-FY-2027-Administration-Research-and-Development-Budget-Priorities-and-Cross-Cutting-Actions.pdf>. Accessed 30 September 2025.

World Intellectual Property Organization (WIPO). n.d. *Knowledge and Technology Transfer*. Geneva, Switzerland: WIPO. Available at <https://www.wipo.int/en/web/technology-transfer>. Accessed June 2025.

World Intellectual Property Organization (WIPO). 2020. *What Is Intellectual Property?* Geneva, Switzerland: WIPO. Available at <https://www.wipo.int/about-ip/en/>. Accessed August 2025.

World Intellectual Property Organization (WIPO). 2024. *Global Innovation Index 2024: Unlocking the Promise of Social Entrepreneurship*. Geneva, Switzerland: WIPO. Available at <https://doi.org/10.34667/tind.50062>. Accessed June 2025.

World Intellectual Property Organization (WIPO). 2026. *WIPO Statistics Database: IPC Technology Concordance*. Geneva, Switzerland: WIPO. Available at <https://www.wipo.int/search/en/results?q=ipc+technology+concordance+march+2026>. Accessed 31 March 2026.

Yoffie DB. 1993. Foreign Direct Investment in Semiconductors. In Froot KA, editor, *Foreign Direct Investment*, pp. 197–230. Chicago, IL: University of Chicago Press. Available at <https://www.nber.org/books/froo93-1>. Accessed 31 July 2023.

Notes

- 1** Scientific field normalization of citations helps account for differences in citation practices from one scientific field to another. For example, one scientific field may have citation norms where authors generously cite existing work that a given article is building on, while another may only cite the most essential and influential work. Without normalization, the former scientific field in the preceding example may be overrepresented in the global top 1%, whereas the latter scientific field may have no articles in the global top 1%. This ensures proportionality with total output and highly cited output.
- 2** The employment affiliation is voluntarily supplied by GitHub users in their profiles; as a result, the sector and agency are not listed for a notable share of developers. This incomplete coverage may affect the reliability of location and sector analyses, which should be regarded as experimental at this time. Please see the [Technical Appendix](#) for more information on the limitations of this data source.
- 3** The designations of large companies (more than 500 employees), small companies (fewer than 500 employees), and startup companies in this section are designated by AUTM in its Licensing Survey. They differ from the size designations within business establishment surveys elsewhere in this report, including the Annual Business Survey.
- 4** The number of licenses and license options executed by startups was not collected by AUTM after 2022.
- 5** For more information on federal agency obligations, see the *Indicators 2026* report "[Discovery: R&D Activity and Research Publications](#)" (NSB 2025) and NCSSES (2025b).
- 6** The classification of CETs discussed in this section differs from the ISIC-based KTI taxonomy discussed in the following section [Production Patterns of Knowledge- and Technology-Intensive Industries](#).
- 7** R&D-intensive manufacturing industries may engage in design, processes, or materials analyzed in the literature under several headings, including advanced manufacturing and intelligent manufacturing. Examples include additive or nano-based manufacturing and biotechnology and biomanufacturing. For additional information, see Brocal, Sebastián, and González (2019), IDA (2012), and PCAST (2020).
- 8** See Thomas (2026) for comprehensive economic statistics on U.S. manufacturing.
- 9** See the [Glossary](#) section for the definition of total private services used in this report.

Acknowledgments and Citation

Acknowledgments

The National Science Board extends its appreciation to the staff of the National Center for Science and Engineering Statistics within the U.S. National Science Foundation (NSF) and to the many others, too numerous to list individually, who contributed to the preparation of this report.

The following agencies reviewed this report:

Bureau of Economic Analysis

Bureau of Labor Statistics

National Institute of Standards and Technology

NSF

The Board is especially grateful to the Committee on National Science and Engineering Policy for overseeing preparation of the volume and to the National Science Board Office.

Citation

National Science Board, National Science Foundation. 2026. Translation to Impact: U.S. and Global Science, Technology, and Innovation Output. *Science and Engineering Indicators 2026*. NSB-2026-2. Alexandria, VA. Available at <https://ncses.nsf.gov/pubs/nsb20262>.

Contact Us

To report an issue with the website, please e-mail ncsesweb@nsf.gov. For questions about the U.S. National Science Foundation (NSF), please visit the NSF help page at <https://nsf.gov/help/>. To see more from the National Science Board, please visit <https://nsf.gov/nsb/>.

NCSES

National Center for Science and Engineering Statistics
Directorate for Social, Behavioral and Economic Sciences
U.S. National Science Foundation
Randolph Building, 401 Dulany Street
Alexandria, VA 22314
Tel: (703) 292-8780
FIRS: (800) 877-8339
TDD: (800) 281-8749
ncsesweb@nsf.gov