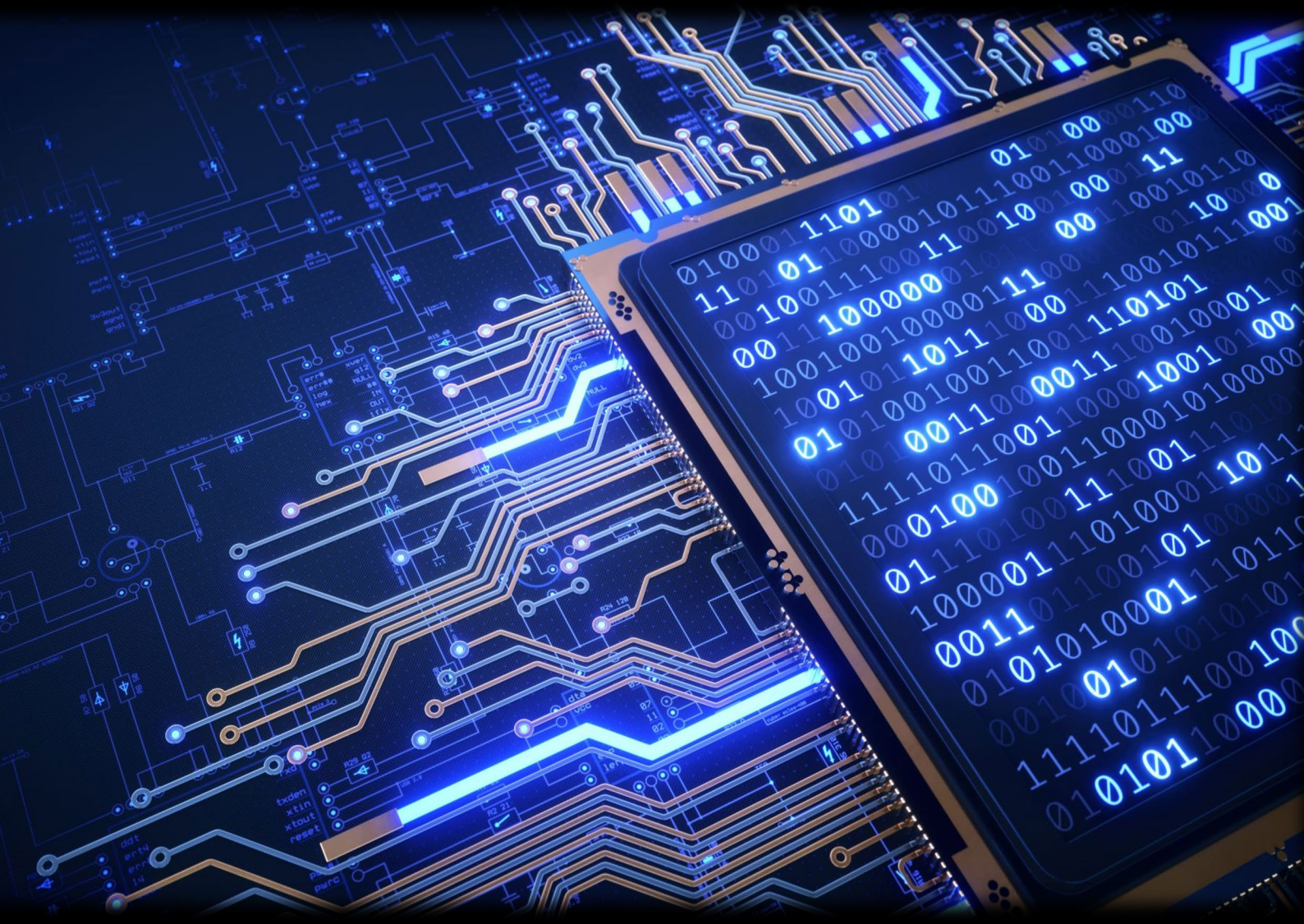
Unlocking the Economic Potential of the US Generative AI Ecosystem



accenture Microsoft

November 2024

Disclaimer

This document is intended for general informational purposes only. The report was commissioned by Microsoft and is a collaboration between Accenture and Microsoft.

Views and opinions expressed in this document are based on the companies' knowledge and understanding of its area of business, markets and technology. The companies do not provide medical, legal, regulatory, audit, or tax advice, and this document does not constitute advice of any nature.

While the information in this document has been prepared in good faith, the companies disclaim, to the fullest extent permitted by applicable law, any and all liability for the accuracy and completeness of the information in this document and for any acts or omissions made based on such information. Opinions expressed herein are subject to change without notice.

Contents

Executive Summary

Generative AI technology has transformative potential for workers, businesses, and broader society, but is still in the early stages of adoption.

Generative AI ("gen AI") represents a step change in technology, where computer systems modelled after the human brain are now capable of creating novel content. In the US, advances in gen AI are driving rapid growth across the ecosystem.

However, overall gen AI adoption in the US is still in its early stages, with only 14% of households and around 6% of firms regularly using gen AI.

Due to the breakthrough nature of gen AI technology and its wide-ranging potential use cases, its economic potential is significant and far-reaching. Productivity benefits alone could provide a $3.8 trillion uplift to the U.S economy by 2038.

Gen AI delivers economic benefits primarily by lifting worker productivity—augmenting human capabilities and streamlining repetitive processes. This increased productivity can lead to higher wages and greater business value. In addition, gen AI spurs both greater business innovation—new occupations, products, and services—and scientific breakthroughs. It also promises to catalyze a capital investment boom, both in AI infrastructure and in the broader physical assets needed to support the economy's gen AI-uplifted production potential. Despite some concerns about gen AI's potential impact on jobs, its productivity benefits and job creation potential are likely to outweigh temporary disruptions, especially with effective skilling initiatives.

The value generated across these dimensions can unlock downstream benefits, including continued US technological leadership and international competitiveness, greater wellbeing and improved health outcomes for Americans.

The US gen AI ecosystem is diverse and competitive, home to more than 1,500 small and large companies, attracting billions in new investment each year.

Despite its rapid recent growth, the ecosystem's breadth and complexity are still in their infancy and not yet widely understood among the general public. It consists of at least six different and interacting layers, starting from AI accelerator chips (aka Graphics Processing Units or "GPUs") and extending through cloud and networking, data and storage, foundation models, tooling, and ultimately to applications.

Cross-ecosystem collaboration is critical to mobilizing the investment and capabilities that different ecosystem participants require to innovate and facilitate broader adoption of gen AI.

Partnerships—and the funding and shared know-how they deliver—have helped drive innovation and the diffusion of gen AI across US industries. Some tangible benefits resulting from these partnerships include:

- Reduced input cost: model developers can leverage subsidized computational costs whether in the form of cloud credits or otherwise
- More R&D: published gen AI research is up 90x since 2016
- Lower prices: the prices of GPT-4 and Claude families of models, for example, have decreased by ~80% in recent months
- Better models: performance matches or exceeds baseline benchmarks

As the US seeks to build on recent gen AI progress and capture potential benefits, key pillars to guide stakeholders include:

1. Dynamic and innovative ecosystem
2. Skilled workforces
3. Scalable and accessible infrastructure
4. Clear policy frameworks
5. Public trust in generative AI

The Gen AI Revolution

1

Generative artificial intelligence ("gen AI") is a revolutionary type of AI with transformative potential for workers, businesses, and broader society.

The technology marks a step change in the development of AI (see **Exhibit 1**). Gen AI goes beyond the ability to analyze and classify existing data and can create entirely new content.[1]

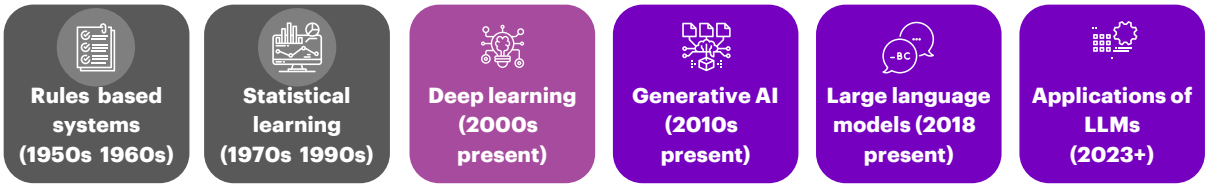
Gen AI models are built on neural networks—computer systems modeled after the human brain that can learn from and process diverse data inputs. Using that data, gen AI creates novel content across many forms or "modalities," including text, code, image, audio, and video.[2]

At the core of generative AI technologies are massive neural networks, known as foundation models, which are trained on vast datasets. The terms foundation model and large language model ("LLM") are often used interchangeably, although foundation models encompass a broader range of AI models beyond just LLMs.

Each of these foundation models serves different purposes, but they are all pre-trained on large datasets and adaptable to a variety of downstream tasks through fine-tuning. Leading foundation models such as GPT-4o and Claude 3.5 display advanced cognitive abilities, from writing and programming to idea generation and customer service.

With each passing generation, foundation models grow significantly in capability. Foundation models now go beyond simply inputting and outputting text and can perform tasks across multiple modalities, for example creating content based on text and image data together.

Exhibit 1: Generative AI is a step change in the evolution of AI



Artificial intelligence (AI) refers to technology that can perform tasks that ordinarily require human intelligence.[1]

Historically, these tasks have been limited to pattern recognition and processing, with improvements in complexity and accuracy developing over time.

Gen AI is a step change in AI development. As well as recognizing complex patterns and processing data, it can create new content in response to user prompts.

Large Language Models (LLMs), pretrained on extremely large datasets, can generate human-like text, and can be fine-tuned for specific tasks.

Such "foundational models" provide a platform for applications to be built on top, leading to more use cases and wider accessibility. For example, GPT-4 is an LLM, and ChatGPT is a chatbot application built on top of it.

Note(s): 1) Definition of AI adapted from the Executive Order on the Safe, Secure, and Trustworthy Development and Use of Artificial Intelligence (2023).

[1] *Accenture, 'A new era of generative AI for everyone' (2023).*
[2] *The term "modalities" in this context refers to distinct types of data that these models can process and create from.*

Select types of Foundation Models

1. **Language Models (LMs):** designed for natural language processing tasks, such as text generation, translation, and comprehension.
2. **Vision Models:** designed for image recognition and object detection.
3. **Multimodal Models:** designed to handle multiple types of data, such as text and images.
4. **Speech Models:** designed for speech recognition and generation.
5. **Omnimodal Models:** capable of processing and integrating multiple types of data (text, images, audio, video) simultaneously.

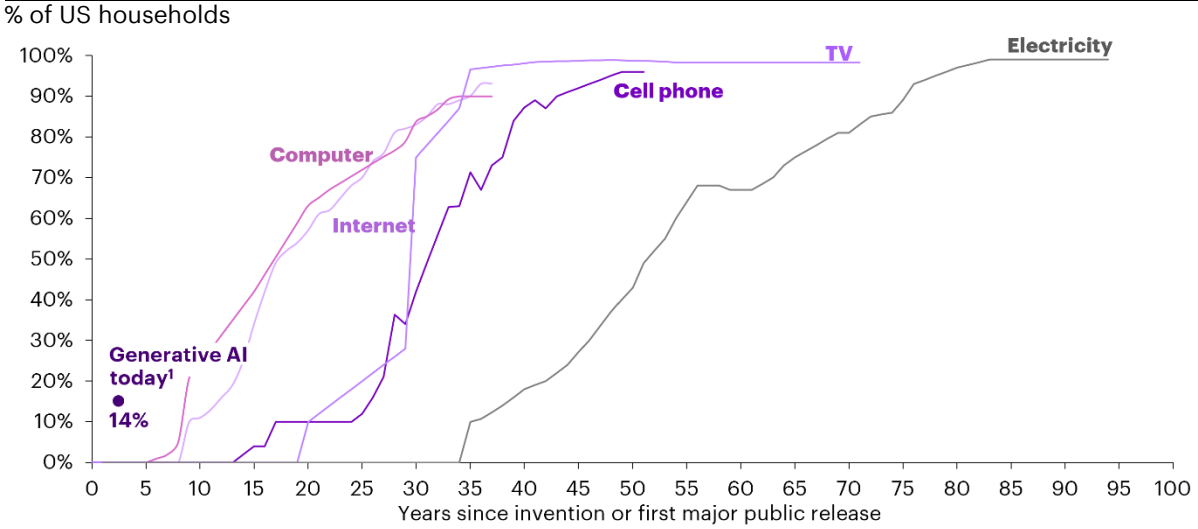
ChatGPT, developed by US-based OpenAI, marked a significant milestone in the gen AI landscape. Based on the Generative Pre-Trained Transformer ("GPT") architecture, a type of LLM, ChatGPT demonstrated a remarkable leap in natural language understanding and generation, showcasing the potential of large-scale Transformer models. This breakthrough in gen AI technology meant it was now applicable across various fields such as healthcare, robotics, and more, where understanding multiple data types is crucial.

As technology has progressed, foundation models have become more accessible and affordable. Since November 2023, the cost of utilizing such models has dropped by over 80%, largely due to innovations in model efficiency, better hardware utilization, and heightened competition among foundation model providers (see **Exhibit 17**).

Despite the promise of gen AI, adoption in the US is only in its early stages.

Only about 14% of US households use gen AI tools regularly, according to the US Census Bureau (see **Exhibit 2**). Meanwhile, at the corporate level, only around 6%[3] of US firms have integrated gen AI into their operations. Low adoption rates suggest that we are still in the early stages of gen AI's journey to becoming a mainstream, widely used technology. Continued innovation, infrastructure development, and workforce skilling[4] will drive adoption and diffusion of gen AI technology, which is essential to realizing gen AI's potential economic benefits.

Exhibit 2: Adoption of key technologies in the US



[3] *US Census Bureau (2024); adoption rate refers to all AI, and not gen AI specifically.*
[4] *A recent LinkedIn study observed a 142x increase in LinkedIn members adding AI skills, like Copilot and ChatGPT, to their profiles and a 160% increase in non-technical professionals using LinkedIn Learning courses to build their AI aptitude (2024).*

Gen AI's Economic Potential

2

Due to the breakthrough nature of gen AI technology and its wide-ranging potential use cases, its economic potential is significant and far-reaching.

From a macroeconomic perspective, gen AI's key channels of value creation can be broadly grouped as (see **Exhibit 3**):

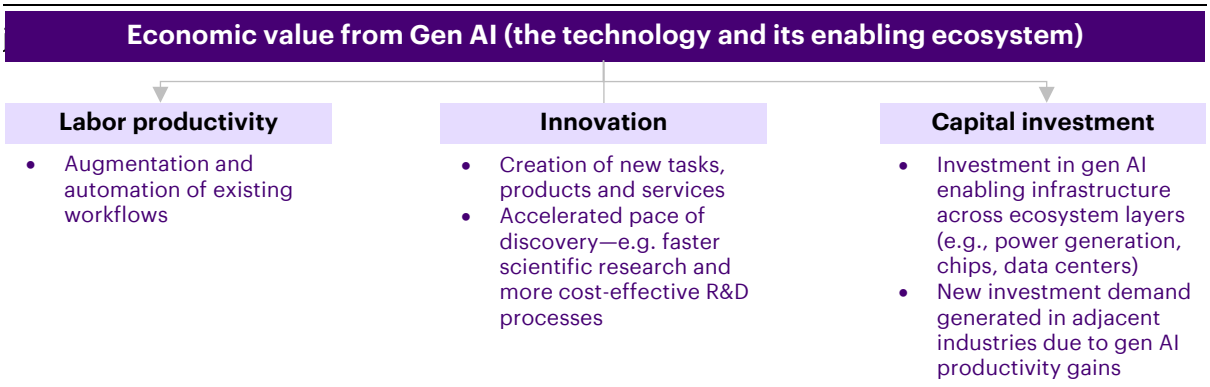
- **Labor productivity**—making existing workflows more productive and cost-effective via task automation and augmentation, allowing human resources to focus on higher value-added workflows
- **Innovation—**enabling the creation of new occupations, products and services, which stimulate job growth and business formation; and accelerating the pace of research and scientific progress
- **Capital investment—**catalyzing the buildout of AI-specific and broader enabling infrastructure, as well as the higher future capital investment needed to fulfill the economy's gen AI-uplifted production potential

Collectively, the value generated across these dimensions can also unlock various downstream benefits, including stronger US technology leadership and international economic competitiveness, as well as improved health and living standards for Americans.

The magnitude of these impacts will depend on the speed and scope of gen AI adoption and the development of its enabling ecosystem. To provide some approximation but remain conservative in the face of such uncertainty, we focus on quantifying the labor productivity uplift to GDP from the time savings and improved efficiency of existing tasks. Relative to other benefit categories, this labor productivity impact can be: (a) estimated with somewhat greater precision; and (b) is likely to be gen AI's largest measurable and direct benefit.[5]

For the other benefit categories—innovation, capital investment, and broader downstream impacts—we provide some directional estimates and examples. As a result, the economic value estimates below should be viewed as a lower bound on the magnitude of gen AI's potential benefits, with significant potential upside.

Exhibit 3: Key channels of gen AI's economic value creation



Note(s): Channels are not exhaustive nor mutually exclusive, and there are inherent interlinkages—e.g., new product, services or process innovation yields labor productivity benefits, and vice versa.
Source(s): Accenture analysis

[5] *To isolate the impact of productivity, we also assume constant share of capital and labor. Gen AI is also expected to have an impact on labor allocations, which are discussed in Box 1 on gen AI's potential job enhancement and creation potential and the importance of skilling efforts ensure effective labor transitions.*

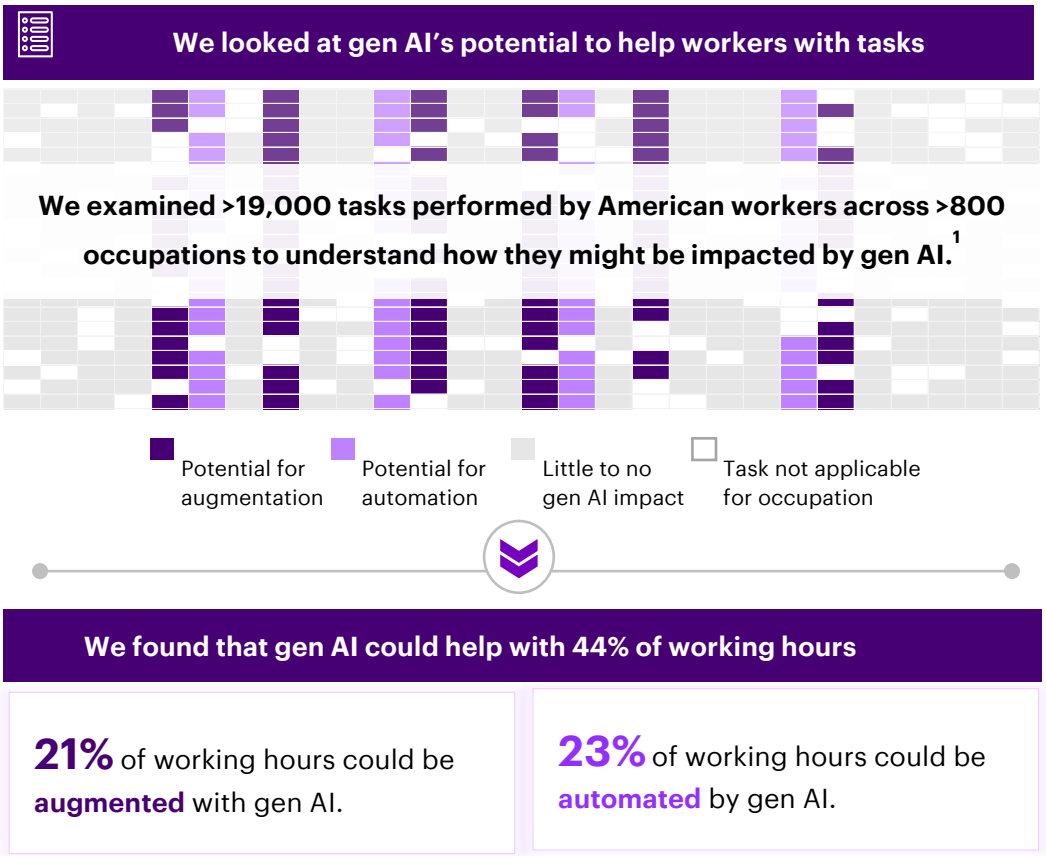
2.1 Labor productivity uplift

Productivity is crucial to the long-term growth of the US economy, and can generate value in several ways, including:

- Higher wages
- Reduced prices for consumers
- Increased innovation
- Greater business value.[6]

Gen AI makes workers more productive by helping them complete tasks faster and streamline repetitive tasks. For example, software coders using gen AI tools complete tasks in 56% less time than non-users.[7] And research shows that gen AI tools can reduce time spent on writing tasks by 37%, with improved quality.[8] These time savings enable workers to reallocate effort to higher-value activities that require human creativity and intelligence. The result is that workers achieve more overall with less time, boosting their overall productivity.

Exhibit 4: Gen AI can help workers with tasks covering 44% of working hours



Note(s): 1) We classified tasks based on four criteria: (A) requires human to human interaction; (B) non-routine and/or non-well-defined; (C) language intensive; (D) requires human involvement enforced by law, ethics, or social conventions. We used a combination of human and machine learning classification to classify all the tasks.
*Source(s): Accenture Research "Work, workforce, workers: Reinvented in the Age of Gen AI" (2024), Accenture analysis based on O*NET and US Bureau of Labor Statistics (BLS) data*

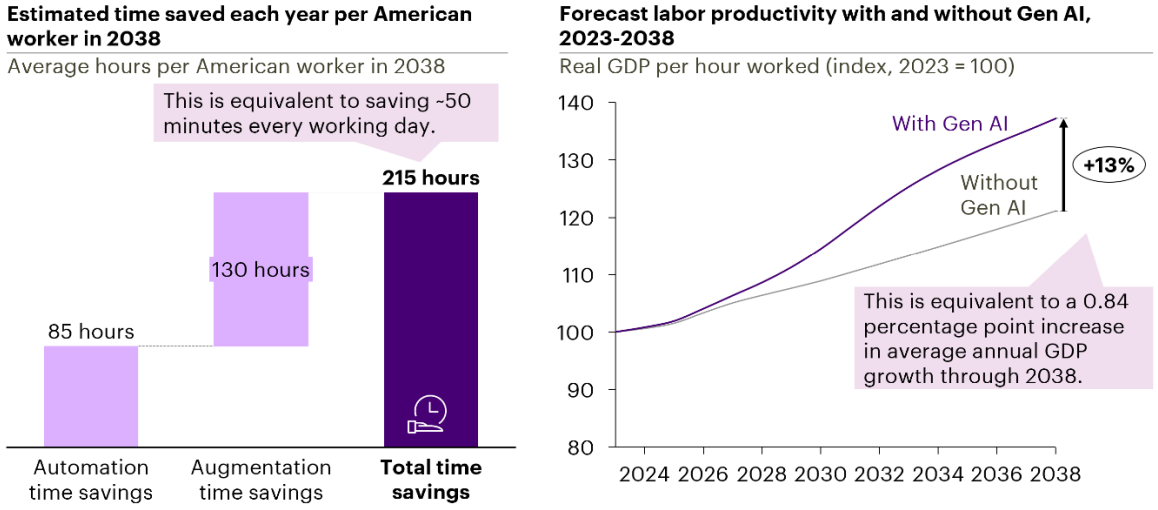
[6] *Hornbeck and Moretti (2019); US Bureau of Labor Statistics (2024).*
[7] *Peng et al., 'The Impact of AI on Developer Productivity: Evidence from GitHub Copilot' (2023).*
[8] *Noy and Zhang, 'Experimental evidence on the productivity effects of generative artificial intelligence' (2023).*

To size up the economy-wide potential for such increases to the productivity of existing workflows, we reviewed over 19,000 work tasks and found that gen AI could automate or augment tasks that account for 44% of working hours (see **Exhibit 4**).[9]

In aggregate, the resulting time savings to workers—up to 215 hours each year by 2038, or 50 minutes per working day—amount to an estimated 13% increase in their labor productivity by 2038 (see **Exhibit 5**). This equates to a 0.84 percentage point boost to GDP growth each year due to labor productivity increase from gen AI adoption over this 15-year period, a significant uplift considering US annual productivity growth has averaged 1.4% since 2004.[10]

This projected increase in labor productivity translates to a $3.8 trillion annual uplift to US GDP by 2038 (see **Exhibit 6**).[11] That impact is over 80% greater than the GDP contribution of the US's finance and insurance sector, and over double the contribution of the retail trade sector.

Exhibit 5: Gen AI could save American workers almost an hour (50 minutes) every working day and boost US labor productivity by 13% by 2038



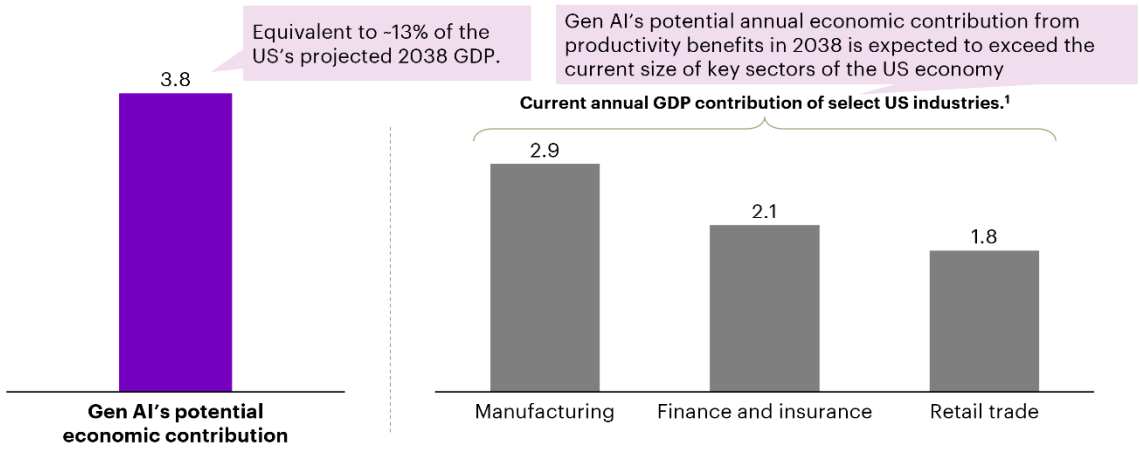
Source(s): Accenture Strategy analysis.

While there are valid concerns that the automation of certain tasks through gen AI could lead to job losses, experience with historical episodes of major technological change suggests such labor displacement is likely to be transitory and, over time, outweighed by the productivity benefits and new job opportunities created (see **Box 1**). As those new job opportunities are created, appropriate coordination with skills measures can also ensure that those workers who are impacted can more successfully respond to the demand for new skills. Investing in people's capabilities and enabling them to acquire new digital skills will be key to ensuring they benefit from gen AI technology and share in its full economic potential.[12]

[9] Tasks that have high potential to be augmented by gen AI include explaining policies or procedures, preparing draft documents or reports, and evaluating data quality. Tasks that have high potential to be automated by gen AI include reading and summarizing large documents, responding to simple customer inquiries, and reconciling datasets. Tasks that are unlikely to be impacted include inspecting facilities and equipment, sorting materials, and providing food services. Accenture Research "Work, workforce, workers: Reinvented in the Age of Gen AI" (2024)
[10] Productivity growth measured as the change in Real GDP per hour worked. OECD, 'Productivity levels' (2024).
[11] This amount is the contribution to GDP of higher productivity only. It does not reflect additional potential gen AI-related increases to GDP from capital deepening and other impact channels.
[12] International Labor Organization (2019, 2023)

Exhibit 6: Gen AI could deliver a $3.8 trillion productivity uplift annually to the US economy by 2038

Annual value added (USD, trillions; 2024 dollars)



Note(s): Seasonally adjusted at annual rates, quarter one of 2024. These figures are current GDP numbers, they do not represent gen AI's economic impact in each of those industries.
Source(s): US Bureau of Economic Analysis (2024); Accenture Research "Work, workforce, workers: Reinvented in the Age of Gen AI" (2024), Oxford Economics; Accenture analysis

Box 1: Gen AI's job enhancement and creation potential

Gen AI helps workers augment their capabilities and save time on tasks, enabling greater value creation and job satisfaction.

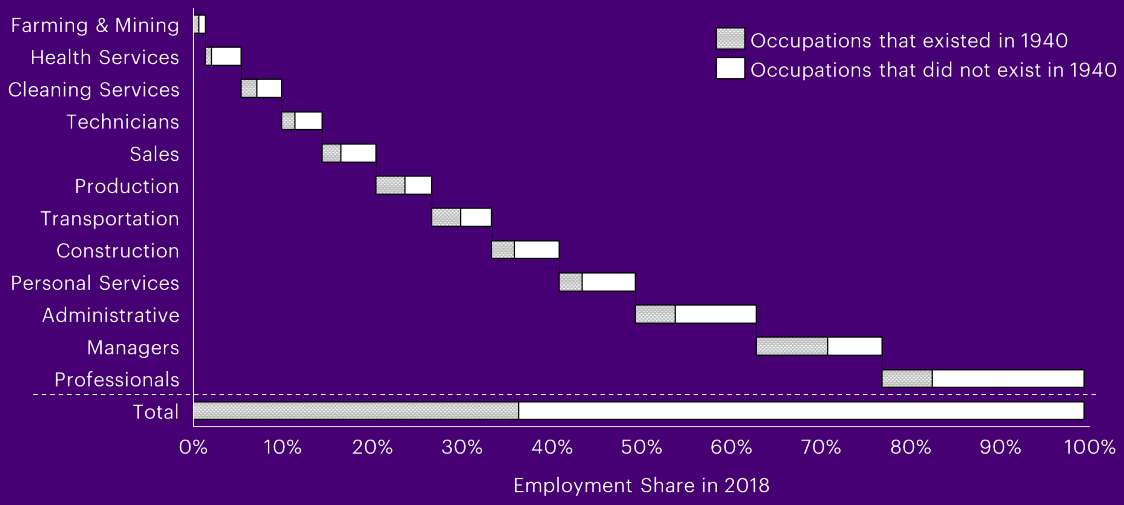
Our analysis demonstrates that gen AI has the potential to increase productivity by saving workers up to 13% of their working hours, primarily by streamlining or automating well defined, repetitive and often tedious tasks. This enables workers to focus on more complex and creative aspects of their roles, enhancing both job satisfaction and output quality.

As gen AI technology evolves, it is also expected to spur the creation of new markets and generate new job opportunities.

The creation of new markets and jobs through technological progress is well supported by historical trends in various sectors. More than 60% of US jobs in 2018 were in occupations that did not exist in 1940, illustrating how new roles have consistently emerged to replace those lost to technological advancements.[13] As these new roles are created, investment in skilling initiatives has often played a key role in equipping the workforce to meet demand for new skills and maintain career opportunities.

Technology-driven creation of new occupations is a key driver of employment growth

Employment share in new and pre-existing occupations, 2018



For instance, the share of jobs in Health Services grew five fold post 1940 due to the creation of new occupational titles over time, such as Certified Medical Technician (1990) and Pediatric Vascular Surgeon (2018). Collectively, this technology driven creation of new occupations accounts for more than 85% of employment growth over the last 80 years.[14] Following this trend, with targeted skilling efforts, individuals whose jobs may be affected by AI could transition into more specialized or new occupations, contributing to continued employment growth.

Additionally, empirical evidence suggests that innovations which augment worker capabilities drive employment growth in the occupations they impact most.[15] This is consistent with some recent surveys where businesses using AI report that they are twice as likely to add workers than businesses not using AI.[16]

2.2 Innovation

Gen AI can enable the development of new products and services that were not previously possible.

Some examples include intelligent robotics, virtual health coaches, intelligent policy analysis tools, intelligent threat and fraud detection platforms, personalized skilling platforms, and smart energy grid management systems. In turn, these new innovations can lead to the creation of new markets, driving business and job creation, and broader economic growth.

Examples of such promising gen AI-led innovation are already popping up across the US economy, notably in foundational sectors for growth and prosperity such as healthcare, travel and energy (see **Box 2**). In addition to the new types of innovation it can enable, gen AI also promises to accelerate the pace at which this innovation occurs. An important example of this is the process of scientific research, where gen AI can help, among other things, enhance the speed and cost efficiency of experimentation.

For example, a recent collaboration between the Department of Energy's Pacific Northwest National Laboratory and Microsoft Azure Quantum Elements successfully tested new inorganic materials for battery development in a record-breaking 80 hours (less than 4 days), compared to the years it traditionally took.[17] This breakthrough underscores the transformative potential of integrating advanced quantum computing[18] with gen AI, significantly accelerating innovation in energy storage technologies.

The evolution of foundation models is revolutionizing healthcare diagnostics by improving accuracy, efficiency, and cost-effectiveness, given their ability to process vast amounts of data quickly and accurately. For example, AI models can analyze mammogram images to detect early signs of breast cancer with over 90% accuracy, surpassing that of traditional diagnostic methods and enhancing clinicians' ability to rapidly evaluate tumors.[19]

In fact, late or misdiagnosis is linked to nearly 800,000 deaths or cases of permanent disability in the US every year.[20] Using AI to diagnose may reduce treatment costs by up to 50%, increase access to care, and improve health outcomes by up to 40%.[21]

Indeed, since 2019, new patents across all field-specific gen AI applications (excluding software) have increased by 24,960, nearly 6.3 times more than the 3,945 new patents filed over the 2014-18 period. The life sciences field leads in this gen AI-catalyzed innovation, with 4,816 new patents filed between 2019 and 2023, accounting for 17% of the total increase

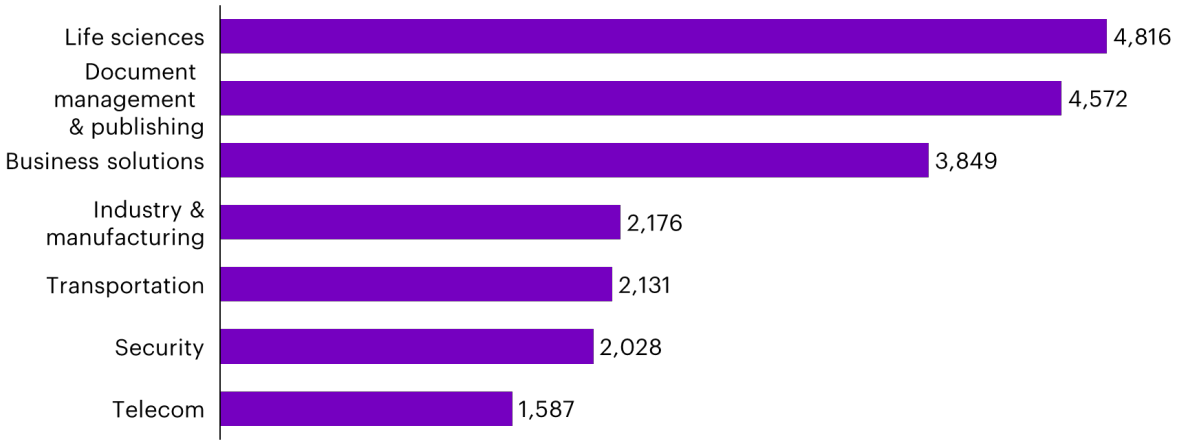
---

[13] Autor et al. (2022), National Bureau of Economic Research (2022), Accenture Strategy
[14] Goldman Sachs, 'Gen AI: too much spend, too little benefit?' (2024)
[15] Autor, David., National Bureau of Economic Research, "The labor market impacts of technological change: from unbridled enthusiasm to qualified optimism to vast uncertainty", Working Paper 30074, (2022)
[16] US Census Bureau, 'Tracking Firm Use of AI in Real Time: A Snapshot from the Business Trends and Outlook Survey' (2024).
[17] Microsoft, "Discoveries in weeks, not years: How AI and high-performance computing are speeding up scientific discovery " (2024), Pacific Northwest National Laboratory, "PNNL-Microsoft Collaboration", (2024)
[18] Like classical supercomputers, quantum computers perform multiple calculations concurrently. Quantum Computing is an advanced computing paradigm that perform computations at speeds exponentially faster than classical computers for specific complex problems. Think of more accurate prototype testing for manufacturing; optimized traffic and route planning; faster, more accurate drug development (2024)
[19] The Harvard Gazette, "Model uses features of a tumor's microenvironment across 19 different cancer types", (2024)
[20] Harvard University, "Diagnostic Errors Linked to Nearly 800,000 Deaths or Cases of Permanent Disability in U.S.", (2023)
[21] The Harvard School of public health, "Applied Artificial Intelligence for Health Care", (2022)

during this period (see **Exhibit 7**). Already, gen AI tools are revolutionizing drug development, with over 30% of new drugs expected to be discovered using gen AI in some way by 2025.[22]

Exhibit 7: Gen AI-catalyzed innovation surged since 2019

New patents for gen AI applications, by industry (cumulative over the 2019-2023 period)



Source(s): World Intellectual Property Organization (2024), Accenture Strategy analysis.

Box 2: Generative AI's real-world impact

Gen AI can solve real world problems in healthcare, travel and clean energy...

Biologics drug discovery usually takes ~10 years and $1B+ for one new drug to market.[1]

US flight disruptions, including those due to weather, cause ~116 million minutes of passenger delays each year.[2]

Traditional methods yield smaller energy improvements through trial-and-error and manual optimization.[3]

...By accelerating drug discovery, easing travel disruptions and optimizing energy infrastructure

US-based Absci leverages gen AI to accelerate the drug discovery process by ~50%.[1]

United Airlines' gen AI delivers personalized messages and end-to-end re-booking experiences for a seamless passenger experience.[2]

SparkCognition's Industrial AI Suite for Renewables can increase energy production by 5% and decrease operating costs by 10%.[3]

Note(s): 1) Absci, "An introduction to AI Drug Discovery (2023), 2) United Airlines (2023, 2024) 3) SparkCognition (2023)

[22] *CB Insights, '7 applications of generative AI in healthcare' (2023).*

2.3 Capital investment

The buildout of the gen AI ecosystem requires significant physical investment.

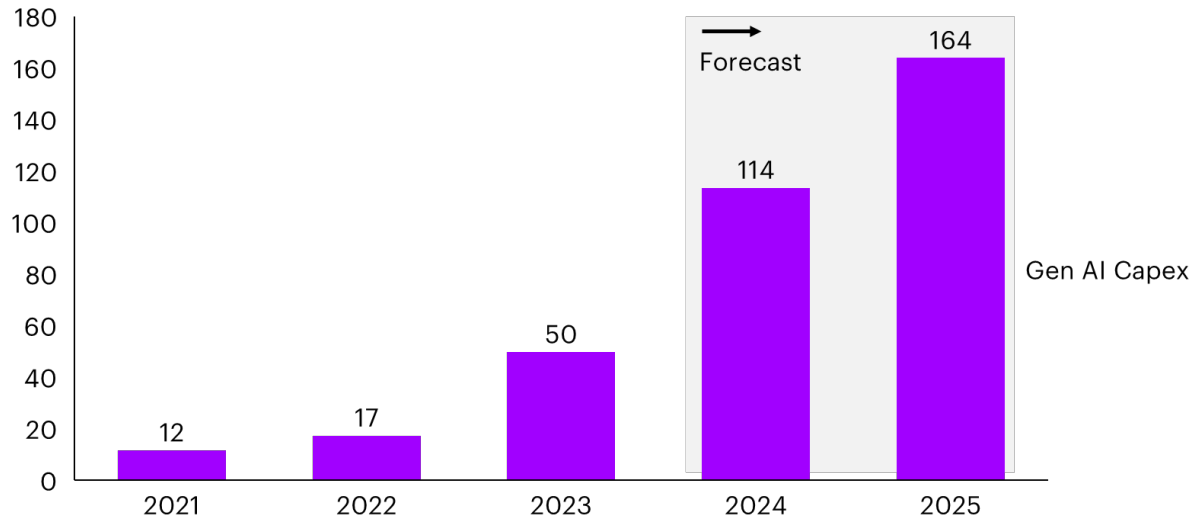
This includes not only the specialized hardware and computing resources (e.g., graphics processing units, data centers) to run gen AI models, but also the underlying energy and telecommunication infrastructure.

Though IT-related capital investment in the US has already been expanding rapidly over the past decade amidst digital transformation across companies and industries, gen AI has shifted this investment growth into higher gear. In 2024 alone, gen AI-specific business capex is projected to exceed $100 billion, mostly concentrated in the AI infrastructure layers (see **Exhibit 8**). And in the coming years, global companies are expected to spend approximately $1 trillion on AI-related capex,[23] more than 2.5 times the annual average amount of total IT capex in the US since 2015.[24] Nearly half of this capex will be allocated to the buildout of data centers, creating a large number of temporary jobs during construction, as well as permanent roles for data center operation such as skilled technicians, engineers, and IT specialists. According to Gartner, every dollar of GDP is expected to be influenced by AI by 2030.[25]

Additionally, the productivity gains from gen AI are likely to have a further multiplier effect on broader non-AI-related capital investment. This is because, as the economy becomes more productive, companies and workers require more capital to support their now-higher production potential.

Exhibit 8: Business capital expenditures on gen AI

Gen AI-specific business capex[1], (USD billions)



Note(s): 1) Gen AI-specific capital expenditures (capex) in the cloud & networking layer are based on Oppenheimer & Co. estimates of capex by key players in the cloud & networking layer, as of June 2024.
Source(s): AlphaSense, Oppenheimer & Co., Inc. (2024), Goldman Sachs (2024), Accenture Strategy analysis.

[23] *Goldman Sachs, 'Gen AI: too much spend, too little benefit?' (2024)*
[24] *U.S. Bureau of Economic Analysis, "Investment in Private Fixed Assets, Equipment, Structures, and Intellectual Property Products by Type" (2023)*
[25] *Gartner, "IT Spending Forecast, 3Q23 Update: The Impact of GenAI", (2023)*

Overall, this gen AI-catalyzed investment boom provides economic value in two key ways:

- It uplifts the growth of the US economy's capital stock—which is a key driver of longer-term GDP growth—to a materially higher trajectory;
- It will help scale up and improve the quality of public infrastructure—e.g., energy, water, telecoms—thus benefitting various non-AI sectors, as well as households and businesses in areas of the US that may currently not have high-quality access.

2.4 Broader downstream benefits

The combined impact of higher labor productivity, innovation, and growth-enabling infrastructure can enhance the US's international competitiveness across industries.[26]

This will help American companies unlock new export opportunities for their products and services, including those built with gen AI technology. US exports of database and other information services, which includes gen AI uses, are already seeing an uplift—growing roughly 30% between 2021 and 2023, compared to muted annual average growth of ~1% over the 2012-2021 period.[27]

Continued growth and innovation in the US gen AI ecosystem will also be critical in maintaining US global technological leadership.[28] This becomes even more important as competition over strategic technologies intensifies amidst rising geopolitical tensions and concerns around national economic independence and security. Over 60 countries have already established national AI strategies or identified AI as a key strategic sector.[29]

As gen AI has many use cases, some of which are strategic in nature, such as defense or cybersecurity, leadership in this field could potentially bring greater security to the US.
As early as 2019, the federal government recognized the strategic importance of AI, and the emphasis on it has only heightened in the years since.

> *"AI promises to drive growth of the United States economy, enhance our economic and national security, and improve our quality of life. The United States is the world leader in AI research and development (R&D) and deployment. Continued American leadership in AI is of paramount importance to maintaining the economic and national security of the United States and to shaping the global evolution of AI in a manner consistent with our Nation's values, policies, and priorities."*
>
> Executive Order 13859 (2019)

In parallel, generative AI can help small and medium-sized enterprises (SMEs) in the US[30] compete with larger corporations by closing gaps in content, insights, and technology. Tools like Jasper AI and ChatGPT enable SMEs to efficiently produce high-quality blogs, social media posts, emails, and product descriptions without large marketing teams. With their smaller size and greater flexibility, SMEs are

[26] *World Economic Forum, "How Countries are Performing on the Road to Recovery" (2020)*
[27] *US Bureau of Economic Analysis, "Table 2.1. U.S. Trade in Services, by Type of Service" (2024)*
[28] *MITRE, "Science and technology, U.S. competitiveness, and international collaboration", (2024)*
[29] *OECD.AI Policy Observatory (2024)*
[30] *There are more than 33 million small businesses in the US, which represent 99.9% of all US businesses, 97.3% of all US exporters and ~33% of export value. See US Chamber of Commerce, "The State of Small Business Now", (2023)*

generally well equipped to quickly adapt and innovate with gen AI solutions and stand to be key beneficiaries of the technology.[31]

Last, gen AI could also have broader benefits for Americans' health and happiness. In fact, gen AI is transforming medical diagnostics and making high-quality treatment options accessible to more patients by swiftly identifying those who would benefit from specific therapies.[32]

> *"AI has emerged as an era-defining technology and has demonstrated significant and growing relevance to national security…The United States' competitive edge in AI development will be at risk absent concerted United States Government efforts to promote and secure domestic AI progress, innovation, and competition."*
>
> White House Memorandum on Advancing the United States' Leadership in Artificial Intelligence; Harnessing Artificial Intelligence to Fulfill National Security Objectives; and Fostering the Safety, Security, and Trustworthiness of Artificial Intelligence (2024)

Productivity growth has been linked to greater wellbeing, as incomes rise and governments have more resources to spend on wellbeing.[33] In addition, higher levels of employee health can help employers reduce the nearly $530 billion per year in productivity losses caused by illness.[34] Likewise, greater wellbeing and improved health outcomes can have a positive impact on productivity, creating a mutually reinforcing growth cycle.

In sum, generative AI represents a rare opportunity to not only boost the economy, but also to reinforce America's global economic and technological leadership and to directly improve the wellbeing of Americans.

[31] *Harvard Business Review, "GenAI Can Help Small Companies Level the Playing Field" , (2024)*
[32] *The Harvard Gazette, "New AI tool can diagnose cancer, guide treatment, predict patient survival" (September 2024)*
[33] *International Labor Organization (2022).*
[34] *World Economic Forum, "A healthy workforce is good for business. Here's why" (2023)*

Growth and Innovation in the Gen AI Ecosystem

3

The gen AI ecosystem in the US is vibrant and rapidly growing, but its breadth and complexity are not widely understood by the general public yet.

The US ecosystem expands beyond the well-known applications and established players to include thousands of startups across several layers. Underpinning the entire stack is the land and power necessary to support the ecosystem. How those layers interact is critical to understanding how gen AI solutions are developed and deployed, enabling individuals and businesses to realize gen AI's potential benefits via productivity or other channels.

Equally important is understanding how investment in gen AI—capex in chips and AI infrastructure, as well as funding for more than 1,500 startups and larger companies—is driving the ecosystem's growth. Every year, billions of dollars are invested in companies across the ecosystem, leading to significant advancements in gen AI capabilities and creating high-quality jobs for Americans. Nonetheless, the ecosystem is still nascent, with more than 65% of gen AI companies in the early stages of their development as of the end of 2023.[35]

3.1 Ecosystem overview

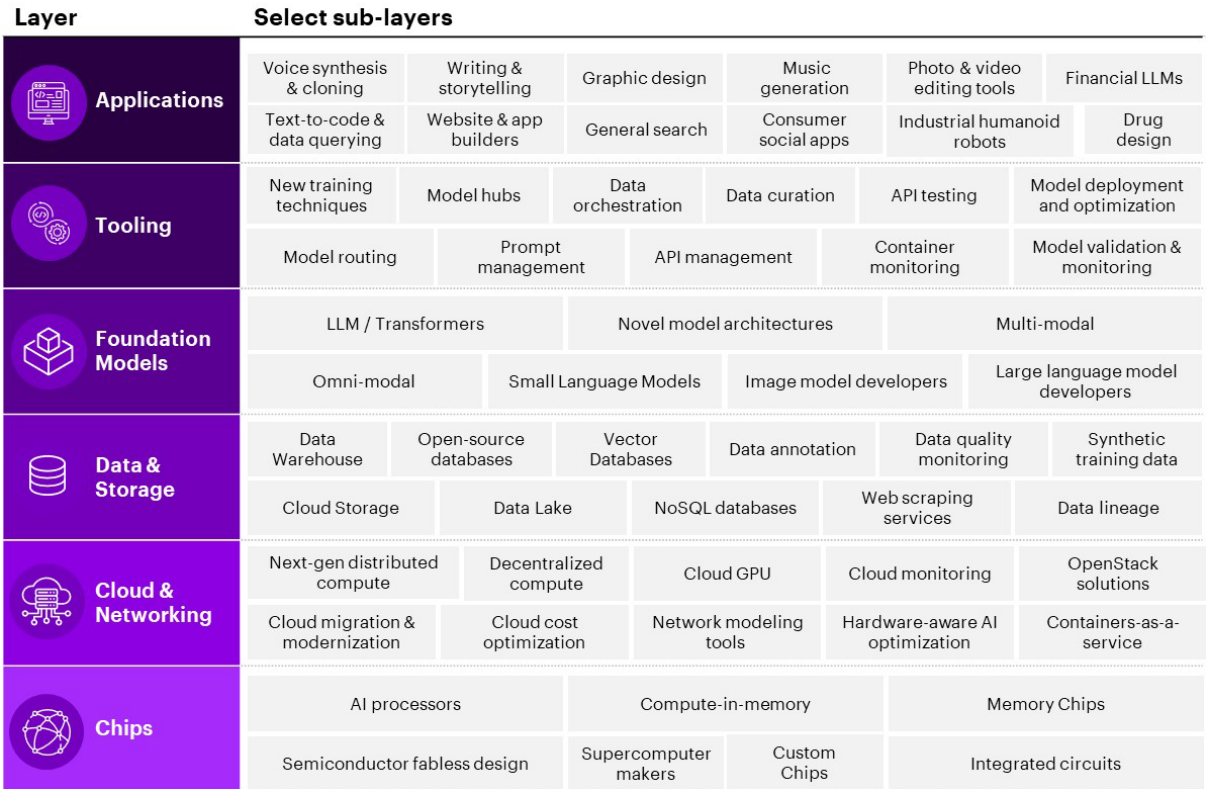
The gen AI ecosystem is composed of at least six layers, each playing a unique role in developing and deploying advanced gen AI technologies (see Exhibit 9):

- At the base of the gen AI ecosystem are specialized **chips** crucial for AI processing. Companies in the chips layer design and sell graphics processing units ("GPUs") amongst other advanced AI-specific chips, providing the computational power needed to train and run gen AI models effectively.
- Building on chips, the **cloud & networking** layer offers cloud-based compute power for training and inference of AI models. This also includes the network infrastructure needed to enable AI model training and inferencing.[36]
- The **data & storage** layer comprises two types of companies that ensure high-quality data is both accessible and securely managed, supporting the development of advanced foundation models. The first type specializes in collecting and processing vast amounts of structured and unstructured data. The second type provides scalable cloud storage solutions to securely store and process that data.
- Using the specialized chips, infrastructure, data, and storage solutions, companies in the **foundation models** layer develop and train these models.
- Firms in the **tooling** layer provide tools to manage and orchestrate foundation models, enabling scalable deployment, integration with data pipelines, and fine-tuning for optimal performance. In this layer, platform services offer a suite of optimization tools and standalone solutions, distinct from end-user applications. Through accessible APIs[37], developers can securely and reliably integrate gen AI capabilities into their applications.
- Lastly, at the top of the gen AI stack, companies and developers build specialized **applications** tailored to enable users—individuals, businesses, and governments—to leverage the power of gen AI.

---

[35] *CB Insights, State of Generative AI 2023" (2023)*
[36] *Inferencing is a process of using a trained foundation model to generate predictions and outputs based on new input data.*
[37] *API (Application Programming Interface) refers to a set of defined rules, protocols, and tools that enables developers to integrate AI capabilities, models, or services into their applications.*

Exhibit 9: Key layers in the gen AI ecosystem



Note(s): This exhibit is a non-exhaustive listing of select sub-layers and gen AI ecosystem players. Land and power are not included in this representation but are foundational to enabling the entire gen AI ecosystem. Companies in the cloud and networking layer are the primary developers and owners of AI data centers. The applications layer includes both first- and third-party applications. Part of this ecosystem are also various distributors of the products and resources of constituent layers, including independent software vendors, resellers, and gen AI diffusers and deployers (see Box 3).
Source(s): CB Insights (2024), Accenture Strategy analysis.

As gen AI technology has evolved, so has the complexity of this ecosystem, with established and emerging gen AI-native firms playing increasingly specialized roles along the value chain.

Delivering innovation requires coordinated action across ecosystem layers, combining complementary strengths, resources, and expertise to create solutions that benefit businesses and individuals alike. Across the layers, professional service partners also help end users such as businesses deploy gen AI applications and find product-market fit (see **Box 3**).

Ecosystem growth has also been characterized by continued innovation and competition across all six layers.

At the **chips** layer, Nvidia has been a leading player with its cutting-edge GPUs, but Google has also developed tensor processing units (TPUs) for its own AI workloads. Other semiconductor companies such as Advanced Micro Devices (AMD), Intel and Cerebras Systems are also investing in new chip designs to improve processing capabilities and compete for market share.[38]

[38] *CNBC, "AMD announces new AI chips amid intensifying competition with Nvidia, Intel" (2024)*

Box 3: Gen AI Diffusers and Deployers

Complementing the six ecosystem layers, professional services partners such as Accenture help organizations harness the disruptive power of gen AI to reinvent their businesses and realize gen AI's potential benefits.

These partners help accelerate the widespread use of gen AI solutions by facilitating knowledge sharing and best practices across industries, enabling businesses to adapt the technology to their specific needs.

Partners also help companies deploy generative AI models into their existing systems and workflows, enabling them to automate tasks, generate content, enhance decision making, and improve customer experiences, among other use cases.

In some recent examples, Accenture has partnered with several cloud providers to help companies deploy and realize the potential of generative AI technologies[39]:

- Partnership with Microsoft Azure to help create an intelligent, AI powered system for the Radisson Hotel Group that manages guest cancellations, and creates draft responses to guests' reviews
- Collaboration with Amazon Web Services to implement an end to end approach to create a regulatory document authoring solution for the pharmaceutical industry

In the **cloud and networking** layer, competition is intense as established players such Amazon Web Services (AWS), Microsoft Azure, Google Cloud Platform (GCP), Oracle Cloud Infrastructure, and International Business Machines (IBM), along with innovative startups such as CoreWeave, Lambda, Paperspace, and Cirrascale strive to win customers. While the US currently holds an edge in technology, competition in this layer extends globally, with non-US providers such as China-based Alibaba Cloud, Tencent Cloud and Huawei Cloud seeking to expand their presence in the global cloud market.[40]

While there is a significant amount of data available to train gen AI models, high quality data is not necessarily available or scalable for all ecosystem participants. At the **data and storage layer**, companies such as Databricks and Snowflake are competing to structure, manage, and provide secure access to datasets to train gen AI models. This competition extends beyond services to the underlying data itself: proprietary data libraries, owned and licensed by individuals or companies, often compete with open-source data libraries, such as those offered by Nvidia, highlighting the complex balance between exclusivity and accessibility in data resources

In the **foundation model layer**, competition is intense with US leaders like OpenAI, Google, Meta, xAI, and Anthropic battling for global market share alongside international players such as China's Baidu, and European newcomers like Mistral AI and LightOn. Innovation is essential in this layer for capturing and expanding market share, yet it comes with increasing demands for costly computational resources. Companies in this layer are continuously making large investments to push technological boundaries and maintain their competitive edge.

[39] *Accenture (2023 and 2024), Amazon Web Services (2024)*
[40] *Center for Strategic & International Studies, "An overview of global cloud competition" (2023)*

Most foundation models are built for general-purpose use, with some specialized models developed with specific industry applications in mind, such as in healthcare. Companies in the **tooling** layer offer crucial resources for creating, fine-tuning, securing, and managing LLMs to meet specific business needs. They also offer monitoring and compliance solutions for specialized models to track model performance, flag potential biases, and ensure adherence to regulatory standards.

Companies in the tooling layer also help foundation models orchestrate usage with other models, enabling interoperability, or even compete outright with established models. Specialized platform services like MosaicML (part of Databricks) challenge established players such as Nvidia in optimizing and improving model training efficiency. Additionally, this layer includes safety and orchestration tools, such as Azure AI Content Safety[41], which provide protective layers to ensure secure and reliable integration of LLMs within applications. Together, these tools enable tailored, responsible deployment and diffusion of gen AI.

Finally, companies in the **applications** layer, like OpenAI, Character.ai, Salesforce, Zoom, Cursor, Perplexity AI and Runway AI, compete to deliver innovative, gen AI-driven solutions that enhance productivity for businesses and individuals. These developers not only compete within their layer but also against foundation model developers, requiring continuous innovation to meet evolving customer demands.

3.2 Ecosystem growth and investment

The US gen AI ecosystem is home to more than 1,500 companies which are attracting billions of dollars in new investment each year.

The US gen AI ecosystem has been growing rapidly across all its layers, with the number of small and large companies operating in the ecosystem increasing by 26% annually since 2019—to over 1,500 as of July 2024:

- The highest growth has been in the tooling layer (41% annually), followed by the data & storage layer (~28%) and the applications layer (~25%). This growth in business formation reflects the dynamic and rapidly evolving nature of the gen AI industry.
- In contrast, the relatively slower growth in the chips layer (~10%) and cloud & networking layer (~4%) indicates relatively more mature and resource-intensive markets.
- The number of employees in the foundation model, tooling, and applications layers has increased nearly fivefold since 2019—to 73,270 as of July 2024.[42]

This ecosystem growth reflects substantial investment over the past five years (see **Exhibit 10**). From November 2019—when OpenAI's GPT-2 was released—until 2023, financial investment in the US gen AI ecosystem has grown by an average rate of 35% per year, leading to the creation of hundreds of new companies and high-quality jobs in the US. This funding has come from a variety of sources including private equity, traditional financial institutions, and venture capital (including corporate venture capital), reflecting a wide degree of interest

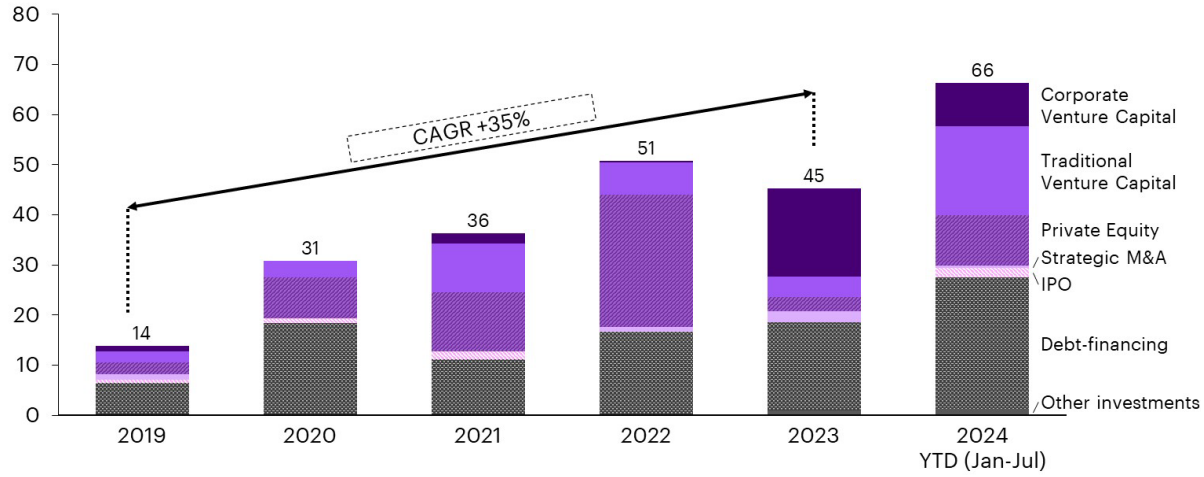
[41] Detect and block violence, hate, sexual, and self-harm content. Safeguard AI applications against prompt injection attacks and jailbreak attempts, configure severity thresholds and adhere to responsible AI policies. (2024)
[42] Analysis excludes upstream layers (Chips, Cloud & Networking, and Data & Storage), as they consist of large multinationals (e.g., Microsoft, Alphabet, Amazon) with extensive global operations and global employee footprint.

in the ecosystem. Public funding has played a somewhat less prominent role, thought it still has accounted for around 25% of all AI funding in the US, to date.[43]

Compositionally, much of the recent investment in gen AI has been channeled into foundation models in the midstream and applications downstream, where the ecosystem is growing rapidly. Nearly 70% of gen AI-specific funding since 2015 has flowed to foundation model and application developers—46% and 24% of the total, respectively (see **Exhibit 11**). Mid- and down-stream investment helps to develop more powerful foundation models and more tailored and specialized applications, driving greater adoption.

Exhibit 10: Financial investment in the gen AI ecosystem, by funding source

Annual funding of US gen AI startups, completed deals (USD billions)[1]



Note(s): Corporate VC data sourced from publicly available information for deals sized above ~$1B and does not capture the entire deal universe of corporate investment. Deals captured in the chart also reflect fundraising rounds led by corporate players but not necessarily funding the entire round. "Other investments" comprises general corporate purpose investments, private secondary transactions, joint ventures and unclassified deal types.
Source(s): Pitchbook Data, Inc (2024), TechCrunch (2023), Forbes (2023), Inflection.ai (2023), TechCrunch (2023), CNBC (2024), Accenture Strategy analysis

In parallel, established tech players within the ecosystem have allocated a sizable portion of their capex to building the ecosystem's infrastructure foundation. Amazon, Google and Microsoft allocated more than $23 billion in combined gen AI-specific capex in 2023, and this figure is expected to more than double in 2024 and triple in 2025.[44] The resulting improvements in computing hardware and cloud infrastructure, along with increased availability of large-scale and diverse training datasets, have been instrumental in enabling the development of larger and more powerful foundation models.

Moreover, the fast pace of innovation in gen AI technologies has created new tools and capabilities that require employees to adapt quickly. There is an increased need for employees to reskill to work alongside these technologies, ensuring they can perform more complex roles that require human oversight and creativity. US companies are increasingly recognizing the importance of investing in training programs to upskill and reskill their existing workforce, ensuring competitiveness and productivity in the workforce.

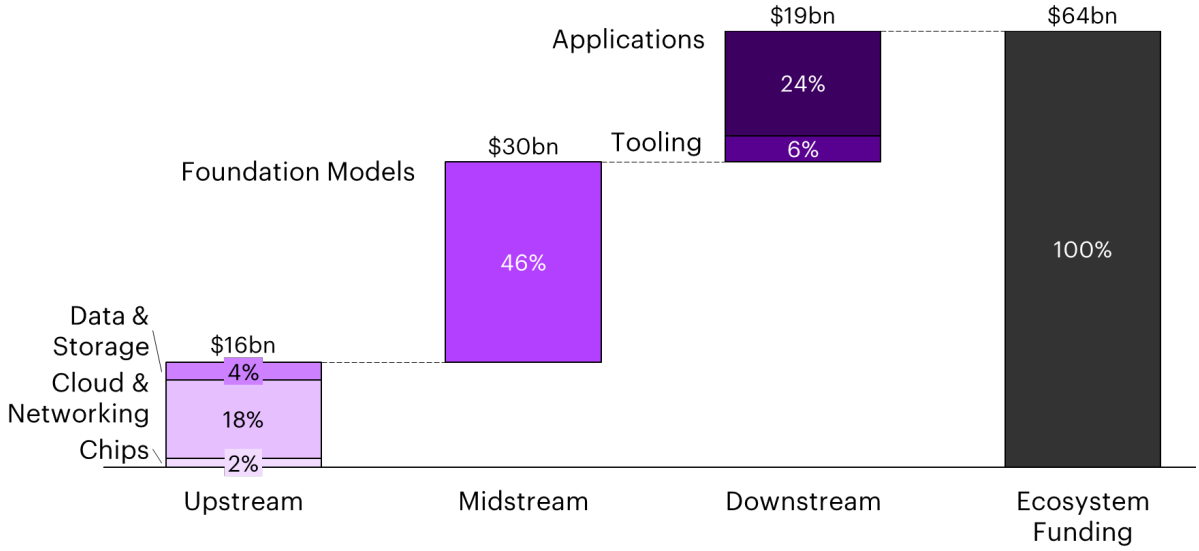
---

[43] Per Senate AI Blueprint to ramp up non-defense AI R&D spending to at least $32 billion per year. Figures are estimated based on average government AI R&D spending and estimate from US Government Accountability Office, (~$15bn), (2024) (2022), while private investment in AI is sourced from the Stanford University Human Centered Artificial Intelligence (2024)
[44] Per Oppenheimer & Co., Inc. (June 2024)

A late 2023 survey found that 53% of service companies and 47% of manufacturers planning to adopt AI expected to retrain their workforce within the next six months—up from the 24% and 31%, respectively, reported six months earlier.[45]

Exhibit 11: Funding for gen AI startups, by ecosystem layer

Cumulative investment in gen AI startups established post-2015, (USD billions)



Note(s): 1) Total cumulative capital raised, since 2019, per layer in companies founded post-2015, the year OpenAI was launched.
Source(s): Pitchbook Data, Inc. (2024), Accenture Strategy analysis.

[45] *Bureau of Labor Statistics, "Artificial intelligence and firm-level labor and organizational dynamics" , (2023)*

Role of Partnerships in Growth and Innovation

4

The growth and development of the gen AI ecosystem hinges on collaboration and complementary resources and capabilities.

Due to the high costs of developing foundation models and infrastructure, the complexity of the technology, and the specialized talent needed to advance it, resource needs across the ecosystem are significant and diverse.

Cross-ecosystem collaboration is therefore critical to mobilizing the investment and capabilities that different ecosystem participants require to continue innovating and developing applications tailored for businesses and individuals, which, in turn, facilitates wider adoption of gen AI.

Though the ecosystem is still developing, partnerships are already playing this vital resource-mobilizing and connective role and yielding tangible benefits for both established and emerging ecosystem players. The resulting innovation and competition are driving improvements in the capability of foundation models, lowering costs, and increasing access to and adoption of the technology. Such progress helps drive greater adoption and value for the economy and is likely to accelerate, if encouraged.

4.1 Ecosystem resource needs and the value of partnerships

Companies across ecosystem layers require diverse and often-costly resources, including advanced GPUs, AI-enabled data centers, and specialized AI talent (see Exhibit 12).

Exhibit 12: Key inputs needed to operate competitively in each layer

Layer	Select resources needed to operate (not exhaustive)		
Applications	AI talent[1]	Foundation model integration	
	Compute for inference	Application-specific data	Distribution channels
Tooling	AI talent[1]	AI frameworks and code libraries	
	Synthetic data generation		
Foundation models	Compute	Large-scale, training data	AI talent[1]
	Distribution channels	Algorithm design IP	
Data & storage	AI talent[1]	AI data libraries	Interoperability
	High-quality structured and unstructured datasets	Scalable Infrastructure	
Cloud & Networking	Scalable infrastructure	Customer relationships	High bandwidth networking
	AI talent[1]	Energy	
Chips	Compute for chip design	AI talent[1]	Management and licensing of Intellectual Property
	Supplier relationships	Customer relationships	

Note(s): 1) Per Skillsoft, nearly 66% of business leaders feel the AI skills gap burden. Leaders, in a survey, identified 21 areas with greatest difficulty for hiring talent, including AI and machine learning (30%), cyber and info security (30%), cloud computing (26%), data science (23%), application development (18%), Blockchain (13%) and DevOps (12%).
Source(s): Accenture Strategy analysis, Skillsoft (2023)

These resource requirements drive companies to seek access to capabilities and/or funding to grow and innovate in ways they could not achieve alone.

Foundation model developers, in particular, rely on significant compute power, specialized chips, vast datasets, and other resources to develop and train their models. For instance, Gemini Ultra, a leading foundation model launched in February 2024 by Google, reportedly cost an estimated $190 million to develop.[46]

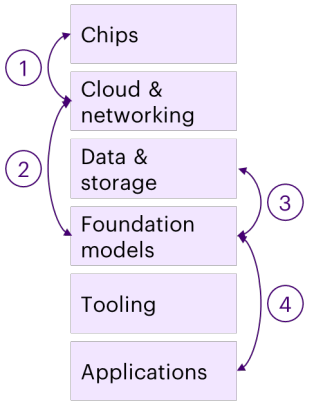
Though a subset of these resource requirements is specialized and layer-specific, many are common for companies across the ecosystem, indicating high potential for complementarities and synergies from partnerships.

In this context, partnerships have emerged in recent years as a common mechanism to meet the challenge of high and diverse resource requirements, pairing participants' complementary resources and capabilities to help them grow and achieve unique innovations.

A partnership is a vertical commercial collaboration that provides participants mutual access to resources needed to compete, innovate, and grow. Partnerships leverage the complementary strengths of each partner, unlocking levels of innovation that would be difficult for either to achieve independently. To date, four main partnership types have emerged that are contributing to the innovation and resulting diffusion of gen AI technology (see **Exhibit 13**).

Exhibit 13: Four emerging partnership types in the gen AI ecosystem

Key partnership types	Value to first partner	Value to second partner	Benefits of collaboration
1 Chips and Cloud & Networking	• Gain cloud integration expertise and broader market reach	• Access high-performance AI chips	• Shorter gen AI research and development cycles • Creation of innovative products and services • Pioneering scientific breakthroughs • Faster diffusion of gen AI technology • Shared risk management • Reduced costs
2 Cloud & Networking and Foundation Models	• Access cutting-edge foundation models (like GPT)	• Leverage cloud infrastructure for broader deployment and scaling	
3 Data & Storage and Foundation Models	• Expand their market by supporting advanced AI workloads	• Access large, scalable data and storage solutions	
4 Foundation Models and Applications	• Gain access to new markets through AI-driven applications	• Access foundation models for integration	



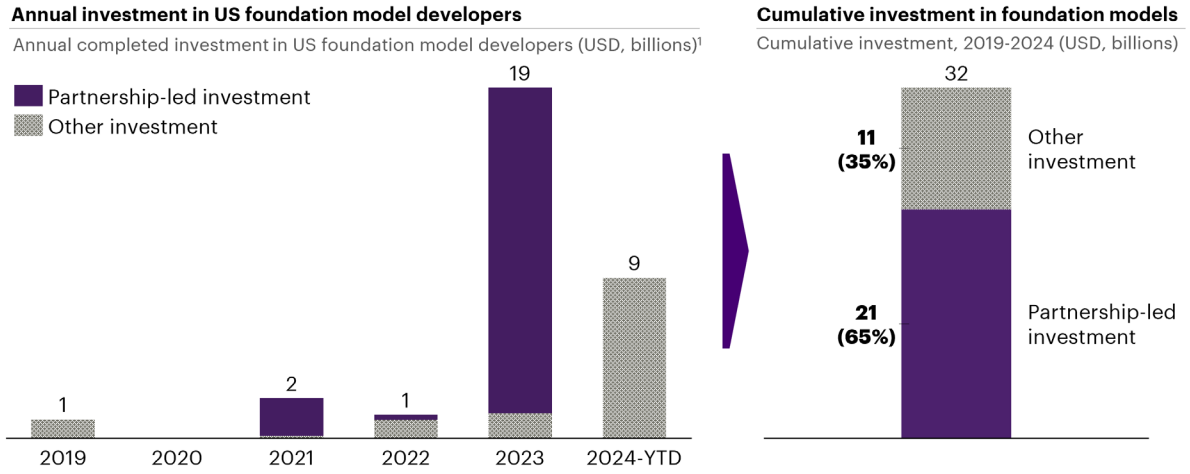
Source(s): Company announcements; Accenture Strategy analysis.

These collaborations have often been accompanied by significant financial or in-kind investment, which has been critical to funding the gen AI ecosystem. This has included resources such as cloud credits, providing partners with access to expensive compute power at a lower cost, or capabilities such as efficient handling of large data sets, helping to accelerate data access and processing for model training.

[46] *Per Stanford University Human-Centered Artificial Intelligence (2024).*

In particular, foundation model developers, who have been at the core of gen AI's recent ascent, have received significant support from partnerships—65% of the estimated $32 billion in funding[47] since 2019 (see **Exhibit 14**).

Exhibit 14: Partnership-led investments have contributed 65% of the funding for foundation model developers since 2019



Note(s): 1) The set of partnership-led investments does not include non-publicized or minor deals. Total annual investment captures corporate and non-corporate led funding into gen AI's foundation model layer in the US as of July 15, 2024. Numbers may not sum due to rounding. 2) Other investment in 2024 includes DAMAC's $1.3B investment in Anthropic and $6B raised by xAI.
Source(s): Pitchbook Data, Inc. (2024), Accenture Strategy analysis

These partnerships—and the funding, cloud credits, and shared know-how they deliver—have been critical to driving innovation across the gen AI ecosystem, enhancing model capabilities, decreasing costs, and accelerating the diffusion of gen AI technology.

Some key partnership examples include:

- The **Microsoft and OpenAI** partnership to accelerate the development of AI products, enabling gen AI start-ups to enter, expand, and succeed in the AI market while allowing both companies to remain separate and compete independently (see **Case Study 1**).

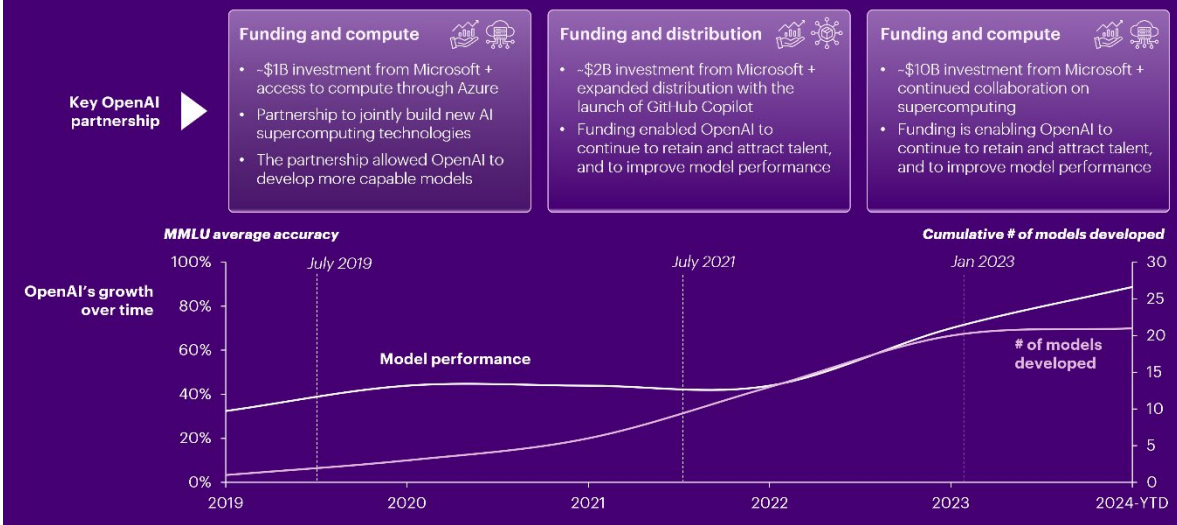
- **Nvidia's partnership with CoreWeave** (a lesser-known cloud provider), which gave CoreWeave access to Nvidia's cutting-edge GPU resources and enabled it to scale its infrastructure and compete with established cloud service providers (see **Case Study 2)**.

- **Anthropic's partnerships with Amazon and Google**, which enabled access to vast computational resources and advanced infrastructure that accelerated its model development and deployment, positioning it to compete with other AI labs and large language model developers such as Google DeepMind (see **Case Study 3**).

Case Study 1: Microsoft OpenAI

Partnerships played a crucial role in enabling OpenAI[48] to innovate and scale by providing it with funding, compute, and a global infrastructure for distribution.

- Microsoft and OpenAI have had a collaborative partnership since 2019, providing OpenAI with computing power and other key resources.
- Microsoft builds supercomputers which enable OpenAI to develop and train cutting edge models and to host its technology on Microsoft's computing infrastructure, enabling commercialization of OpenAI's products.
- Through this partnership, OpenAI can take advantage of Microsoft's capital investment to build and operate AI ready computing infrastructure, including data centers (whose costs can run into the billions of dollars).[49]
- The partnership agreement has fostered successive funding agreements, providing OpenAI with a cumulative $13B over the 2019 23 period that enabled it to scale up its model training capability and to recruit top AI researchers & engineers.[50]



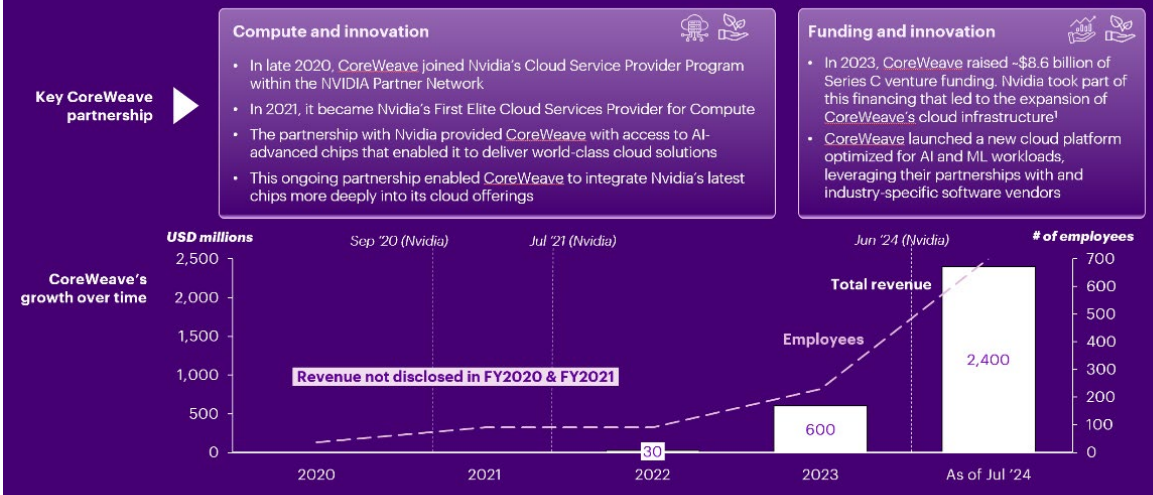
- Today, OpenAI is a leading company in the gen AI space, a key player in the development of advanced AI technologies, and a driver of innovation.[51]
- OpenAI remains an independent company, and the partnership allows OpenAI and Microsoft to compete independently. As such, OpenAI also partners with other ecosystem participants including Apple, IBM, Reddit, Salesforce, Upwork, Stripe, among others.

[49] *Per Stanford University Human-Centered Artificial Intelligence (2024).*

Case Study 2: Nvidia-CoreWeave

Nvidia enabled CoreWeave to scale its operations and position itself as a key player in cloud computing, directly competing with established players in the Cloud space.

- In 2020, Nvidia's partnership with CoreWeave enabled the latter to secure access to their latest cutting-edge A100 GPUs, significantly boosting their compute capacity.
- Over the 2021-2022 period, CoreWeave scaled its cloud services rapidly, benefiting from Nvidia's hardware and technical guidance.
- In 2023, CoreWeave became one of Nvidia's key partners, receiving funding support and access to the latest H100 GPUs that delivers up to 7x higher performance, further enabling the company's cloud infrastructure and offerings.[52]
- Today, CoreWeave offers innovative scalable computing power at competitive prices, allowing access to high-performance GPUs through a flexible cloud-based rental model without the need for substantial upfront investment in infrastructure.



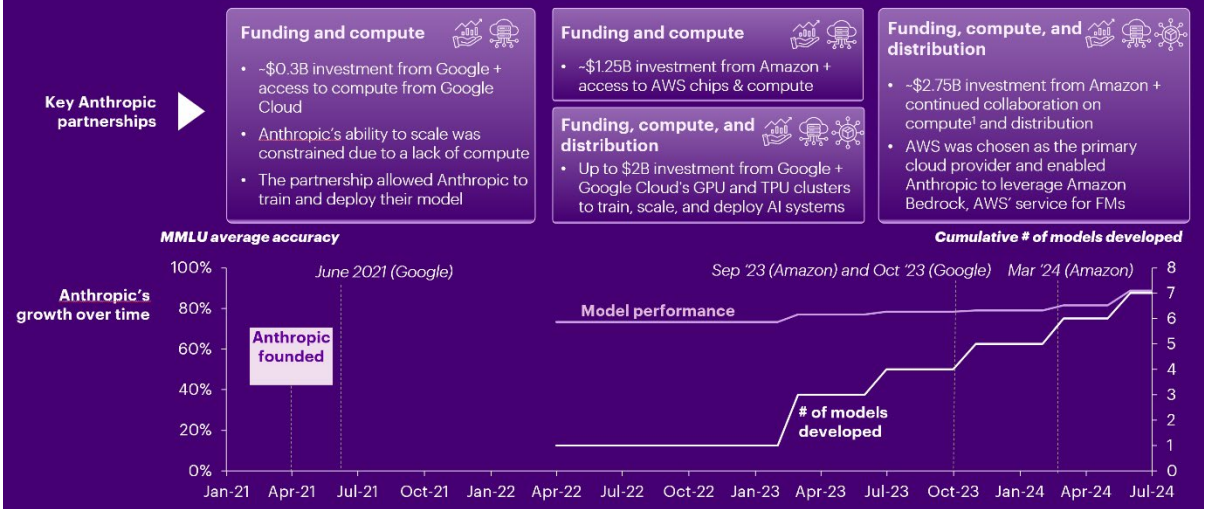
- CoreWeave's partnership with NVIDIA and the inherent cost advantages enabled it to scale and compete with established cloud providers like Google Cloud,
- CoreWeave is growing its global footprint with plans to invest $2.2bn to build three data centers in Norway, Sweden and Spain by the end of 2025.[53]

[50] Per company announcements, Pitchbook Data, Inc. (2024), CB Insights (2024), Paperswithcode (2024), Stanford University "The Center for Research on Foundation Models" (2024).
[51] This breakthrough in gen AI technology meant it was now applicable across various fields such as healthcare, robotics, and more
[52] Nvidia's broader investment amounts into CoreWeave remain undisclosed, with disclosed transactions includes the $100 million investment and $2.3 billion in debt collateralized by Nvidia chips that were announced in 2023. Investors in the round included Blackstone, Coatue, Magnetar Capital, BlackRock, and Carlyle along with other investors. CoreWeave's post-money valuation jumped 2.7x from end-2023 to $19B by May 2024.
Source(s): Pitchbook Data, Inc. (2024), CNBC (2023), CoreWeave partnerships (2024), Financial Times (2024).
[53] Financial Times, "How an upstart is using its Nvidia ties to challenge cloud computing giants" (2024).

Case Study 3: Alphabet & Amazon Anthropic

Partnerships helped ensure Anthropic[54] was well funded and had access to compute and effective distribution channels.

- Google parent Alphabet's partnership with Anthropic provided access to key resources including funding, compute, and clusters of specialized AI graphics processing units (GPUs) and tensor processing units (TPUs), helping to train and deploy the Claude family of models.



- Likewise, Anthropic signed partnership agreements with other cloud providers, such as AWS, to expand its access to compute power and distribution.[55]

- Anthropic's partnership with Google has unlocked an estimated $1 2 billion in funding and access to compute from Google Cloud, and the partnership agreements with Amazon an additional $2 3 billion in funding and compute power.[56]

- Together, these partnerships have helped models in the Claude family to remain competitive, with performance on par relative to OpenAI's GPT or Meta's Llama.

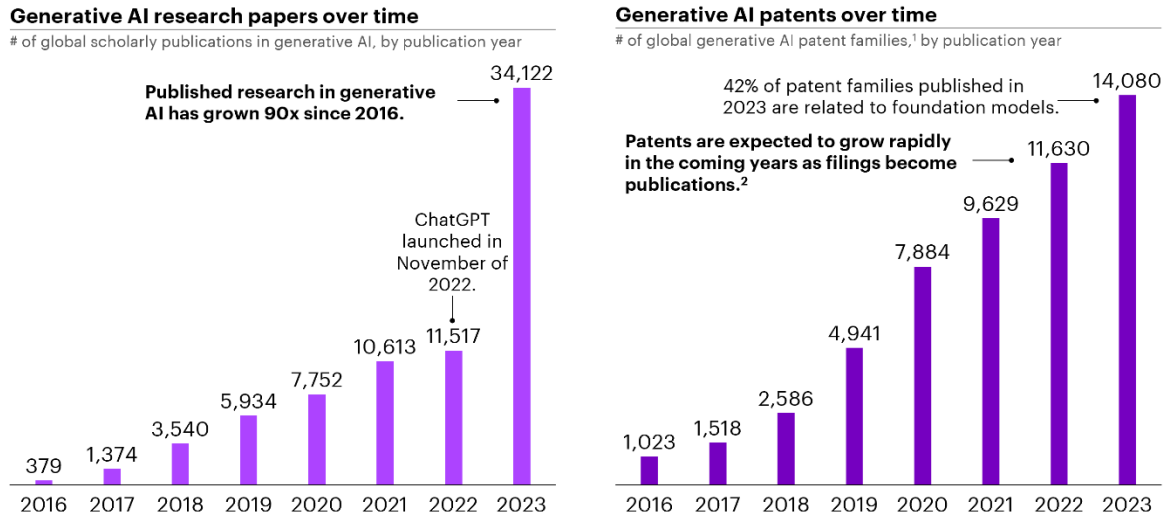
[54] *Other Anthropic partnerships include Zoom, Scale AI, Quora, DuckDuckGo, among other ecosystem players.*
[55] *Anthropic commits to a long-term deal to integrate its future AI FMs with AWS, leveraging AWS's Trainium and Inferentia chips for development and deployment. Chart shows number of models developed based on Stanford's center for Research on FMs and includes Claude 3.5 Sonnet per company announcement in June 2024.*
[56] *Company announcements; CB Insights (2024), Paperswithcode (2024), Stanford University "The Center for Research on Foundation Models" (2024), The Verge (2023), Anthropic (2023) (2023) (2023), Bloomberg (2024), Context.ai (2024)*

4.2 Improving model capabilities and falling costs

More gen AI research and development has resulted in tangible benefits such as improved gen AI model performance and lower costs, which help drive wider diffusion and adoption of gen AI.

R&D for gen AI has surged in recent years, with published research growing 90x over 2016-2023 and patents expected to rise as research leads to filings (see **Exhibit 15**). This innovation has also rapidly improved foundation models, boosting the performance of many to match or exceed baseline benchmarks (see **Exhibit 16**).

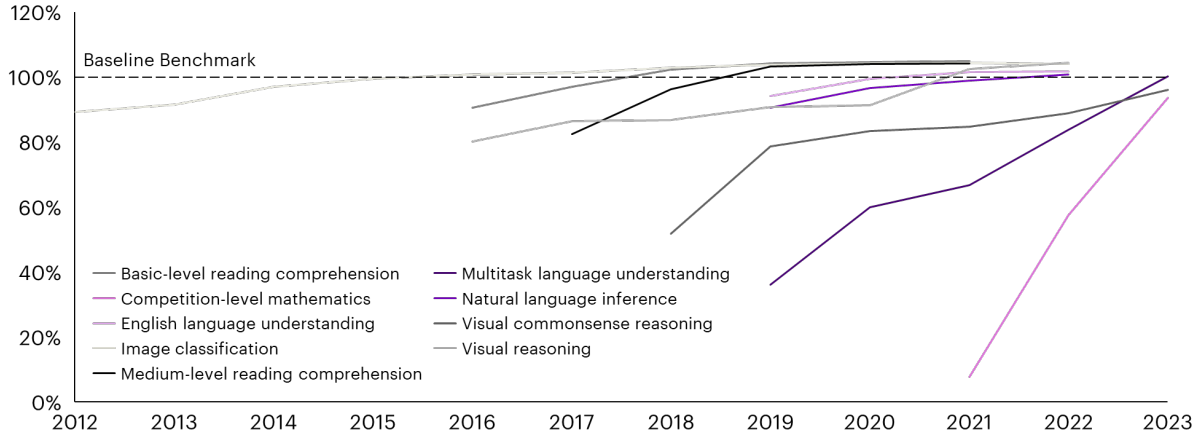
Exhibit 15: Generative AI research publications and patent filings since 2016



Note(s): 1) A patent family is a collection of patent applications covering the same or similar technical content (i.e., the same invention). 2) There is generally an 18-month lag between filing and publication.
Source(s): World Intellectual Property Organization (2024), Accenture analysis

Exhibit 16: AI model performance versus baseline benchmark

AI performance across a range of benchmarks compared to baseline
AI technical performance score, scaled to enable comparison



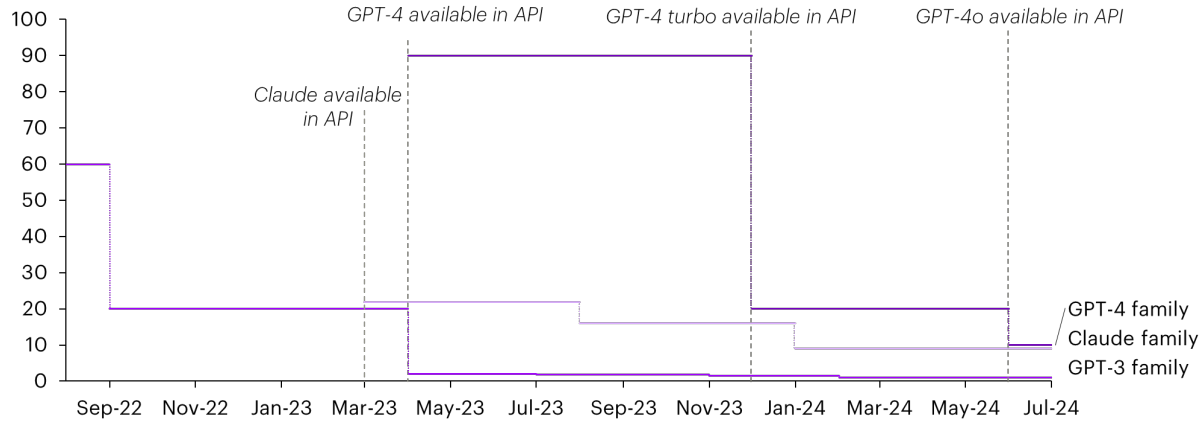
Note(s): Baseline benchmark refers to standard metric of human-level performance.
Source(s): Stanford Human-Centered Artificial Intelligence (2024).

As model capabilities have risen, the cost for developers to access leading foundation models has sharply decreased, whether measured by data processing costs or application programming interface (API) input/output expenses (see **Exhibit 17**). Since these models underpin many downstream generative AI applications, lower costs have driven significant growth and innovation in the tools and applications that rely on them. This in turn drives greater adoption.

Exhibit 17: Decreasing cost to access leading foundation models

Cost for developers to access leading foundation models over time

Average API input and output token price of the leading model within each family at each point in time (USD per 1 million tokens)[1]



Note(s): 1) Pricing for generative AI developers typically depends on how many small pieces of text (tokens) the AI reads or writes while being used.
Source(s): OpenAI (2024); Anthropic (2024); Historical prices found using Wayback Machine.

4.3 Competition from open models

Continued innovation has also helped drive a boom in open foundation models.

Open foundation models[57] typically have publicly available model architecture, pre-trained models and/or possibly training data, allowing anyone to modify, share, and collaboratively develop them. Indeed, there is a spectrum of openness in models, ranging from fully closed to various degrees of access: hosted access, API access, API access for fine-tuning, open weights, open weights with restricted data and code, and fully open weights, data, and code without restriction.

Increased R&D and better, cheaper closed models help the open-source community:

- The success of frontier closed models has demonstrated the potential of LLMs and the high consumer demand for them
- Closed models have been used to refine and improve open models
- Increased R&D has supported the development of more and better open models.

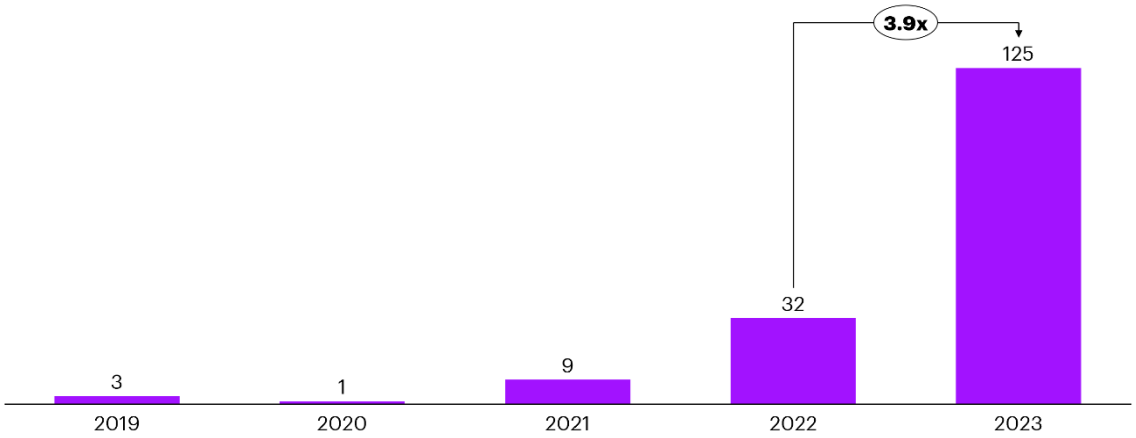
In addition, there has been a sharp increase in the number and capability of open models (see **Exhibit 18**). Compared to closed models, open models are cheaper to access and are often smaller and more efficient at simple tasks, reducing cost for developers (by 10x or more).

[57]*Proprietary models can be both open or closed and this report assumes open models can be both proprietary or non-proprietary. Proprietary open models offer some level of transparency and accessibility while maintaining more control and potential commercial restrictions compared to fully open models. Both proprietary and non-proprietary open models compete with closed models, driving further innovation and technological diffusion.*

Exhibit 18: Boom in open foundation models

Open models released each year

# of open foundation models released in each year



Note(s): Other reasons for the explosion of open models include general diffusion of gen AI, increased commercialization opportunities, greater prestige and attention for researchers, heightened competition driving innovation in model capabilities, ethical considerations for transparency and accessibility, and the potential for collaborative improvement. Additionally, these models allow for affordable customization and fine-tuning, enabling organizations to adapt them to specific use cases at significantly less expense than proprietary closed-source models.
Source(s): Stanford University Human-Centered Artificial Intelligence (2024), Merlyn Mind (2024), Deepgram (2024), Inferless (2023), HatchworksAI (2024)

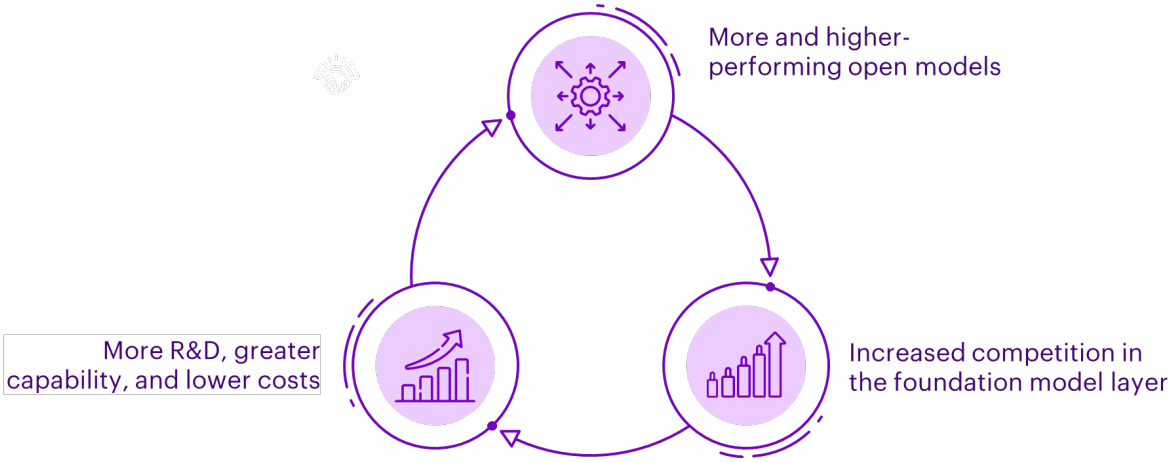
Open models have increased competition among foundation model developers, leading to more R&D, better models, and lower prices, which ultimately promotes wider adoption of gen AI (see Exhibit 19).

The success of proprietary models inspires the broader AI community and attracts new entrants who leverage advanced architectures and training methods. By using open-source libraries and serverless infrastructure, these entrants can develop open models with fewer resources. This increases competition in the foundation model layer, spurring more R&D, improving model capabilities, reducing access costs, and driving broader diffusion of gen AI technology downstream. Such innovation is often powered by partnerships and additional investment.

The proliferation of open models is democratizing access to gen AI, allowing more developers, researchers, and businesses to build and integrate AI capabilities affordably. With both open and proprietary models, users typically only pay for inference costs, not training, which significantly lowers compute expenses.

More open models also mean users have greater choice when balancing model costs. Open models offer greater flexibility in controlling infrastructure costs and avoiding managed API fees, whereas proprietary models often come with ongoing, usage-based pricing. However, open models may come with higher maintenance, compliance, or scaling costs, as these responsibilities would typically be managed by proprietary model providers. As inference costs decrease, foundation models become more accessible for developers and for different use cases, increasing demand for tools and opportunities for application development. This in turn allows for greater specialization and innovation for business needs, further driving growth, competition, and adoption (see **Case Study 4**).

Exhibit 19: The role of open models in supporting ecosystem growth



Source(s): Accenture Strategy analysis.

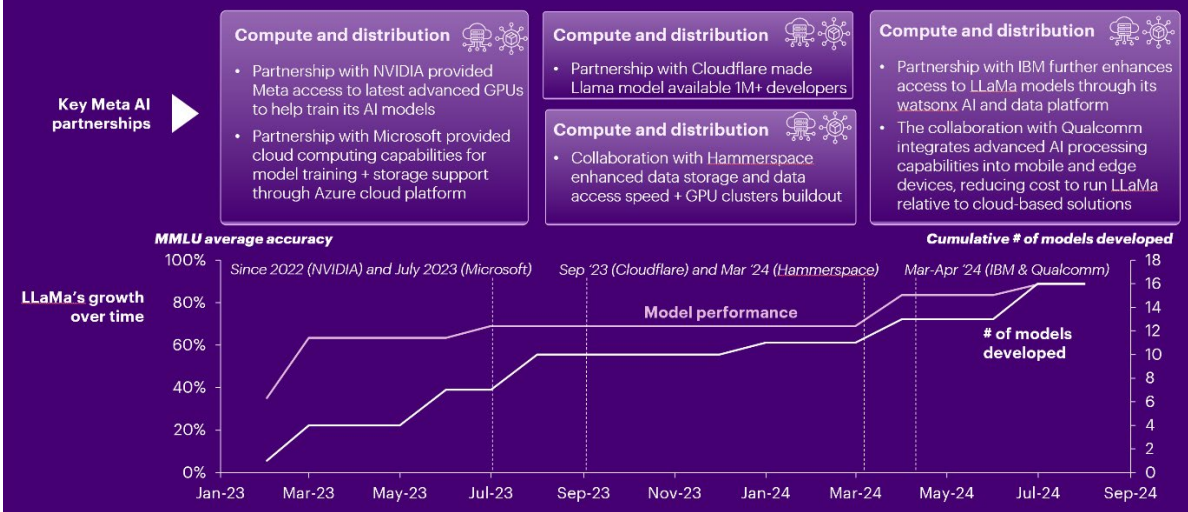
As gen AI technology becomes more accessible via more R&D and via open models, other ecosystem innovations such as smaller language models also help to decrease costs and increase adoption.

Smaller language models (SLMs) provide cost-efficient alternatives to larger, proprietary models. These models, such as Mistral Small, need significantly less computational power and resources than LLMs, making them more feasible for different applications or for smaller companies with limited budgets or technical capabilities. Built for specialized purposes, SLMs are more efficient for specific applications, offering a more accessible and cost-effective option that contributes to broader gen AI adoption.

Case Study 4: Meta's AI partnerships[58]

Partnerships have been crucial in increasing the accessibility and reducing the costs associated with deploying and managing open models like Meta's LLaMa model[59]:

- Meta's partnership with **NVIDIA**, since 2022, has helped train what Meta calls the first "frontier level" open source AI model on cutting edge GPUs LLaMa 3.1 405B, released in July 2024, with performance on par relative to OpenAI's GPT 4o.
- **Microsoft** and Meta have had a collaborative partnership since 2023, providing Meta with cloud computing capabilities for model training and storage support through Azure cloud platform.
- A 2023 alliance with **Cloudflare** has expanded Meta's distribution network, allowing LLaMa family of models to reach more than 1 million developers.
- The collaboration with **Hammerspace** since March 2024 has advanced Meta's capabilities to handle large datasets efficiently, speeding up data access and processing, which is crucial for training advanced foundation models.
- In parallel, Meta has further enhanced the capabilities of its LLaMa models by partnering with **IBM** since March 2024 to gain access to advanced AI tools tailored for specific industries, leveraging IBM's Watson AI and data platforms.
- Additionally, Meta inked a partnership agreement with **Qualcomm** in April 2024 which has helped reduce the cost and complexity of deploying LLaMa models on decentralized platforms, expanding their practical applications.[60]



[58] *Other LLaMa-related corporate partners include Amazon Web Services, Google Cloud, Databricks and Dell.*
[59] *Other open models that advanced innovation include BLOOM, DALL-E, and Phi 3 family of models*
[60] *Meta and Qualcomm collaborated to integrate AI processing capabilities into mobile and edge device.*

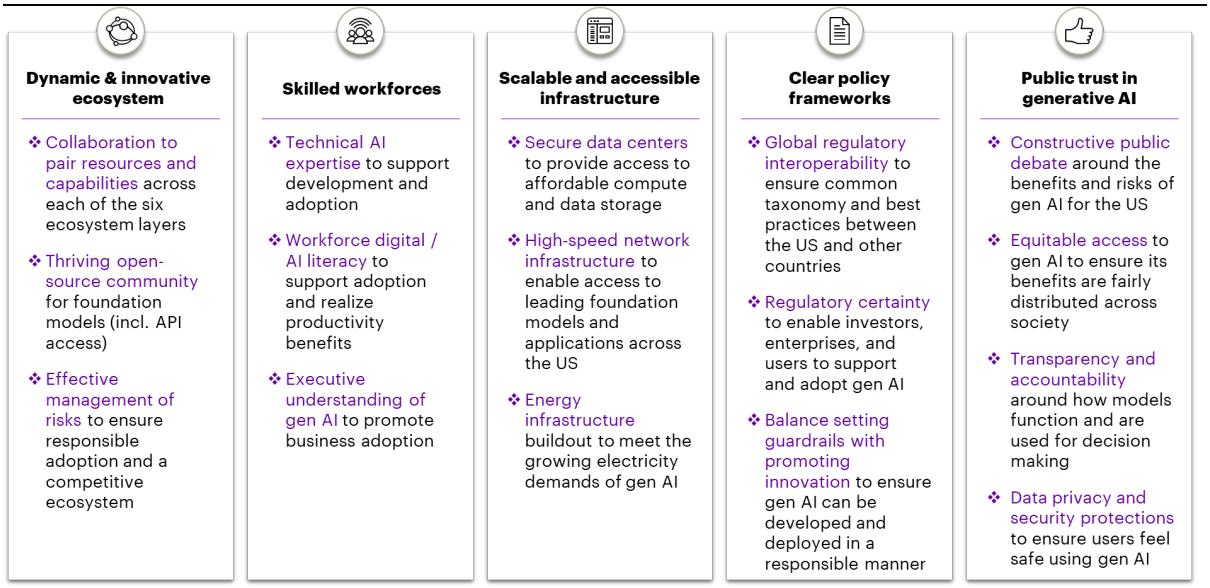
Capturing the Potential

5

Many stakeholders—from industry, government, and civil society—will need to work together to foster the growth and widescale adoption of gen AI.

Inspired by Microsoft's AI Access Principles, this chapter examines five critical pillars that offer a proposed guide to help realize the economic potential of gen AI in the US (see **Exhibit 20**).[61] The pillars are interrelated, and each plays a critical role in unlocking the transformative benefits of gen AI.

Exhibit 20: Five key pillars to help realize gen AI's economic potential in the US



5.1 Dynamic and innovative ecosystem (Pillar 1)

A gen AI ecosystem that promotes innovation and growth helps enhance model capabilities, reduce costs, and enable more specialized applications for US businesses, ultimately driving broader adoption and diffusion of AI technology. Participants across the layers of the US gen AI ecosystem depend on **collaboration to pair complementary resources and capabilities** to drive that innovation and growth. Collaboration in the form of partnerships helps mobilize investment and connect ecosystem participants with resources and capabilities, helping them to achieve greater levels of innovation.

Knowledge-sharing is also critical for technological diffusion. A **thriving open-source community for foundation models** helps support this by first diffusing AI knowledge and providing access to gen AI models via public APIs, both for developers and for other users. Open-source communities also help promote innovation, collaboration, and competition among developers, driving advances in gen AI technology. Enhanced access to tools and models through these communities enables more seamless integration and scalability, facilitating the development of AI-powered applications and helping businesses adopt and reinvent using gen AI. More broadly, these communities facilitate AI skilling across the public.

Lastly, **effective risk management** is essential for balancing broad access to gen AI, responsible adoption, and the compliance with evolving laws and regulations. A robust governance framework for regular risk assessment and monitoring supports safe and secure gen AI development, minimizing disruptions while offering ecosystem participants clearer

[61] *Microsoft's AI Access Principles (2024)*

guidelines on best practices. Such clarity ultimately accelerates adoption by ensuring stakeholders understand model development standards and deployment protocols across industries.

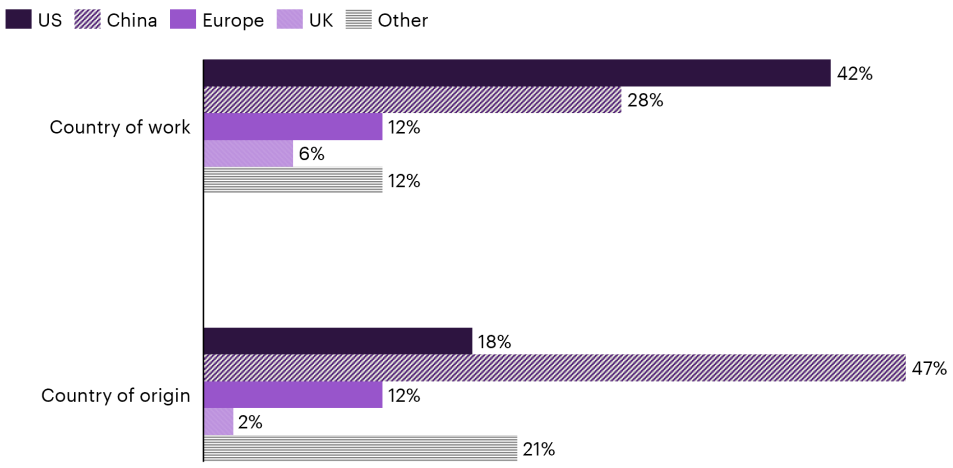
5.2 Skilled workforces (Pillar 2)

Human talent is critical to realizing the economic promise of generative AI. Workers are needed to develop cutting-edge models, to adapt models for specific applications, and to deploy those applications in businesses, requiring new sets of skills and expertise.

The US is well-positioned when it comes to AI talent now, but this could change if other nations are better able to retain the workers they train—the US produces only 18% of the world's top AI researchers (see **Exhibit 21**). The talent pipeline also appears to be narrowing—the number of PhDs in computer science graduating in the US has been relatively stagnant for over a decade, up only 176 (9%) from 2012 to 2022.[62]

Exhibit 21: A plurality of the world's top AI researchers work in the US, but it produces only 18% of them

Country of work and origin of top-tier AI researchers[1] (share of total)



Note(s): 1) Top-tier researchers are defined as those with accepted papers for the highly prestigious Neural Information Processing Systems conference. Country of origin based on location of undergraduate degree. Country of origin data is not US-specific; i.e., it reflects the global distribution of country of origin for top AI researchers.
Source(s): MacroPolo, 'The Global AI Talent Tracker 2.0' (2024).

When it comes to the workforce needed to scale up gen AI adoption, the US has some room to improve. It ranks 71st globally in terms of the technology and digital skills of its workers, per Coursera.[63] Prior research has also found that nearly a third of US workers lack fundamental digital skills.[64] Businesses cannot adopt gen AI unless they have the skilled workers to use the technology. To build the workforces needed to capture the gen AI opportunity, academia, industry, civil society, and government must work to ensure the US has:

- **Technical AI expertise** to lead the innovation, buildout, and adoption of gen AI
- **Workforce digital and AI literacy** to enable adoption and realize productivity benefits
- **Executive understanding of gen AI** to promote business adoption

[62] *Stanford University Human-Centered Artificial Intelligence (2024).*
[63] *Coursera, 'Global Skills Report' (2024).*
[64] *OECD, 'Survey of Adult Skills' (2014).*

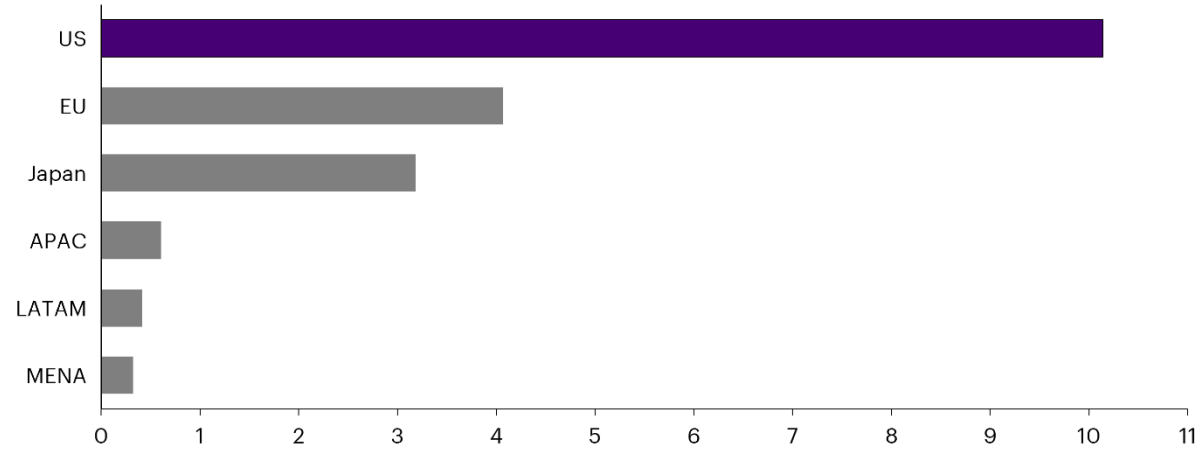
5.3 Scalable and accessible infrastructure (Pillar 3)

Foundation models require large clusters of specialized hardware, such as GPUs or other high-powered chips. These clusters are typically housed together in data centers. Establishing scalable and accessible infrastructure, including computing resources, energy systems, and telecommunications networks, is essential for the US to drive innovation, ensure widescale adoption, and fully harness the potential of gen AI.

The US already boasts the largest data center capacity in the world, with over 3,300 large and enterprise-sized data centers,[65] representing nearly 40% of global capacity (see **Exhibit 22**). This extensive computing infrastructure provides the US with a critical strategic edge in gen AI; affordable and **secure data centers** drive US competitiveness and ensures the country remains at the forefront of the technology and can broadly adopt and put the technology to practical use across industries.

Exhibit 22: The US is the global leader in large- and enterprise-scale data center infrastructure

Number of large and enterprise data centers per capita (based on 2023 population)



Note(s): 1) Figures reflect Enterprise and Large Data Centers and exclude Midsize DC and Single data centers and Rack/Computer Room that may have limited or lower resources and scalability to support gen AI endeavors. 2) US is proxied by North America in this analysis.
Source(s): Gartner, 'Forecast Analysis: Data Center Sites, Worldwide' (2023), International Monetary Fund (April 2024)

The expansion and integration of energy-efficient, **high-speed network infrastructure** is critical to deliver the ultra-fast, low-latency broadband necessary for gen AI.[66] The rapid advancement in gen AI requires at least 10 times more fiber connections within data centers, according to Lumen Technologies.[67] The US' fiber optic and 5G network infrastructure must meet that growing demand for connections, which in turn will provide businesses and individuals broader access to foundation models and applications.

Like network infrastructure, the US' **energy infrastructure** must also evolve to meet the growing demands of gen AI. Annual electricity demand from US data centers is estimated at over 280 terawatt-hour (TWh) in 2024 and is expected to increase to 530 TWh by 2028, fueled by the computationally intensive gen AI ecosystem.[68] The supply-side response needs to occur in a manner consistent with climate goals for a low-carbon future. There is already

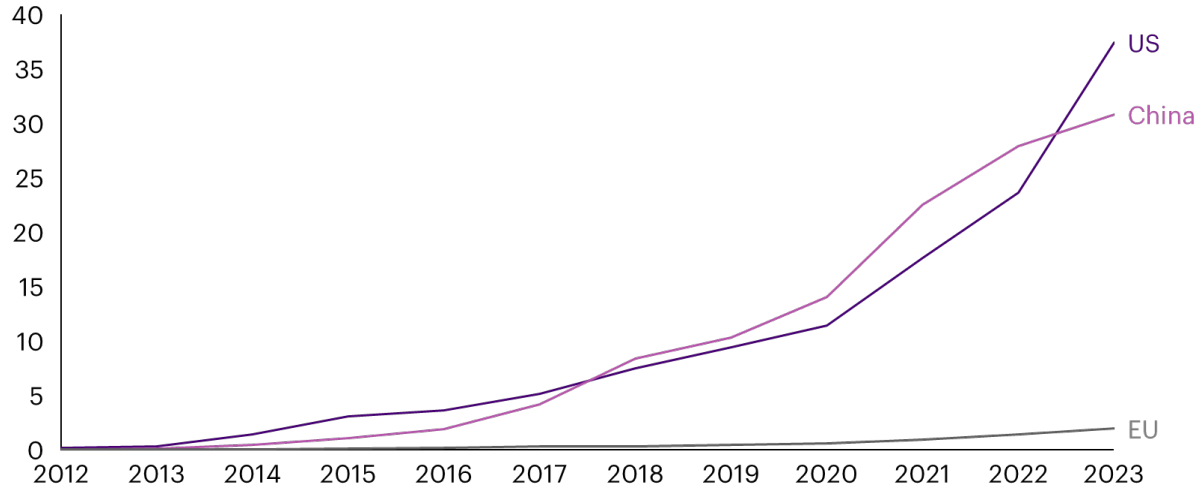
[65] *Gartner, 'Forecast Analysis: Data Center Sites, Worldwide' (2023), Datacenters.com (2024)*
[66] *A robust fiber optic network is essential for transmitting large volumes of data between data centers, as AI models rely on high-bandwidth, low-latency connections for efficient data sharing and distributed computing.*
[67] *Per Lumen Technologies, (2024)*
[68] *S&P Global Market Intelligence, 'US datacenter and energy outlook – Powering the AI economy' (2024)*

some progress on this front—data centers are set to contract 36 GW of renewable energy capacity by 2024, in wind, solar, and battery capacity—but this trend will need to continue to ensure sustainability.[69]

Although the US currently leads in private investment in AI infrastructure, outpacing the EU and China (see **Exhibit 23**), further infrastructure buildout is necessary as gen AI adoption and computational needs grow. By some recent estimates, global companies are expected to spend approximately $1 trillion on AI-related capex in the coming years, including for data centers, chips, other AI infrastructure, and the power grid.[70]

Exhibit 23: US leads the pack in private infrastructure investment to support the computational demands of gen AI

Cumulative private investment (VC) in AI compute, (USD Billions), 2012-2023



Note(s): Private investment in AI infrastructure is more easily compared than public investment, in particular between the US and China, because of 1) the focus of government spending—the US government tends to focus on promoting AI via research, development, and governance while the Chinese government invests relatively more in AI infrastructure (e.g., $6.1 billion announced for nationwide computing hubs in 2024)—and 2) how funding is allocated—the US government promotes AI infrastructure indirectly via contracts, procurement, and grants, while China invests in AI infrastructure directly, via subsidies, and via public-private guidance funds, where the delineation between public and private funds is less clear.
Source(s): Oecd.ai (2024) based on Preqin's data, CSET (2023), Accenture Strategy

This infrastructure acts as the nervous system of the nation's gen AI ecosystem, connecting data centers, edge devices, businesses, and individuals. It will also be critical to broadening access to gen AI benefits for a wider segment of households and businesses in the US.

As AI infrastructure scales, the US must ensure it remains accessible to developers, allowing them to train and deploy more foundation models. Beyond fostering growth in the gen AI ecosystem, investment in accessible and secure AI infrastructure delivers a range of benefits. By prioritizing scalable, secure data centers and high-speed networks, the US can bolster global technology leadership, strengthen national security, and safeguard American interests against cyber threats. It also helps to accelerate advancements in fields such as healthcare and transportation, while unlocking value in new AI-driven products and market opportunities.

[69] *S&P Global Market Intelligence, "Exploring the Energy Dynamics of AI Datacenters: A Dual-Edged Sword", (2024)*
[70] *Goldman Sachs, 'Gen AI: too much spend, too little benefit?' (2024)*

5.4 Clear policy frameworks (Pillar 4)

A clear policy framework is essential to guide the development of the generative AI ecosystem and its underlying technology. This framework should establish clear and consistent guidelines and regulatory oversight for AI development and deployment, ensuring responsibility and accountability while also promoting innovation.

To date, US AI policy has focused on creating strategies and frameworks for AI development and deployment, achieving significant milestones with the release of the National Artificial Intelligence and Development Strategic Plan (2016, updated 2019 and 2023), the Office of Science and Technology Policy (OSTP) Blueprint for an AI Bill of Rights (2022), and the National Institute of Standards and Technology (NIST) AI Risk Management Framework (2023) and AI Risk Management Framework: Generative AI Profile (2024) (see **Exhibit 24**).

Exhibit 24: Evolution of AI policy in the United States

Period	Pre-2016	2016-2018 (pre-GPT)	2019-2022	2023-today
Description	**Developing the chips, cloud, and networking infrastructure which is critical to gen AI development**	**Setting high-level frameworks and the strategic plan for AI development and use**	**Coordinating federal oversight, regulation, and strategic planning**	**Developing a cohesive national AI strategy**
Key policy measures	• Executive Order 13702: Creating a National Strategic Computing Initiative (NSCI) (Jul 2015)	• National Artificial Intelligence Research and Development Strategic Plan (Oct 2016)	• Executive Order 13859: Maintaining American Leadership in Artificial Intelligence (Feb 2019) • Updated National Artificial Intelligence Research and Development Strategic Plan (Jun 2019) • Executive Order 13960: Promoting the Use of Trustworthy Artificial Intelligence in the Federal Government (Dec 2020) • National Artificial Intelligence Initiative Act of 2020 (effective Jan 2021) established the "National Artificial Intelligence Initiative Office" ("NAIIO") under White House Office of Science and Technology Policy ("OSTP") • OSTP released the "Blueprint for an AI Bill of Rights" (Oct 2022)	• NIST "Artificial Intelligence Risk Management Framework" (Jan 2023) • Executive Order 14091: Advancing Racial Equity and Support for Underserved Communities Through the Federal Government (Feb 2023) • Updated National AI Research and Development Strategic Plan (May 2023) • Executive Order on the Safe, Secure, and Trustworthy Development and Use of AI (Oct 2023) • Creation of US AI Safety Institute Consortium (AISIC) (Feb 2024) • NIST "AI Risk Management Framework: Generative AI Profile" (Jul 2024) • White House National Security Memorandum on AI (Oct 2024)

Source(s): The White House (2015, 2019, 2021, 2021, 2023, 2024), The National Science and Technology Council (2016), Federal Register (2020), The White House's Office of Science and Technology Office (2022), National Institute of Standards and Technology (2023, 2023, 2024, 2024)

Accelerating and deepening implementation of these strategies and frameworks is a key next step. To progress implementation effectively, there is a need to build upon the technical research efforts to create safe and trustworthy artificial intelligence. This effort is being advanced by the US Artificial Intelligence Safety Institute (USAISI) and its 200+ member companies and organizations. Building upon technical expertise in science-based and empirically backed safety guidelines, in coordination with global partners, will ensure a responsible approach to AI risk evaluation and mitigation and will act as a foundation for the development of safety standards and best practices that are relevant across regions worldwide. Future regulatory and policy frameworks should aim to:

- Promote **global regulatory interoperability**—i.e., consistency in policy frameworks between the US and its international partners—by proposing common taxonomy and best practice
- Provide **regulatory certainty** to enable investors, enterprises, and users to support and adopt gen AI

- **Balance setting guardrails with promoting innovation**, ensuring that gen AI development is responsible, but not unduly stifled

5.5 Public trust in generative AI (Pillar 5)

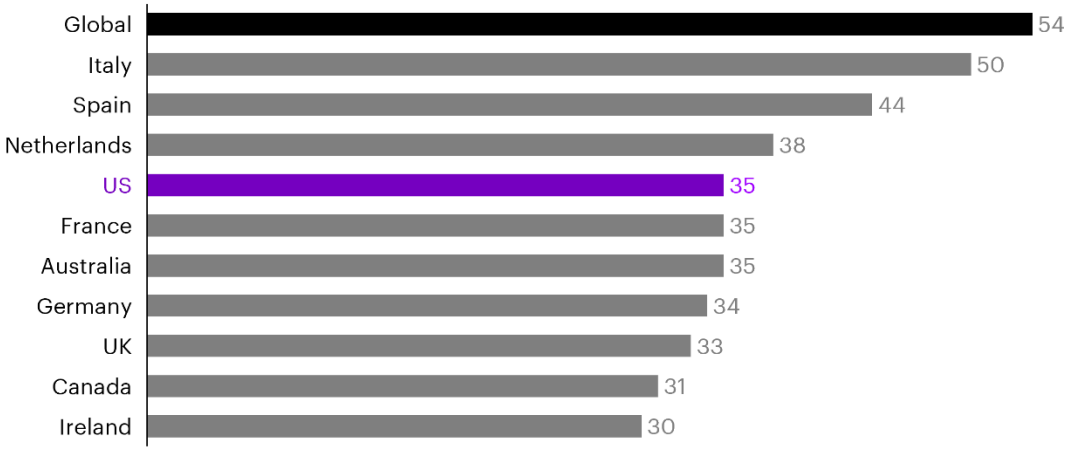
Public trust in generative AI is critical, as low trust can hinder its adoption and integration into various industries. When businesses and governments believe that customers or citizens lack trust in AI, they face increased risk in rolling out generative AI-powered products and services. Indeed, a lack of trust stifles experimentation and hinders innovation.

Despite its importance, public trust in AI is currently low in the US (see **Exhibit 25**). And like many other nations around the world, it has been on the decline—just five years ago, 43% more Americans trusted AI than they do today.[71]

Exhibit 25: Public trust in AI in the US is well below the global average but middle of the pack among Western advanced economies

Trust in AI by country

% of survey respondents who trust businesses in AI, 2024



Source(s): Edelman, 'Edelman Trust Barometer, Supplemental Report: Insights for the Tech Sector' (2024).

To strengthen public trust, generative AI developers and regulators must work to ensure:

- There is a **constructive public debate** around the benefits and risks of generative AI.
- A wide range of potential users have **equitable access** to gen AI technology and the technology's benefits are inclusive and fairly distributed, including the skills needed to use it.
- There is **transparency and accountability** around the development and use of gen AI models, particularly in sensitive applications such as those regarding national security.
- There are **data privacy and security protections** in place to give users confidence that their data is safe and secure when using generative AI models.

[71] *Edelman, 'Edelman Trust Barometer, Supplemental Report: Insights for the Tech Sector' (2024).*

5.6 Conclusion

Generative AI represents a revolutionary advance in technology with transformative potential for the United States. Its impact on productivity alone could generate up to $3.8 trillion in economic gains by 2038, with broader potential benefits stemming from increased investment, innovation, greater well-being and health outcomes.

The US is home to a diverse and rapidly expanding generative AI ecosystem, encompassing over 1,500 companies, both large and small. Across this ecosystem, participants are collaborating to leverage complementary resources and expertise, fueling unprecedented innovation.

Partnerships are crucial to this process, mobilizing funding and connecting stakeholders with the resources they need to innovate, scale and compete.

However, advancing the gen AI ecosystem is not just about frontier technological innovation. Expanding access to gen AI and ensuring responsible use is also critical. These broader goals will require active and sustained collaboration—between industry, government, and communities—to drive continued investments and workforce upskilling, promote competition, lower the development costs and user prices of cutting-edge models, and put in place policies and safeguards conducive to public trust in gen AI. All of these elements are crucial for the technology's broad-based adoption across industries, where it can help reinvent business processes, power scientific advancements, and drive inclusive growth.

Each stakeholder has an important role to play in harnessing this transformative power of gen AI. This paper provides the context and roadmap to guide this collaborative future ecosystem development, and facilitate continued gen AI investment, innovation, and adoption, positioning the U.S. to fully realize the economic potential of gen AI and remain a leader in this global technological revolution.

References

Acar, O. A., & Gvirtz, A. (2024). GenAI Can Help Small Companies Level the Playing Field. Harvard Business Review. Retrieved from https://hbr.org/2024/02/genai-can-help-small-companies-level-the-playing-field

Accenture. (2023). *A new era of generative AI for everyone*. Retrieved from https://www.accenture.com/content/dam/accenture/final/accenture-com/document/Accenture-A-New-Era-of-Generative-AI-for-Everyone.pdf

Accenture. (2023, June 21). Accenture and Microsoft Expand Collaboration to Help Organizations Accelerate Responsible Adoption of Generative AI. New York, New York, USA. Retrieved from https://newsroom.accenture.com/news/2023/accenture-and-microsoft-expand-collaboration-to-help-organizations-accelerate-responsible-adoption-of-generative-ai

Accenture. (2024). *Accenture's blueprint for responsible AI*. Retrieved from Accenture.com: https://www.accenture.com/sg-en/case-studies/data-ai/blueprint-responsible-ai

Accenture. (2024, April 9). Best Buy, Google Cloud and Accenture Partner to Create a Better Customer Support Experience with Generative AI. Minneapolis and Las Vegas, Minnesota and Nevada, USA. Retrieved from https://newsroom.accenture.com/news/2024/best-buy-google-cloud-and-accenture-partner-to-create-a-better-customer-support-experience-with-generative-ai

Accenture. (2024). Reinvention in the age of generative AI. Retrieved from https://www.accenture.com/content/dam/accenture/final/accenture-com/document-2/Accenture-reinvention-in-the-age-of-generative-AI-executive-summary.pdf

Accenture. (2024). What is Quantum computing? Retrieved from https://www.accenture.com/gb-en/insights/quantum-computing

Analysis, B. o. (2024, October). *Investment in Private Fixed Assets, Equipment, Structures, and Intellectual Property Products by Type*. Retrieved from BEA: https://apps.bea.gov/iTable/?ReqID=10&step=2&_gl=1*8kqa93*_ga*NTc1ODI5MTEwLjE3MjEwNjkzNjQ.*_ga_J4698JNNFT*MTcyMzc1MjcxNC40LjEuMTcyMzc1NTM3OS4xMS4wLjA.#eyJhcHBpZCI6MTAsInN0ZXBzIjpbMiwzXSwiZGF0YSI6W1siVGFibGVfTGlzdCIsIjUxIl1dfQ==

Anthropic. (2023, February 3). *Anthropic Partners with Google Cloud*. Retrieved from https://www.anthropic.com/news/anthropic-partners-with-google-cloud

Anthropic. (2023, May 23). *Anthropic Raises $450 Million in Series C Funding to Scale Reliable AI Products*. Retrieved from https://www.anthropic.com/news/anthropic-series-c

Anthropic. (2023, August 9). *Releasing Claude Instant 1.2*. Retrieved from https://www.anthropic.com/news/releasing-claude-instant-1-2

Atkinson, R. D. (2018). ICT Innovation, Productivity, and Labor Market Adjustment Policy. In R. D. Atkinson, *Digitized Labor* (pp. 179-200). Retrieved from https://www.researchgate.net/publication/324948090_ICT_Innovation_Productivity_and_Labor_Market_Adjustment_Policy

Autor, D., & Salomons, A. (2017, June 19). *Does Productivity Growth Threaten Employment?* Retrieved from https://www.ecb.europa.eu/press/conferences/shared/pdf/20170626_ecb_forum/D_Autor_A_Salomons_Does_productivity_growth_threaten_employment.pdf

Bank of International Settlements. (2024). *Survey evidence on gen AI and households: job prospects amid trust concerns*.

Bence, R. (2023). Intelligent airport operations powered by generative AI with United. *AWS re:Invent*. Las Vegas: AWS. Retrieved from https://d1.awsstatic.com/events/Summits/reinvent2023/AIM242-S_Intelligent-airport-operations-powered-by-generative-AI-with-United-sponsored-by-Tata-Consultancy-Services.pdf

Bessen, J. E. (2016, October). *How Computer Automation Affects Occupations: Technology, Jobs, and Skills*. Retrieved from BU School of Law: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2690435

Bloomberg Intelligence. (2024, March 8). Generative AI races toward $1.3 trillion in revenue by 2032. Retrieved from https://www.bloomberg.com/professional/insights/data/generative-ai-races-toward-1-3-trillion-in-revenue-by-2032/

Brookings. (2024, July 3). *AI's impact on income inequality in the US*. Retrieved from https://www.brookings.edu/articles/ais-impact-on-income-inequality-in-the-us/

Catherine Bolgar. (2024, January 9). Discoveries in weeks, not years: How AI and high-performance computing are speeding up scientific discovery. Retrieved from https://news.microsoft.com/source/features/sustainability/how-ai-and-hpc-are-speeding-up-scientific-discovery/

CB Insights. (2023). 7 applications of generative AI in healthcare .

CB Insights. (2024). *Artificial Intelligence Expert Collection*. Retrieved from https://app.cbinsights.com/i/emerging-tech?tab=collections#data-management

Chiang, S. (2024, June 3). AMD announces new AI chips amid intensifying competition with Nvidia, Intel. Retrieved from https://www.cnbc.com/2024/06/03/amd-unveils-new-ai-chips-amid-rising-competition-with-nvidia-intel.html

Context.ai. (2024). Retrieved from https://context.ai/model/claude-v2

Coursera enterprise. (2024). *Global Skills Report*. Retrieved from https://www.coursera.org/skills-reports/global

Datacenters. (2024). *Global Data Center Locations*. Retrieved from https://www.datacenters.com/locations?query=canada

David Autor. (2022). The Labor market impacts of technological change: from unbridled enthusiasm to qualified optimism to vast uncertainty. Retrieved from https://www.nber.org/papers/w30074

Day, M., & Metz, R. (2024, March 27). Retrieved from Bloomberg: https://www.bloomberg.com/news/articles/2024-03-27/amazon-invests-additional-2-75-billion-in-ai-startup-anthropic

Dickens, S. (2023, September 26). Amazon Invests $4 Billion In Anthropic: A Paradigm Shift In AI. *Forbes*. USA. Retrieved from https://www.forbes.com/sites/stevendickens/2023/09/26/amazon-invests-4-billion-in-anthropic-a-paradigm-shift-in-ai/

Edelman Trust Institute. (2024). 2024 Edelman Trust Baramoter, Supplemental Report: Insights for the Tech Sector. Retrieved from https://www.edelman.com/sites/g/files/aatuss191/files/2024-

03/2024%20Edelman%20Trust%20Barometer%20Supplemental%20Report%20Insights%20for%20Tech.pdf

Financial Times. (2024). How an upstart is using its Nvidia ties to challenge cloud computing giants.

Gartner. (2023, November 20). *Forecast Analysis: Data Center Sites, Worldwide*. Retrieved from https://www.gartner.com/document/4954531?ref=solrAll&refval=423381972&

Gartner. (2023). Forecast Analysis: Data Center Sites, Worldwide.

Gartner. (2023). IT Spending Forecast, 3Q23 Update: The Impact of GenAI.

Goldman Sachs. (2024, June 27). Gen AI: too much spend, too little benefit? Retrieved from https://www.goldmansachs.com/insights/top-of-mind/gen-ai-too-much-spend-too-little-benefit

Grønstad, A. (2023, July 19). A healthy workforce is good for business. Here's why. World Economic Forum. Retrieved from https://www.weforum.org/agenda/2023/07/business-benefits-of-boosting-employee-health-and-well-being/

Health, H. S. (2022, May). Applied Artificial Intelligence for Health Care. Retrieved from https://www.hsph.harvard.edu/event/exec-ed-online-applied-artificial-intelligence-for-health-care-2/

Hobijn, B., & Comin, D. (2004). Historical Cross-Country Technology Adoption (HCCTA) Dataset. United States.

Hornbeck, R., & Moretti, E. (2019, January). Who Benefits from Productivity Growth? Direct and Indirect Effects of Local TFP Growth on Wages, Rents, and Inequality. *National Bureau of Economic Research, Working Paper 24661*. Retrieved from National Bureau of Economic Research: https://www.nber.org/system/files/working_papers/w24661/w24661.pdf

House, T. W. (2024, October 24). *Memorandum on Advancing the United States' Leadership in Artificial Intelligence; Harnessing Artificial Intelligence to Fulfill National Security Objectives; and Fostering the Safety, Security, and Trustworthiness of Artificial Intelligence*. Retrieved from https://www.whitehouse.gov/briefing-room/presidential-actions/2024/10/24/memorandum-on-advancing-the-united-states-leadership-in-artificial-intelligence-harnessing-artificial-intelligence-to-fulfill-national-security-objectives-and-fostering-the-safety-se

Inflection.ai. (2023, June 29). Inflection AI announces $1.3 billion of funding led by current investors, Microsoft, and NVIDIA. Palo Alto, CA, USA. Retrieved from https://inflection.ai/inflection-ai-announces-1-3-billion-of-funding

International Labor Organization. (2019). *Work for a Brighter Future.* Global Commission on the Future of Work. Geneva: International Labor Organization. Retrieved from https://www.ilo.org/sites/default/files/wcmsp5/groups/public/%40dgreports/%40cabinet/documents/publication/wcms_662410.pdf

International Labor Organization. (2023). *Aligning Skills Development and National Social Protection Systems.* Social Protection Department / Skills Development Branch, Geneva. Retrieved from https://unglobalaccelerator.org/sites/default/files/2024-02/Aligning%20skills%20development%20wcms_900970.pdf

James Andrew Lewis. (2023). *An overview of Global Cloud Competition.* Center for Strategic & International Studies. Retrieved from https://www.csis.org/analysis/overview-global-cloud-competition

Jared Spataro. (2024, May 8). Microsoft and LinkedIn release the 2024 Work Trend Index on the state of AI at work. Retrieved from https://blogs.microsoft.com/blog/2024/05/08/microsoft-and-linkedin-release-the-2024-work-trend-index-on-the-state-of-ai-at-work/

Jared Spataro. (2024, May 8). Microsoft and LinkedIn release the 2024 Work Trend Index on the state of AI at work. Retrieved from https://blogs.microsoft.com/blog/2024/05/08/microsoft-and-linkedin-release-the-2024-work-trend-index-on-the-state-of-ai-at-work/

Lumen Technologies. (2024, August 1). Corning and Lumen Reach Supply Agreement on Next-Generation Fiber-Optic Cable to Support Data Center AI Demands. Retrieved from https://news.lumen.com/2024-08-01-Corning-and-Lumen-Reach-Supply-Agreement-on-Next-Generation-Fiber-Optic-Cable-to-Support-Data-Center-AI-Demands

Luong, N., & Konaev, M. (2023, August 10). *In & Out of China: Financial Support for AI Development*. Retrieved from Center for Security and Emerging Technology (CSET): https://cset.georgetown.edu/article/in-out-of-china-financial-support-for-ai-development/

Microsoft Corporation. (2023, September 12). Developing and deploying AI responsibly: Elements of an effective legislative framework to regulate AI. Retrieved from https://blogs.microsoft.com/on-the-issues/2023/09/12/developing-and-deploying-ai-responsibly-elements-of-an-effective-legislative-framework-to-regulate-ai/

MITRE. (2024). *Delivering the Future: Science And Technology, U.S. Competitiveness, and International Collaboration*. MITRE. Retrieved from https://www.mitre.org/sites/default/files/2024-08/PR-24-01820-8-Science-Technology-US-Competitiveness-International-Collaboration.pdf

Novet, J. (2024, May 1). Nvidia-backed GPU cloud provider CoreWeave surges to $19 billion valuation. *CNBC*. USA. Retrieved from https://www.cnbc.com/2024/05/01/nvidia-backed-gpu-cloud-provider-coreweave-is-worth-19-billion.html

Noy, S., & Zhang, W. (2023, July 13). Experimental evidence on the productivity effects of generative artificial intelligence. *Science*, pp. 187-192. Retrieved from https://www.science.org/doi/10.1126/science.adh2586

OECD. (2016). *The Survey of Adult Skills*. Retrieved from https://www.oecd.org/en/publications/2016/06/the-survey-of-adult-skills_g1g68f4f.html

OECD. (2024). *Productivity levels*. Retrieved from OECD Data Explorer: https://data-explorer.oecd.org/vis?tm=gdp%20per%20hour&pg=0&snb=11&vw=tb&df[ds]=dsDisseminateFinalDMZ&df[id]=DSD_PDB%40DF_PDB_LV&df[ag]=OECD.SDD.TPS&df[vs]=1.0&dq=USA.A.GDPHRS..XDC_H%2BUSD_PPP_H.V%2BQ...&pd=2000%2C2025&to[TIME_PERIOD]=false

Oecd.ai. (2023). Policy Observatory - Live Data. Retrieved from https://oecd.ai/en/data?selectedArea=investments-in-ai-and-data&selectedVisualization=vc-investments-in-ai-compute-by-country

Oppenheimer & Co., Inc. (2024). *Deep Dive on OpenAI/Microsoft Partnership: The Premier AI Platform*.

Pacific Nothwest National Laboratory. (n.d.). PNNL-Microsoft Collaboration. Retrieved from https://www.pnnl.gov/pnnl-microsoft-collaboration

Paperswithcode. (2024). *Multi-task Language Understanding on MMLU'*. Retrieved from https://paperswithcode.com/sota/multi-task-language-understanding-on-mmlu

Peng et al. (2023, February 13). *The Impact of AI on Developer Productivity: Evidence from GitHub Copilot*. Retrieved from Arxiv: https://arxiv.org/pdf/2302.06590

Pesheva, Ekaterina. (2024, September 4). New AI tool can diagnose cancer, guide treatment, predict patient survival. The Harvard Gazette. Retrieved from https://news.harvard.edu/gazette/story/2024/09/new-ai-tool-can-diagnose-cancer-guide-treatment-predict-patient-survival/#:~:text=The%20AI%20model,%20which%20works%20by%20reading%20digital

Pew Research Center. (2023, November 21). *What the data says about Americans' views of artificial intelligence*. Retrieved from https://www.pewresearch.org/short-reads/2023/11/21/what-the-data-says-about-americans-views-of-artificial-intelligence/

Pitchbook Data, Inc. (2024). *Gen AI Emerging Space*. Retrieved from https://my.pitchbook.com/emerging-spaces/387

Risk Management Foundation of Harvard Medical Institutions Incorporated. (2023, July 19). Diagnostic Errors Linked to Nearly 800,000 Deaths or Cases of Permanent Disability in U.S.

Rodgers, E. M. (2013). Diffusion of Innovations. Retrieved from https://archive.org/details/diffusionofinnov00roge_0/page/n5/mode/2up

S&P Global. (2024). Exploring the Energy Dynamics of AI Datacenters: A Dual-Edged Sword. Retrieved from https://www.spglobal.com/marketintelligence/en/news-insights/blog/exploring-the-energy-dynamics-of-ai-datacenters-a-dual-edged-sword

S&P Global Market Intelligence. (2024). Exploring the Energy Dynamics of AI Datacenters: A Dual-Edged Sword. Retrieved from https://www.spglobal.com/marketintelligence/en/news-insights/research/us-datacenter-and-energy-outlook-powering-the-ai-economy#:~:text=Datacenters%20have%20long%20warranted%20close%20attention%20from%20electricity,expected%20to%20reach%20over%20280%20TWh%

S&P Global Market Intelligence. (2024, June 13). US datacenter and energy outlook – Powering the AI economy. Retrieved from https://www.spglobal.com/marketintelligence/en/news-insights/research/us-datacenter-and-energy-outlook-powering-the-ai-economy#:~:text=Datacenters%20have%20long%20warranted%20close%20attention%20from%20electricity,expected%20to%20reach%20over%20280%20TWh%

S&P Market Intelligence. (2024). US datacenter and energy outlook – Powering the AI economy.

Sharpe, A., & Fard, S. M. (2022). *The current state of research on the two-way linkages between productivity and well-being*. International Labor Organization. ILO Working Papers. doi:10.54394/TMUV3384

Shilov, A. (2024, February). Surging AI demand sees Nvidia full-year revenue hit $60.9 billion in 2023. Tom's Hardware. Retrieved from https://www.tomshardware.com/tech-industry/surging-ai-demand-sees-nvidia-full-year-revenue-hit-dollar609-billion-in-2023

Shook, Ellyn; Daugherty, Paul. (2024, January). Work, Workforce, Workers: Reinvented in the Age of Gen AI. New York, New York, USA: Accenture. Retrieved from

https://www.accenture.com/content/dam/accenture/final/accenture-com/document-2/Accenture-Work-Can-Become-Era-Generative-AI.pdf

Smialek, J. (2024, February 21). *The New York Times*. Retrieved from https://www.nytimes.com/2024/02/21/business/economy/economy-productivity-increase.html

Smith, B. (2024, February 26). *Microsoft's AI Access Principles: Our commitments to promote innovation and competition in the new AI economy*. Retrieved from Microsoft.com: https://blogs.microsoft.com/on-the-issues/2024/02/26/microsoft-ai-access-principles-responsible-mobile-world-congress/

SparkCognition. (2023, December). SparkCognition Industrial AI Suite for Renewables. Austin, Texas, USA. Retrieved from https://www.sparkcognition.com/products/industrial-ai-suite/renewables/

Stanford University. (2024). *The Center for Research on Foundation Models*. Retrieved from https://crfm.stanford.edu/ecosystem-graphs/index.html?mode=table

Stanford University Human-Centered Artificial Intelligence. (2024). *Artificial Intelligence Index Report 2024*. Stanford University.

The State of Small Business Now. (2024). U.S. Chamber of Commerce.

The Verge. (2024, February 16). How much electricity does AI consume? Retrieved from https://www.theverge.com/24066646/ai-electricity-energy-watts-generative-consumption

The White House. (2023, October 30). Executive Order on the Safe, Secure, and Trustworthy Development and Use of Artificial Intelligence. United States. Retrieved from https://www.whitehouse.gov/briefing-room/presidential-actions/2023/10/30/executive-order-on-the-safe-secure-and-trustworthy-development-and-use-of-artificial-intelligence/

Thompson, D. (2024, July). Exploring the Energy Dynamics of AI Datacenters: A Dual-Edged Sword. S&P Global Market Intelligence. Retrieved from https://www.spglobal.com/marketintelligence/en/news-insights/blog/exploring-the-energy-dynamics-of-ai-datacenters-a-dual-edged-sword

U.S. Bureau of Economic Analysis. (2024, October 2). Retrieved from https://apps.bea.gov/iTable/?ReqID=10&step=2&_gl=1*8kqa93*_ga*NTc1ODI5MTEwLjE3MjEwNjkzNjQ.*_ga_J4698JNNFT*MTcyMzc1MjcxNC40LjEuMTcyMzc1NTM3OS4xMS4wLjA.#eyJhcHBpZCI6MTAsInN0ZXBzIjpbMiwzXSwiZGF0YSI6W1siVGFibGVfTGlzdCIsIjUxIl1dfQ==

U.S. Bureau of Economic Analysis. (2024, July). *Table 2.1. U.S. Trade in Services, by Type of Service*. Retrieved from https://apps.bea.gov/iTable/?reqid=62&step=9&isuri=1&6210=4#eyJhcHBpZCI6NjIsInN0ZXBzIjpbMSw5LDZdLCJkYXRhIjpbWyJQcm9kdWN0IiwiNCJdLFsiVGFibGVMaXN0IiwiMjQ1Il1dfQ==

U.S. Bureau of Labor Statistics. (2023). Artificial intelligence and firm-level and organizational dynamics.

U.S. Bureau of Labor Statistics. (2024). Retrieved from https://www.bls.gov/k12/productivity-101/content/why-is-productivity-important/to-individuals.htm#:~:text=Increases%20in%20productivity%20offset%20the,reduces%20inflationary%20pressure%20on%20prices.

U.S. Census Bureau. (2024). *Tracking Firm Use of AI in Real Time: A Snapshot from the Business Trends and Outlook Survey*. Retrieved from https://www.census.gov/hfp/btos/downloads/CES-WP-24-16.pdf

United Airlines. (2024, July 3). *United Media Room*. Retrieved from United Airlines: https://united.mediaroom.com/2024-07-03-United-Now-Texts-Live-Radar-Maps-and-Uses-AI-to-Keep-Travelers-Informed-During-Weather-Delays

US Bureau of Economic Analysis. (2024, July 3). *Table 2.1. U.S. Trade in Services, by Type of Service*. Retrieved from International Data: International Transactions, International Services, and International Investment Position Tables: https://apps.bea.gov/iTable/?reqid=62&step=9&isuri=1&6210=4#eyJhcHBpZCI6NjIsInN0ZXBzIjpbMSw5LDZdLCJkYXRhIjpbWyJQcm9kdWN0IiwiNCJdLFsiVGFibGVMaXN0Iiwi MjQ1Il1dfQ==

US Census Bureau. (2024). *Tracking Firm Use of AI in Real Time: A Snapshot from the Business Trends and Outlook Survey* . Washington, DC.

Vincent, J. (2023, February 3). *The Verge*. Retrieved from https://www.theverge.com/2023/2/3/23584540/google-anthropic-investment-300-million-openai-chatgpt-rival-claude

Wiggers, K. (2023, April 20). CoreWeave, a GPU-focused cloud compute provider, lands $221M investment. *TechCrunch*. USA. Retrieved from https://techcrunch.com/2023/04/20/coreweave-a-gpu-focused-cloud-compute-provider-lands-221m-investment/

Wiggers, K. (2023, January 23). Microsoft invests billions more dollars in OpenAI, extends partnership. USA: TechCrunch. Retrieved from https://techcrunch.com/2023/01/23/microsoft-invests-billions-more-dollars-in-openai-extends-partnership/

World Economic Forum. (2020). *How Countries are Performing in the Road to Recovery*. World Economic Forum. Retrieved from https://www3.weforum.org/docs/WEF_TheGlobalCompetitivenessReport2020.pdf

Appendix

Economic impact estimation methodology

A1. Calculating the economic opportunity of generative AI

Generative AI could impact the economy through a variety of channels, including through labor productivity gains, broader innovation (including in the process of scientific research), and capital investment. To be conservative, we focus on quantifying only the labor productivity channel, because it is likely to be generative AI's largest measurable economic benefit. **Exhibit 26** provides an overview of the approach.

Exhibit 26: Overview of methodology to estimate the economic opportunity of Gen AI by 2038 in the US

Labor productivity gains

i. We first estimate gen AI's productivity impact at an occupation level by looking at its impact on tasks.

ii. We then simulate labor force transitions in the economy based on exposure to gen AI and a modelled transition probability between occupations.

iii. We then estimate gen AI's economy-wide productivity impact based on the above results.

iv. Finally, we calculate the final productivity impact in 2038 based on the productivity impact, assumed adoption rate, and GDP forecast.

Step 1: Estimate the productivity increase at an occupation level

- The Occupational Information Network (O*NET) database from the US Department of Labor provides an overview of the tasks performed by workers in over 900 occupations in the US economy, and the time spent on each of these tasks.
- Data from O*NET is used to map the occupation-task information to the US workforce. We calculate the share of time spent on tasks for each occupation, based on the task frequency of >19,000 tasks and >900 occupations.
- We then investigate the potential of gen AI to automate or augment each task. Tasks are first tagged as being "Language" or "non-Language" tasks. Language tasks are those that require a certain level of language ability (natural, mathematical, or

computational).[72] We next assess the level of skill required to complete the task. This considers whether the task involves: (a) solving ambiguous problems; (b) collaborating with others in real-time; and (c) validation from subject matter experts. Language tasks that meet none of these criteria are labelled with the 'automation' tag. If a language task meets just one of the criteria it is labelled with the 'augmentation' tag. A combination of human tagging and machine learning classification (few shot prompting of LLMs such as GPT-4) is used to label each task.

- The share of time spent on tasks for an occupation is combined with the task labels result to determine the share of task hours that can be automated or augmented by gen AI for an occupation. This gives us the overall potential for gen AI to transform an occupation.
- We combine the transformation potential results with real world productivity gain estimates from academic experiments to calculate the final productivity gain for an occupation. There are existing research papers which estimate the productivity impact of gen AI on certain tasks, such as writing or coding. We use a regression to predict the productivity impact of gen AI on other tasks.
- The productivity gain for an occupation is an average of the productivity increase for all tasks in that occupation, weighted by the time share of each task.

Step 2: Simulate labor force transitions

- It is likely that gen AI will impact the composition of the labor force—i.e., the number of workers in each occupation. Occupations that benefit most from gen AI in terms of productivity may experience an excess supply of workers, and vice versa. This, in turn, leads to movement between occupations. We simulate these transitions.
- To determine where workers may go, we model how likely (or unlikely) it is for a person to move from one job to another.
    - We built a machine learning model to predict the likelihood of transition between a pair of occupations, based on a set of occupation characteristics. The logic is that a worker in occupation "A" is more likely to transition to occupation "B" if the two occupations share similar characteristics.
    - Key characteristics considered are—skill similarity, wage similarity, job popularity, education requirements, previous experience, training opportunities provided, and expected future growth potential. This data is sourced from Lightcast US job postings data and US Bureau of Labor Statistics 2022.
    - The model is trained using data from the US Current Population Surveys Annual Social and Economic supplement (2019-2022), which reports frequency of change between jobs.
- The outcome of this analysis is a new labor composition, after accounting for the impact of gen AI and likelihood of transitions between jobs.

Step 3: Calculate the economy-wide productivity boost

We next calculate the economy-wide productivity boost, which is the ratio of the aggregate wage bill post- and pre-gen AI adoption minus one. The formula to calculate this is as follows:

[72] *Since LLM's have shown significant leaps in capability and performance, we focus our assessment on these models. This means the analysis does not include the impact of image-generating models and other modalities.*

$$Productivity\ boost = \frac{\sum_{i=1}^{I} w_i(1+p_i)\hat{L}_i}{\sum_{i=1}^{I} w_i L_i} - 1$$

Where:

- w_i *is the average wage for workers in occupation* i
- p_i *is the productivity increase for workers in occupation* i
- L_i *is the labour force size pre Gen AI adoption for occupation* i
- $\hat{L}_i$ *is the labour force size post Gen AI adoption for occupation* i

Step 4: Calculate final productivity benefit in 2038

- The adoption of new technologies typically follows a distinct pattern known as an S-curve.[73] An S-curve begins with a gradual incline as early adopters come on board, then sharply rises as the majority adopt, and finally tapers off as the market approaches saturation. Our base case S-curve is informed by the pattern of Internet adoption in the US, refined with expert input to better anticipate the proliferation of gen AI to 2038.
- We next source the GDP forecast in 2038 for the US from Oxford Economics data.
- We then calculate the incremental GDP increase due to gen AI by multiplying the productivity boost by the adoption rate in 2038 and the forecasted GDP.[74]

Note that the productivity benefits of gen AI are contingent on several factors, including: (a) the pace, scale, and depth of adoption; (b) how gen AI's capabilities evolve; and (c) the extent to which a "people-centric" approach is taken. It is not clear how these factors will evolve. Thus, any estimate of the productivity benefits of gen AI is inherently uncertain.

In this report, we focus on one plausible scenario for gen AI adoption. Accenture's "Work, workforce, workers" report (2024) explores three scenarios, which vary the pace and quality of adoption. The figures in this report align with the "cautious" scenario of that report. Another difference between the two reports is the timeframe.

[73] *Diffusion of Innovations, Everett M. Rogers.*
[74] *Assumes constant labor and capital shares, and no changes in relative wages.*