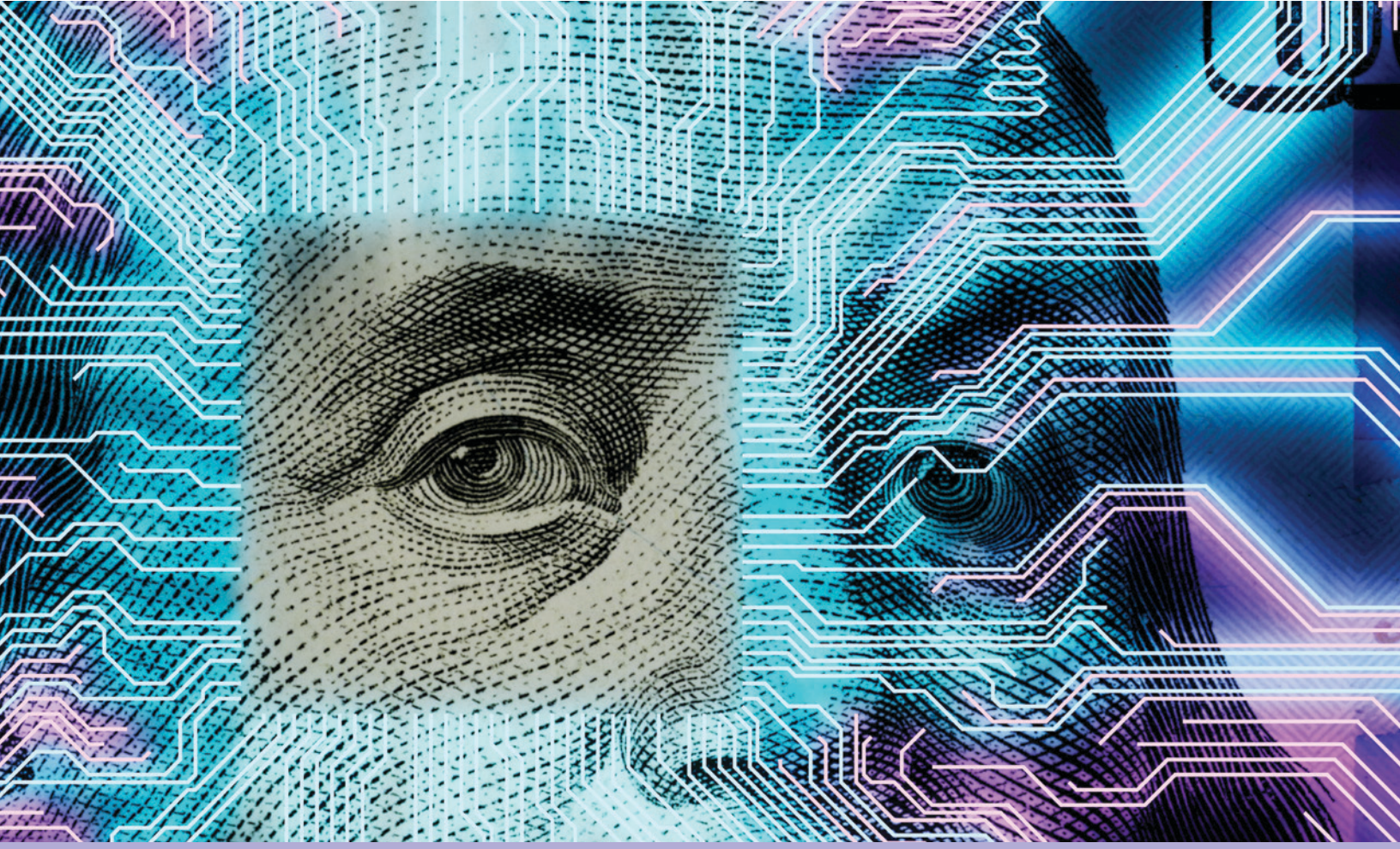

Will AI Investments Pay Off?

Artificial intelligence is taking root in the workplace and beyond. How will it impact labor productivity and the wider economy?

By Matthew Wells

Artificial intelligence (AI) is having a moment. In its Real-Time Population Survey, the St. Louis Fed found that 55 percent of people in the United States reported using AI as of August 2025. Stanford University reported that businesses adopted AI at a 78 percent clip in 2024, up from 55 percent the year before. This adoption rate exceeds those of personal computers and the internet at comparable stages.

In response to this interest, companies are spending billions on the equipment, research and development, and infrastructure required to accommodate the demand from businesses seeking to capitalize on AI's anticipated advantages. In fact, AI investments are now a larger contributor to overall economic activity than consumer spending, accounting for nearly 92 percent of GDP growth in the first half of 2025, the most recent period for which data is available. AI investments have also surpassed GDP growth attributable to the dot-com boom more than 25 years ago, both in terms of levels and share of GDP.

The eventual role of AI in the economy is still unknown, however, as ultimate adoption and productivity patterns are still developing. In a February speech, Federal Reserve Gov. Michael Barr identified three possible outcomes: widespread adoption that is integrated into the broader economy with minimal displacement of human workers; rapid integration with widespread labor losses; and minimal adoption where returns on investments are unrealized, leading to painful economic hardship.

Economists are divided on which one of these scenarios — or others — will emerge. Massachusetts Institute of Technology (MIT) economist and Nobel laureate Daron Acemoglu suggested in a 2024 *Economic Policy* article that after considering the kinds of tasks current AI models are intended to perform, "it is difficult to arrive at very large macroeconomic gains" from AI. Conversely, Stanford University economist Erik Brynjolfsson, who studies the impact of new technology on labor markets and productivity, says, "We're creating the potential to have massive productivity gains and a lot more wealth."

THE INVESTMENT BOOM

Researchers from the St. Louis Fed break AI's contributions to GDP growth into four categories: information processing equipment, software, research and development, and data center construction. The Deutsche Bank Research Institute reported in December 2025 that capital expenditures on data centers alone may reach $4 trillion by 2030. A significant chunk of that investment is coming from well-established "big tech" firms, which are expected to collectively spend at least $650 billion on AI this year. These companies — for example, Amazon Web Services, Microsoft, Meta, Apple, and Alibaba (the online Chinese retailer) — are hyperscalers, building large-scale data centers allowing other businesses to access ever-increasing computing power and storage.

One focus of software investment is large language models, or LLMs. These models develop their capability by training on vast amounts of existing text, which are broken down into basic units called tokens. After exposure to everything from Shakespeare to computer code, they can use that knowledge to perform any number of tasks. AI champions note that frontier models are consistently outperforming earlier ones in reasoning and performance testing, and they are making major strides in visual reasoning, as well.

There are several factors that account for any improvement in the models' performance over time, and one of the primary ones is increasing computing scale. For example, Open AI's GPT-3 model included 175 billion parameters and was trained on 300 billion tokens at a cost of more than $4.6 million in June 2020. GPT-4, which was developed in 2023, had around 1.8 trillion parameters and was trained on about 13 trillion tokens at an estimated cost of $63 million. (OpenAI has not publicly released the size and architecture of current GPT-5 level models.)

THE MATTER OF FUNDING

For most of AI's growth, firms funded investments in data centers and chip and hardware production via cash flows from their operations. This meant they could afford to invest in further infrastructure development without the need for debt financing. But according to a January bulletin from the Bank for International Settlements, that pattern no longer holds, as capital expenditures fueled by the rush to build are now outpacing cash inflows.

To bridge that gap, AI firms are beginning to issue bonds: Oracle, Meta, Alphabet (Google's parent company), and Amazon issued nearly $90 billion worth of bonds in the last quarter of 2025 alone. Relative to cash transactions, bonds provide investors with additional flexibility, allowing them to structure financing plans to better align with the lifespan of AI infrastructure such as data centers and computing clusters.

Private equity is also emerging as a major AI investor. Morgan Stanley anticipates such firms will make about $800 billion in data center-focused investments by 2028. One of the earliest high-profile commitments of this kind materialized last summer, when Meta negotiated a $29 billion data center expansion, with $26 billion raised from debt and the remaining $3 billion in equity. Last October, xAI, Elon Musk's AI firm, also announced it was financing a $20 billion purchase of Nvidia chips through a combination of $7.5 billion in equity and up to $12.5 billion in debt.

If AI ends up delivering on its potential, the returns could justify any risk that might be involved with these deals. But if demand slows or technological advancements hit a wall, there's potential for firms to hold a lot of liabilities and assets that aren't worth the investment.

All this investment into a single sector is also creating spillover effects that impact the rest of the economy. While "crowding out" is a term that generally refers to situations where increased government spending or borrowing reduces private sector investments and limits overall economic growth, there is some evidence that spending on AI is having a similar effect.

In a 2025 paper, researchers from the Aalborg University Business School in Denmark and the Université de Strasbourg in France found that over the past decade, young AI researchers at top-tier academic institutions are migrating to corporate laboratories, leading to concerns about a "brain drain" in basic scientific research. Once at these private firms, the paper's authors found that these leading researchers produced less novel and impactful exploratory science.

The concerns extend beyond human capital investment to resources such as energy. Data center hotspots are experiencing unprecedented demand for energy and water, straining supply and disrupting utility markets. According to the Electric Power Research Institute, northern Virginia is the largest data center market in the world, with 13 percent of all global operational capacity and a quarter of capacity in the Americas. These data centers consumed over a quarter of Virginia's total electrical supply in 2023, with an annual consumption of 24 terawatts. (One terawatt-hour provides a year of electricity to around 93,000 homes.)

Finally, a range of consumer goods including computers, smart appliances, phones, cars, and televisions all use RAM (random-access memory) chips, and the demand for them from AI developers has skyrocketed. Consumer RAM prices recently spiked at over 170 percent year over year, as AI firms are outbidding all other customers. Some consumer electronics vendors have started pricing chips like fresh seafood at "market price" because prices change so frequently. Also, Micron Technology, one of the leading manufacturers of commercial RAM, recently announced it would be leaving the business entirely to focus on supplying its "larger, strategic customers in faster-growing segments."

IS PRODUCTIVITY INCREASING?

Because of AI's ability to perform certain tasks such as summarizing large amounts of information that previously had to be read by humans, writing thousands of lines of code in minutes, or automating complex workflows, proponents argue that an AI-fueled increase in business productivity has already begun. According to the Bureau of Labor Statistics, nonfarm business labor productivity measured in output per hour has increased since the beginning of AI adoption around 2023.

Economists are trying to get a handle on the question of how productivity is changing as AI begins to filter through the economy. In a National Bureau of Economic Research working paper from earlier this year, economists at eight institutions including Stanford University, the Atlanta Fed, the Bank of England, and the Deutsche Bundesbank surveyed nearly 6,000 CEOs, CFOs, and executives from firms of varying sizes and sectors across the United States, United Kingdom, Germany, and Australia. They found that while just under 70 percent of respondent firms reported using AI, over 90 percent indicated that it had no impact on employment, and 89 percent reported no effect on productivity.

The CFO Survey, which the Richmond Fed conducts in partnership with the Atlanta Fed and Duke University's Fuqua School of Business, found similar results at the end of 2025. Generally, surveyed firms reported no change or only minimal increases in productivity in the previous 12 months, and between 65 percent and 70 percent expected either no change or only modest increases in efficiency and productivity in the coming year.

Companies are already moving to do more with less. Goldman Sachs, for example, estimated that last year, firms collectively laid off 5,000 to 10,000 workers per month due to AI.

These data support the views of economists who expect AI to generate muted gains in productivity and growth. Acemoglu, in his 2024 paper, suggested that total factor productivity gains over the next 10 years will be less than 0.55 percent, even when accounting for exposure to AI and associated productivity improvements.

Late last year, a study by Alexander Arnon at the Wharton School of the University of Pennsylvania exhibited a bit more optimism than Acemoglu's prediction of half a percentage point increase in productivity over the next decade. That analysis estimated that AI will boost productivity and GDP by 1.5 percent by 2035, nearly 3 percent by 2055, and 3.7 percent by 2075.

Brynjolfsson, the Stanford University economist, is more optimistic still. He argues that based on historical patterns, for every $1 of investment in tangible technology — data center infrastructure, software — firms are likely to make $9 or $10 in intangible investments. During this period, workers are learning how to use new technology, and businesses are learning how it can help redesign organizational structures and processes. Most of these investments, however, do not show up as output; instead, measured productivity can be lower as resources are diverted to those investments, a phenomenon he calls the productivity J-curve. This finding may explain why The CFO Survey, as well as the larger cross-national firm study, did not show significant productivity gains: Many firms are still figuring out how AI can best benefit them, if at all. (For more on the role of intangible investments, see "Interview with Ellen McGrattan" on pp. 14-18.)

Brynjolfsson believes the economy may be at the point where these investments are beginning to pay off. In an article in the *Financial Times* from February, he estimated that U.S. productivity increased by about 2.7 percent, nearly double the 1.4 percent observed over the past decade and well ahead of Arnon's predicted pace. He pointed to the fact that total payroll growth for 2025 was recently revised downward by 403,000 jobs, while output growth remained strong. This high output with significantly lower input — only 181,000 total nonfarm jobs were added last year — signals strong productivity growth. (When the Bureau of Labor Statistics announced productivity growth in early March of this year, it was 2.8 percent in the fourth quarter and 2.2 percent for the full year.)

Additional research has shown that any returns to productivity from AI are likely to be heavily context-dependent: They depend on the work being done and who is using AI. For example, in a 2023 *Science* article, MIT economists Shakked Noy and Whitney Zhang conducted an online experiment, assigning occupation-specific tasks to 453 college-educated individuals and randomly giving half of them access to ChatGPT. Workers who had ChatGPT showed a substantial increase in productivity over the control group: Average time to complete tasks dropped by 40 percent and output quality increased by 18 percent. Those individuals were also twice as likely to report using ChatGPT in their actual job two weeks later, and still 1.6 times as likely after two months.

WINNERS AND LOSERS

In his February speech, Gov. Barr noted that history is full of innovations, from steam engines to personal computers, that eventually led to increases in productivity and living standards and lasting growth in both the labor market and the wider economy. But along the way, these new technologies led to significant dislocations for some workers, while others found themselves newly indispensable, creating both winners and losers.

Labor economists, policymakers, and, perhaps most acutely, workers are concerned about the winners and losers that will come from AI adoption. Companies are already moving to do more with less. Goldman Sachs, for example, estimated that last year, firms collectively laid off 5,000 to 10,000 workers per month due to AI. In February, Block, a financial technology company, laid off 4,000 workers with Jack Dorsey, the company's CEO and co-founder and former CEO of Twitter, suggesting in a letter to shareholders the move was because of gains from AI: "A significantly smaller team, using the tools we're building, can do more and do it better."

Researchers have tried to understand who is likely to be impacted by these moves by looking at the effects on junior and senior workers. In a recent working paper, Brynjolfsson, along with other Stanford University researchers Bharat Chandar and Ruyu Chen, found dislocation fell primarily on younger workers: They used payroll data from ADP to estimate that early career workers from ages 22 to 25 in

occupations that are highly exposed to AI experienced a 16 percent decline in employment relative to experienced workers, whose employment rates remained stable.

In another 2025 working paper, Harvard University researchers Seyed Hosseini and Guy Lichtinger looked at U.S. resume data for 62 million workers across 285,000 firms and found a sharp drop in junior-level employment after firms adopted AI technology, while senior-level employment remained mostly unchanged. Interestingly, the decline in junior workers came not through layoffs, but rather through slower hiring.

Despite these findings, junior and middle-aged workers still potentially have a significant role to play in driving productivity gains, according to Richmond Fed senior advisor Pierre-Daniel Sarte and research associate Jack Taylor. In a 2024 Economic Brief, they, along with former research associate Erin Henry, argued that productivity is driven more by the age composition of the workforce rather than technological innovation. They noted that while young workers may be the most adept at using new technologies, it takes time and experience to understand how to apply them in the workplace, meaning that productivity growth may pick up as those younger workers reach ages 35 to 44.

"The effects of AI on productivity are only as good as the knowledge and experience of the workers using it," say Sarte and Taylor. "The current composition of the workforce suggests higher productivity gains ahead as younger workers exposed to AI early continue to gain experience in the workplace."

Anthropic, one of the largest AI firms, released a study in March that provided additional insight into how AI might shape employment patterns. It identified some occupations most exposed to AI displacement, which included computer programmers, customer service representatives, data entry operators, and financial analysts. The report estimated that 75 percent of computer programmer tasks currently can be replaced by AI, and the technology can complete 67 percent of a data entry worker's tasks. In terms of the demographics of those most exposed to AI displacement, the study found they are more likely to be female, white, and more educated.

The report also claimed that as AI improves, it will be able to do many more tasks currently done by humans. For example, in occupations that require knowledge of computers and mathematics, Anthropic estimates that Claude, its LLM, can currently accomplish 33 percent of relevant tasks, but it anticipates that it could ultimately complete 94 percent.

If these numbers are true, it could be a good thing for growth, as firms achieve more productivity with lower costs. This would allow them to offer additional services and attract new customers. But as the case of Block suggests, it could also mean significant labor dislocation. The question then becomes one of how to best manage that.

This is an unsettling question, even for those who are enthusiastic about AI's revolutionary potential. "I think we should worry a lot, and we have a track record of blowing it in the past with globalization and other things, where we didn't handle some of these disruptions as well as we could have," says Brynjolfsson. "We're going to have to work hard with the right institutions, the right policies at the company level, and the right worker training."

HOW WILL IT ALL SHAKE OUT?

At the same time, it may not be a sure thing that widespread adoption will occur. In addition to the potential technical limitations described earlier, AI companies may encounter financial headwinds, governments may decide to erect regulatory or legal hurdles, and workers and possibly even consumers may resist in ways that make implementation more difficult.

If the massive investments currently being made ultimately do not pay off for these or any other reasons, the economic effects could be widespread. Investors might have to liquidate their assets, which could create a cycle that spreads to pension funds, mutual funds, insurance companies, and everyday investors. As capital flees the AI market, firms outside of the tech sector could also lose value, and if private equity firms which fund the data centers and other infrastructure were to also fail, the wider economy could also suffer significant losses.

How long AI's moment will last and what the world will look like as a result are open questions. For now, AI firms are betting on a bright future for the technology and working to lock in customers for the long haul through extensive marketing efforts. Anthropic spent at least $10 million for a pair of ads before and during this year's Super Bowl touting its product, and it is also partnering with colleges and students to establish brand ambassadors for Claude. Perplexity, another AI firm, recently gave a year of free access to students at colleges where at least 500 students signed up to use their AI platform. These investments pale in comparison to what it takes to build the AI infrastructure, but if those students become lifelong users when they enter the workforce, they may be the best dollars these firms will have spent. **EF**

READINGS

Brynjolfsson, Erik, Bharat Chandar, and Ruyu Chen. "Canaries in the Coal Mine? Six Facts about the Recent Employment Effects of Artificial Intelligence." Stanford Digital Economy Lab Working Paper, Nov. 13, 2025.

Hosseini, Seyed, and Guy Lichtinger. "Generative AI as Seniority-Biased Technological Change: Evidence from U.S. Résumé and Job Posting Data," Working Paper, Nov. 5, 2025.

Jurowetzki, Roman, Daniel Hain, Kevin Wirtz, and Stefano Bianchini. "The Private Sector Is Hoarding AI Researchers: What Implications for Science?" *AI & Society*, Feb. 1, 2025, vol. 40, pp. 4145-4152.

Noy, Shakked and Whitney Zhang. "Experimental Evidence on the Productivity Effects of Generative Artificial Intelligence." *Science*, July 13, 2023, vol. 381, no. 6654, pp. 187-192.