Panic or Panacea?: The Economic Impact of Artificial Intelligence

Summary
Artificial intelligence has joined the ranks as one of the most important technological revolutions in recent history. Its ability to generate new content instantaneously presents new questions surrounding the future of many economies. In a four-part series of reports, which we collate in this compendium, we discuss the effects the U.S. economy may experience during the technological revolution of generative AI.

We generally are AI optimists in terms of its macroeconomic effects. Generative AI could potentially raise productivity growth and, hence, growth in potential economic output and growth in real per capita income. Stronger economic growth would raise real interest rates, which could lead to higher nominal rates for businesses and consumers. Although generative AI could have a lagged effect on productivity growth, it may have a more immediate effect on the labor market through displacements. But generative AI can complement rather than substitute for many jobs, and it may lead to the creation of new occupations. Additionally, the productivity-boosting effects of AI should increase aggregate real income, thus leading to an increase in demand for all goods and services and employment in those sectors. However, we acknowledge that generative AI could have adverse microeconomic effects on certain individuals through job displacement, creating a need for supportive public policy.

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Part I: The Effects of Technological Revolutions on Productivity Growth

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Summary

- Artificial intelligence is one of the most, if not the most, important technological revolutions in recent memory. The ability for large machine-learning models to generate new content represents a distinct leap in automation technology. But will generative AI be an economic friend or foe in coming years? We will discuss the potential economic effects of artificial intelligence in a four-part series of reports. We focus on the potential effects of AI on productivity growth in this first installment in the series.

- Growth in productivity is an important economic factor because it determines growth in real per capita income (i.e., “living standards”). Much like the widespread adoption of the internet and the networking of computers that occurred during the 1990s, generative AI has the potential to lead to a marked acceleration in total factor productivity. The capital investment needed to implement the latest generation of AI, which is the focus of our second report, could also lead to stronger productivity growth.

- In short, the promise of artificial intelligence is its potential to significantly raise productivity growth and, by extension, living standards. However, generative AI could potentially have profound effects on the labor market, which is the subject of our third report.

- An examination of the historical record shows that technological revolutions have led to a marked increase in living standards, albeit with a long lag. The inventions of the late 18th century, which led to the First Industrial Revolution, did not really begin to show up in real per capita income in Great Britain until the mid-19th century. Similarly, the five “great inventions” of the Second Industrial Revolution did not really lift productivity growth in the United States until a few decades after their inception in the early-20th century.

- There are a number of factors that could hold back rapid adoption of AI in coming years. The training of foundation models requires hundreds of billions, if not trillions, of bits of raw data, and computing power may not be able to keep up. Human oversight may be needed, at least for the foreseeable future, because biased data could lead to biased AI output. Furthermore, it may be cost-effective in the foreseeable future for many businesses to continue to rely on labor, especially for workers who are relatively low paid.

- But the effects of AI adoption on productivity could eventually be considerable. With most economies experiencing a slowdown in their respective growth rates in recent years, a boost to potential economic growth, if even only a few tenths of a percentage point per year, would be welcome.
Is Artificial Intelligence an Economic Game Changer?

Ever since OpenAI launched ChatGPT in November 2022, the world has been abuzz with speculation about the implications of generative artificial intelligence (AI). For example, the number of internet searches on "artificial intelligence" rose more than five-fold between mid-November 2022 and April 2023. The share price of Nvidia Corporation (NVDA), which manufactures graphics processing units (GPUs) that are used in AI applications, has trebled since November 2022. The ubiquitous attention to AI and the moonshot in asset prices of AI-affiliated companies like NVDA bring to mind the euphoria paid to tech companies in the 1990s.

It is not for us to opine on the valuation of AI-affiliated companies. But from an economic point of view, generative AI has the potential to raise productivity growth, much like the widespread adoption of the internet and the networking of computers did in the 1990s. Labor productivity, which is defined as the amount of output produced per hour worked, accelerated considerably starting in the mid-90s, and this strong growth remained in place through the early years of the 21st century (Figure 1).

Economists generally view robust productivity growth positively because it is associated with strong economic growth. Productivity growth and labor force growth are the two major underlying determinants of real GDP growth. An economy can produce more goods and services (i.e., real GDP) if it has more workers (i.e., an increase in the labor force), everything else equal. Likewise, an economy can produce more goods and services if each worker can produce more per hour (i.e., an increase in productivity), everything else equal. The association between real GDP growth, growth in the labor force and productivity growth is evident in Figure 1.

In theory, real GDP is identically equivalent to aggregate real income. That is, the act of producing a good or a service creates an equivalent amount of income for someone. Even if productivity is flat, real GDP (aggregate real income) can rise over time if the labor force grows. But real income per capita, which is also known as “living standards,” would remain essentially unchanged under this scenario. Consequently, an economy needs to experience growth in productivity if it is to enjoy an increase in its standard of living. The considerable rise in American living standards in the 1990s—real GDP per capita grew about 25% between the business cycle peak in 1991 and the following cyclical peak in 2000—was brought about by the acceleration in productivity that sprang, at least in part, from the widespread adoption of the internet and the networking of computers that occurred during that decade. The promise of AI today is the growth-enhancing effects it could have on productivity. In short, AI can potentially lift living standards considerably, at least on an aggregate basis.

Artificial intelligence could also have negative consequences. For example, the number of factory jobs in the United States peaked in 1979 (Figure 2). Manufacturing employment trended lower in the 1980s and 1990s as manufacturers adopted more capital intensive means of production, and
then it nosedived in the first decade of the current century as globalization accelerated. The number of factory jobs today stands nearly 35% below its 1979 peak. Although real per capita income in the United States is more than twice as high today as it was in 1979, the rise has not been shared equally across all segments of American society. The decline in the number of factory jobs, and the associated rise in American income inequality, have had profound social and political effects in the United States. Many fear that widespread adoption of AI could lead to a similar swoon in service-sector employment in coming years, which likely would have its own social and political fallout.

We readily acknowledge that we do not have the expertise to address the non-economic implications of artificial intelligence. Our goal in this series of four reports is more modest. That is, we hope to provide insights to some potential economic implications of AI. In this first installment of our four-part series, we look back at a few technological revolutions in the past for some clues into how generative AI could affect the U.S. economy in coming years.

Lessons from the First Industrial Revolution in Great Britain

An exhaustive discussion of all the technological breakthroughs the world has experienced over the millennia is clearly beyond the scope of this short treatise. But let’s begin with a brief look at the Industrial Revolution, which commenced in Great Britain in the late 18th century. Some of the inventions that occurred around that time include the spinning jenny and the water frame, which revolutionized the textile industry. The inventions of James Watt increased the efficiency of steam engines, thereby leading to a marked increase in power generation. These technological breakthroughs, and the ones that followed in subsequent years, changed Great Britain from an agricultural economy to the richest nation in the world in the 19th century.

But the transformation of the British economy did not happen overnight. As noted previously, real per capita income is roughly equivalent to real per capita GDP, and both are proxies for average living standards. As shown in Figure 3, real per capita GDP in Great Britain rose only 35% between 1770 and 1840. In other words, the standard of living for the average British resident crept up at an underwhelming rate of just 0.4% per annum over that 70-year period. Starting in the mid-19th century, however, real per capita GDP rose more strongly. Specifically, it grew nearly 80% between 1840 and the end of that century, a per annum increase of roughly 1% on average over that stretch. In short, Great Britain did not enjoy a considerable spurt in living standards until a few decades after the Industrial Revolution began.

Part I: Figure 3

As discussed above, productivity needs to grow if an economy is to experience a rise in average living standards. What drives growth in labor productivity? Economists have identified three underlying determinates of labor productivity growth. First, giving each worker more capital can raise their ability to produce more output per hour worked. Second, an increase in labor “composition,” which can be considered as an improvement in labor “quality”, can raise output per hour worked. A more educated
or more skilled worker should be able to produce more, everything else equal, than an individual with lower levels of educational attainment or skill. Third, technological change, known formally as “total factor productivity (TFP),” can raise a worker’s ability to produce more output per hour worked.

The slow rise in British per capita GDP in the early years of the Industrial Revolution that is evident in Figure 3 is consistent with findings in the academic literature. For example, Crafts (2019) estimates that growth in British labor productivity remained lackluster during the first few decades of the 19th century despite the technological advancements that occurred in the late 18th century (Figure 4). It was not until the mid-19th century that these inventions were sufficiently widespread to lead to a considerable rise in TFP growth that boosted overall growth in British labor productivity. In short, it took a few decades for the technological breakthroughs of the late 18th century to filter through to significant increases in British living standards.

The Second Industrial Revolution in the United States

The so-called Second Industrial Revolution occurred between roughly 1860 and the turn of the 20th century, and it helped the United States overtake Great Britain as the world’s largest economy. Gordon (2000) lists the five “great inventions” of this era as electricity, the internal combustion engine, petrochemical & pharmaceuticals, innovations in entertainment, communications & information prior to World War II (e.g., telephone, radio, etc.), and running water, indoor plumbing & urban sanitation. But like the case of the British economy during the First Industrial Revolution, it took a number of years before these inventions showed up in American productivity growth. Bakker, Crafts and Woltjer (2019) estimate that labor productivity in the United States grew at a respectable average of 2.0% per annum between 1899 and 1929 (Figure 5). However, TFP growth, which reflects the technological effects of the five “great inventions” of the early 20th century, was actually stronger between 1929 and 1941 (1.9% per annum) than it was during the first three decades of the 20th century (1.1% per annum).

These inventions of the early 20th century arguably continued to have a positive effect in the first two decades after the end of the Second World War. Using methodology that was discussed in a 2014 paper, Fernald estimates that TFP growth in the United States averaged more than 2% per annum throughout the 1950s and 1960s (Figure 6). Growth in TFP downshifted in the 1970s and 1980s despite the groundbreaking inventions of mobile phones, personal computers and internet protocol in the 70s. As we noted previously, it was not until the widespread adoption of these technologies in the 1990s that total factor productivity accelerated anew. Consequently, American living standards rose considerably in the final years of the 20th century as real disposable income per capita grew nearly 3% per annum between 1995 and 2000. But the productivity-boosting effects of these innovations appear to have run their course in recent years, as TFP growth averaged a paltry 0.7% per annum during the last decade.
Implications for the Future

Work on artificial intelligence has been ongoing since the 1950s. But work on “foundation models,” which are large machine-learning models that are trained on extraordinarily large amounts of raw data, has been underway for only a few years. ChatGPT is an example of a foundation model. Although generative AI has captured the public’s imagination in recent months, the technology is still in its infancy, and it likely will take years for AI to become widely adopted commercially. For example, McKinsey estimates that 50% of the work activities that are performed at present could be automated between 2030 and 2060 with a midpoint of 2045. Much like the technological breakthroughs that occurred in the First and Second Industrial Revolutions, it could take quite some time for AI to have a meaningful effect on productivity growth.

There are a number of factors that could hold back rapid adoption of AI. First, the training of foundation models requires hundreds of billions, if not trillions, of bits of raw data, and computing power may not be able to keep up. Secondly, AI will continue to need human oversight, at least for the foreseeable future, because models that are trained on limited or biased data could produce biased output. Human oversight may be needed to ensure that any biases are removed from the AI output. Third, the training of models is expensive, and it may be cost-effective for many businesses to continue to rely on labor, especially for workers who are relatively low paid. That said, the cost of AI likely will decline over time as demonstrated by many prior technological breakthroughs.

The effects of AI adoption on productivity could eventually be considerable. The McKinsey Global Institute estimated in 2012 that knowledge workers spend about 20% of their time searching for and gathering information. AI could be used for these tasks, freeing these individuals to undertake more productive tasks. More recently, researchers who studied one company with more than 5,000 customer service agents found that the company increased issue resolution by 14% per hour when it employed AI in the issue-resolution process, with the largest effects realized among the lowest skilled and least experienced workers. McKinsey estimates that AI could raise global productivity growth by 0.1 to 0.6 percentage points per year from 2023 to 2040, depending on the rate of adoption. With the global economy growing roughly 3% at present, which is down considerably from the 3.5% per annum growth rate that global GDP averaged between 1980 and 2019, a boost to global economic growth of only a few tenths of a percentage point per year would be welcome.

Conclusion

The size of the British economy, as measured by real GDP, was about ten times larger at the end of the 19th century than it was in the late 1700s. Of course, the British population grew over that period but nevertheless, real GDP per capita more than doubled over that span. This improvement in British living standards was brought about by a rise in labor productivity that was attributable, at least in part, to the technological breakthroughs of the First Industrial Revolution. Similarly, the five “great inventions” of the late-19th and early-20th centuries helped the United States grow into the largest economy in the world.

But it took some time for the innovations of the First and Second Industrial Revolutions to have a meaningful effect on productivity growth. The First Industrial Revolution commenced in the 1770s, yet productivity growth in Great Britain remained lackluster until the mid-19th century. Likewise, productivity growth in the United States was stronger in the mid-20th century than it was in the first decades of the century in the immediate aftermath of the “great inventions.” More recent technological innovations may have filtered through to productivity growth faster than those in earlier periods. Yet, it still took roughly two decades for these innovations to have a measurable effect on productivity growth.

As noted previously, productivity growth can also be boosted by increases in the capital stock. If the moonshot since last autumn in the share price of NVDA is any indication, then market participants expect that capital investment associated with AI adoption will be strong in coming years. We will look more deeply into potential effects on investment spending in Part II of this series. But technological change can also have detrimental effects on specific sectors of the labor market, much as the inventions of the internal combustion engine had on employment at buggy whip manufacturers of lore. Could generative artificial intelligence lead to widespread job losses in the service sector in coming years? We will take a deeper dive into this topic in Part III and offer some general conclusions of our analysis in Part IV.
Endnotes


6 - Morrison, Ryan, "Compute Power is Becoming a Bottleneck for Developing AI. Here's How You Clear It," Tech Monitor, March 17, 2023. (Return)

7 - McKinsey, see endnote 5, p. 13. (Return)

Part II: Prospects for Capital Spending

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Summary

• The present moment of possibility in the field of generative artificial intelligence (AI) is the culmination of a decades-long transition in business spending away from industry and toward technology. In this second installment of our series, we develop a framework to think about the outlook for capital spending in coming years. Specifically, we split business fixed investment spending on equipment and intellectual property products into AI-related spending, potentially AI-related spending and non-AI related spending.

• If AI-related investment were to follow the pattern of the tech boom of the 1990s, then this category of investment could be roughly 50% above trend four years from now. We acknowledge there is a great deal of uncertainty with this estimate, but our analysis suggests that a surge in AI-related capital spending could boost the rate of U.S. economic growth meaningfully over the next few years.

• To the extent that an AI transformation lifts potential GDP growth, then the U.S. economy would also likely face a higher real interest rate environment in coming years. Real interest rates rose during the tech boom of the 1990s when the associated acceleration in productivity and potential GDP caused the so-called “natural” rate of interest (a.k.a. “r-star”) to rise.

• Higher real interest rates are not necessarily detrimental. Although debt servicing costs would be higher, those costs could be managed by the associated rise in real income growth. Perhaps of greater concern is the potential displacement of workers that wholesale adoption of generative AI could entail. We will focus on the labor market implications of generative AI in the next report in this series.
Introduction
In Part I of this series, we described how the integration of novel new technologies in previous business cycles impacted various industries, with the net result of improving living standards by boosting productivity. We also described how the lag time between innovation and implementation of new technologies has had a tendency to get shorter over time. The various historical examples cited in Part I share a common theme in that there are two major ways in which technological change manifests itself: first through increased capital investment and second through stronger productivity growth.

This installment of our AI series considers how a shift in capital spending is already well underway. Additionally, we describe how, if past patterns hold, the output-enhancing characteristics of this spending will result in a higher real interest rate environment, all else equal.

Potential GDP Growth Has Slowed, AI Can Boost it Back Up
The economy's long-run sustainable rate of growth is driven by three factors: labor force growth, capital investment and total factor productivity growth. Given current demographic headwinds (baby boomers are leaving, not entering, today's workforce, and fertility rates are falling), any measure that could boost the other two would have major implications for potential GDP growth and real interest rates.

Perhaps the cleanest way to unpack the potential transformative economic impact of the coming AI revolution is to simply look at potential GDP growth over time and the factors that drove it in prior cycles. Potential growth is essentially how fast the economy can grow on a sustained basis if it were fully using all available resources. It is the sum of the key production-side factors of growth: the labor force, capital spending and total-factor productivity (hereafter referred to as TFP). Growth in TFP is the portion of growth not explained by measured inputs of labor and capital that are used in production. Examples might include factors like increased worker education, novel process improvements or innovation.

The rate of potential GDP growth in the United States has slowed on trend since the 1960s as each of the three drivers has downshifted over time (Figure 1). Families are having fewer children, capital is being directed to uses other than direct investment spending such as M&A activity and share buybacks and productivity growth has been stuck in a rut. Those brief periods when the potential GDP growth rate strengthened were often made possible by a one-off surge in one of the inputs (Figure 2). The most obvious surge in labor force growth occurred in the 1970s and early 1980s as baby boomers reached working age and as women joined the workforce in greater numbers. A similarly pronounced surge in capital investment took place in the 1990s. That spending was followed by major productivity gains culminating in soaring TFP in the latter part of that decade. The TFP improvement carried
well into the 2000s even as growth in capital spending slowed in the wake of the 2001 tech-centric recession.

Similarly, the possibility of a coming AI transformation has scope to influence economic activity in the coming decade and beyond, boosting capital investment as a first-order effect followed by process improvements and efficiencies that will lift growth in productivity as a second-order effect. Together, these developments present the most realistic prospects for lifting potential GDP growth in coming years.

A Framework to Measure AI Spending

In the earlier discussion of the impact on potential GDP, we looked at the economy through the lens of production-side analysis. We now pivot to a more traditional spending-side approach to measure the specific ways the AI transition shows up in the economy.

Start with the very big picture. Business fixed investment spending on equipment and intellectual property products totaled $2.8 trillion (annualized) in the first quarter, or 10.6% of overall nominal GDP. We will refer to this category as fixed capital investment in the remainder of this report.

The challenge now is to determine what share of fixed capital investment falls under the umbrella of AI-related spending. This exercise is subject to a degree of our own discretion; interested readers can consult our end-notes to see how we sorted various categories of spending. In short, we divided all fixed capital spending into three categories:

**AI-related**: spending on hardware and software where the ties to AI are obvious.

**Potentially AI-related**: outlays on R&D in industries such as aerospace and autos where some, but obviously not all, spending is AI-related. (If you doubt the role of AI in R&D spending in autos, just consider the supply-chain disruption tied to the semiconductor shortages in recent years.)

**Non-AI related**: spending that is largely directed toward categories not associated with AI, including Transportation Equipment, Other Equipment, Pharmaceutical & Medicine Manufacturing, Chemical Manufacturing, Other Manufacturing, Nonprofit Institutions, as well as Entertainment & Artistic Originals.

From Industry to Technology: A Revolution Already Underway

The way businesses allocate capex today is very different from what it was in the early 1960s. In Figure 3, we plot the evolution of these three categories of investment spending over the past 60+ years. In the early 1960s, more than four-fifths of all fixed capital investment still went toward old-school categories of spending in what was at the time a manufacturing-centric post-war economy.

Can we really call anything from the 1960s AI-related? After all, information technology was largely limited to punch-cards and mainframes. Compare that to generative AI today and the best technology of the 1960s can feel ancient, yet we would never be where we are today without investment and research in those technologies. Our exercise shows how only a tiny share of capital (less than 15%) was directed toward AI- and potentially AI-related categories of spending in the early 1960s. That share grew only incrementally throughout the 1960s and 1970s despite a number of major innovations occurring in those decades. The programming language COBOL was introduced in the 1960s as well as the computer mouse, although it would take the ingenuity of Apple and IBM to make the mouse an integral device in the 1980s.

The microchip was invented in the 1970s, but chips improved sufficiently in the 1980s so that computer designs made major leaps in features and speed. The 1980s were also characterized by the emergence of new competitors on the scene, such as Microsoft and Apple. By the end of that decade, high-tech business spending rose to represent closer to 40% of fixed capital investment. In 1995, Microsoft launched Windows which catapulted computers to an essential business tool for every engaged member of a burgeoning knowledge-worker economy. The desire of many businesses to spend on two categories in particular (i.e., hardware and software) exploded as those key AI-related categories surged well above trend in the late 90s (Figure 4).
If Anything Could Ever Be This Good Again

The late 1990s spending boom on hardware and software offers a useful lens through which we can focus on the prospects for AI-related capital spending in the years ahead. Although it is difficult to determine precisely how a generative AI boom would impact all of these spending categories, it is reasonable that it might look somewhat like the technology-related spending surge of the late 90s.

If we project out over the next four years the same previously noted deviation from trend in hardware and software capital investment that occurred from 1995-1999 (i.e., Figure 4), then total real spending on hardware and software would rise north of 50% above its existing trend (Figure 5). Such exponential growth in capex has clear implications for GDP growth. After adding just about two-tenths of a percentage point on average to annual GDP growth over the past two decades, this projected AI-boom would cause these components of capital investment to add roughly three-times that amount to the headline rate of annual GDP growth over the next four years, all else equal.

A 90s-like AI tech boom could lift potential output by about half a percent.
beyond hardware and software), our analysis clearly demonstrates that a tech-like spending boom on generative AI could boost the rate of U.S. economic growth by a half to a full percentage point per year.

**Real Yields: AI Can Take You Higher**

A tech-like AI boom would also have potential implications for real interest rates. If a generative AI revolution lifts potential GDP growth, then the U.S. economy would also likely face a higher real interest rate environment in coming years. In remaining focused on the late-1990s, we start by identifying a measure for real short-term interest rates. As a proxy, we used the effective federal funds rate less the six-month annualized change in the core PCE deflator. This measure is obviously highly dependent on Fed policy, but the real federal funds rate averaged 3.7% from 1995-1999 and remained elevated until the U.S. economy slipped into recession in 2001 (Figure 6). Over the past decade or so, real rates have largely been negative. The FOMC kept its target for the federal funds rate near the zero-lower bound during the worst period of the COVID pandemic, and it has subsequently spent the past year or so playing catch-up to the sharp rise in PCE inflation.

Determining where real rates are headed in the future depends largely on the neutral rate, which goes by many names including the natural rate of interest and r-star. In short, r-star aims to measure the real interest rate that is consistent with potential GDP growth and stable inflation, and it is notoriously challenging to estimate in real time. That said, researchers at the Federal Reserve (Thomas Laubach and John Williams) developed a widely followed model that attempts to estimate r-star. As seen in Figure 7, the natural rate of interest has declined on trend since the late-1960s, and it has moved fairly consistently with broad changes in productivity growth. The tech-boom of the late 90s drove productivity growth, and thus r-star, higher. To the extent that the AI transformation leads to a surge in investment that lifts growth in productivity, then real interest rates would likely rise because a higher neutral rate would be required amid stronger potential output growth, all else equal. Consequently, nominal interest rates (i.e., interest rates paid by consumers and businesses) could be higher in coming years than they were during the decade of the 2010s if, as we predict, AI lifts productivity growth.

**Conclusion**

Sustained strong growth in capital spending has the potential to boost productivity growth. A lesson of the 1990s is that the period of robust spending on hardware and software that occurred during those years contributed to the productivity acceleration of the second half of that decade. In short, strong capital spending, in conjunction with an acceleration in TFP, helped to lift the economy’s potential growth rate, which was associated with a marked increase in living standards. If the buildout of generative AI leads to a renewed period of robust spending on hardware and software, then productivity could accelerate anew.
But there are also some consequences to consider. First, a higher rate of potential GDP growth would lead to an environment of higher real interest rates. But higher real rates are not necessarily detrimental, especially if the driver is faster potential GDP growth. Although debt servicing costs would be higher, those costs could be managed by the associated rise in real income growth. Perhaps of greater concern is the potential displacement of workers that wholesale adoption of generative AI could entail. We will focus on the labor market implications of generative AI in the next report in this series.

Endnotes
1 - According to the Bureau of Labor Statistics Total Factor Productivity Technical Notes, “Total factor productivity measures describe the relationship between output in real terms and the inputs involved in its production. They do not measure the specific contributions of labor or capital, or any other factor of production. Rather, total factor productivity is designed to measure the joint influences of technological change, efficiency improvements, returns to scale, reallocation of resources, and other factors on economic growth, allowing for the effects of capital and labor.” (Return)


3 - Measuring the Natural Rate of Interest, Federal Reserve Bank of New York. (Return)
Part III: The Labor Market and Income

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Summary

- Past technological breakthroughs have brought with them concerns about new technology’s impact on the labor market. Artificial intelligence has sparked another such wave of anxiety today, as large language models (LLMs) such as ChatGPT have led to new fears about the future of employment in a world of widely adopted generative AI. Will generative AI displace large numbers of workers, and what will happen to living standards for the average American worker?

- If history is any guidepost, mass unemployment and declining living standards as a result of generative AI seem unlikely for the foreseeable future. Total employment and average living standards in the United States have trended steadily higher despite technological change over the years. U.S. nonfarm employment is 156 million at present, up from 45 million 75 years ago. Although there have been some concerns over widening income inequality and economic challenges for certain industries and occupations, living standards have risen for most American households. Inflation-adjusted income for the median American household has risen over the decades despite some recession-induced dips along the way.

- Technology can often complement rather than substitute for many existing jobs by freeing up time spent on certain tasks and allowing workers to focus on other activities that ultimately lead to more and/or higher quality output. The less time workers spend on rote, time-consuming, lower value-add activities, the more time they can allocate to higher value-added pursuits.

- Another counterbalance is that new types of work often emerge as a result of major technological breakthroughs. Many of the jobs performed today had not yet been “invented” in 1940. While switchboard operators and typists have almost completely disappeared, data scientists, solar panel installers and project management specialists have emerged and flourished.

- If generative AI lives up to the hype and marks a major breakthrough along the lines of the information technology revolution in the 1990s, we would expect the macroeconomic impact to be an acceleration in real GDP, real incomes and overall employment. We doubt the disruption would be completely painless. Some occupations could be automated over time, leading to economic pain at the microeconomic level. Income inequality might widen, and the fortunes of various industries could rise and fall.

- But we believe there is some comfort to be had from the historical record, which shows that real incomes for the typical household have benefited from major technological advances and that prior doomsday scenarios of not enough new jobs have not panned out.

- Could generative AI be more disruptive to the labor market than our historical guideposts? There is certainly a tail risk of that, but making the widespread displacement of jobs the base case risks joining a long historical record of commentators who have rung the alarm bell about surging unemployment due to new inventions that seemed unbelievable to the humans of the time. If the labor market could talk, it might echo Mark Twain’s famous words: “reports of my death are greatly exaggerated.”
Waiting for Godot Bot

Fear about technology displacing workers is not a new phenomenon. The Luddites in early 19th century England are perhaps the most well-known example of opposition to new technology on the grounds of labor preservation. The Luddite movement opposed mechanization in England's key textile industry over concerns that the cost-saving machines would lead to layoffs, lower wages and inferior goods. More than 200 years later, the term Luddite has stuck with us and now references someone who is opposed or resistant to new technologies.

The Luddite movement is far from the only time people have expressed concerns about the impact of technological innovation on employment and living standards. History is rife with similar examples in both earlier and later times. In 1589, Queen Elizabeth I denied inventor William Lee a patent for his stocking frame knitting machine on the grounds that the new product would “assuredly bring [her subjects] to ruin by depriving them of employment, thus making them beggars.” 1 In the 1930’s, John Maynard Keynes coined the phrase “technological unemployment” in reference to innovations that displaced workers faster than new jobs could be created, thereby leading to rising joblessness. 2

In more recent times, much ink has been spilled on this topic. In September 1980, the New York Times ran an article titled “A Robot Is After Your Job: New Technology Is Not a Panacea.” The article claimed, among other things, that “labor-saving technologies are becoming far too pervasive to assume that enough jobs will automatically be created for the number of people displaced” and “many white-collar occupations that promised jobs to displaced blue-collar workers in the past are themselves being automated.” 3 Twenty years later at the peak of the internet boom, then Fed Chair Alan Greenspan postulated that rapid technological change was making jobs less secure in the United States and, by extension, restraining wage growth. 4 Last decade, former Treasury Secretary Larry Summers expressed the view that the primary economic challenge of the future would not be producing enough stuff but rather producing enough good jobs. 5

Despite these worries across numerous periods of tremendous technological change, total employment and average living standards in the United States have trended steadily higher. Nonfarm employment in the United States is 156 million at present, up from 45 million 75 years ago (Figure 1). Although there have been some concerns over widening income inequality and economic challenges for certain industries and occupations, living standards have risen for most American households. As mentioned in Part I, real GDP per capita has trended steadily higher over the decades, and inflation-adjusted income for the median American household has risen despite some recession-induced dips along the way (Figure 2).

But as any good investment disclosure will tell you, past results do not guarantee future returns. Large language models (LLMs) like ChatGPT have burst onto the scene over the past year, and this breakthrough has raised understandable concerns about how the new technology may disrupt labor markets. Will generative AI displace large numbers of workers? Will there be enough new jobs to go around, and will the quality of employment be high enough to keep living standards on the rise for the median American household? Put another way, is this time different?
What Happened to the Labor Market during the 1990s Information Technology Boom?

The most recent major technological revolution to have had a profound impact on U.S. productivity growth was the widespread adoption of the internet and the networking of computers in the 1990s. In 1989, the U.S. Census Bureau estimated that just 15% of U.S. households had a home computer, and only 37% of working adults reported using a computer on the job. The survey did not ask respondents about internet usage, and the 46-page Census Bureau report published did not even use the word “internet” once. By 2003, 62% of households had a computer at home, and 55% had internet at home. At work, 56% of employed adults reported using a computer, and 42% used the internet to do their jobs.

This information technology boom led to surges in capital investment and productivity growth that we discussed in earlier reports. But what happened to employment and living standards? For the most part, the macroeconomic data were quite positive. Nonfarm payrolls grew by 1.8% per year from July 1990 (a business cycle peak) through March 2001 (the next business cycle peak), putting total employment 23 million jobs higher over this nearly 11-year period. The share of the population that was employed hit its highest rate on record in early 2000. Real GDP grew at a robust 3.2% annualized pace over this period, and inflation-adjusted median household incomes accelerated (refer back to Figure 2).

Most occupations and industries added jobs during this period despite the technological disruption. The employment diffusion index, which measures the breadth of job growth across private sector industries, was above its long-run average throughout most of the 1990s (Figure 3). Perhaps unsurprisingly, technology-related employment boomed. Payrolls in the computer systems design and related services industry (think software developers) tripled in the decade (Figure 4). Telecommunications employment soared as cell phones, pagers and the internet became more widely adopted. Strong employment and real income growth spilled over into other non-technology employment categories, such as leisure and hospitality. The rapid technological change even led to a surge in job training employment, as workers sought to gain skills that did not exist or were not as relevant 10 years earlier.
Part III: Figure 3

Employment Diffusion Index
Industries Adding Jobs Over the Past Month

This is not to say the 1990s period of technological adoption was completely painless. Some industries and occupations saw flat lining or declining employment, although not enough to offset the robust job gains added elsewhere. Manufacturing employment fell 4.3% between July 1990 and March 2001 (business cycle peak to business cycle peak), though not all of this decline can be attributed solely to automation (Figure 5). Although a rising tide lifted nearly all boats, real incomes grew fastest for the highest earners, and as a result, income inequality widened throughout the 1990s internet and computer boom (Figure 6). Thus, while a macroeconomic catastrophe of falling employment and living standards was avoided, at the microeconomic level, some workers in certain industries and occupations struggled in this period of rapid technological change.

Part III: Figure 4

Computer Systems Design & Services Employment
Thousands, 1990-2000

Generative AI Boom Amid a Baby Bust

More recently, one of the most pressing issues in the U.S. labor market has been the availability of workers rather than the availability of jobs. Labor shortages have vexed businesses for the better part of the past five years. Finding quality labor frequently ranks as small businesses’ most important problem (Figure 7), while the number of job openings per unemployed worker stands head and shoulders above historic levels.
Difficulty in finding workers has not only stemmed from the strength of the economy but also the structural slowdown in labor supply growth. The factors driving the slowdown—weak growth in the working-age population and more tepid gains in labor force participation with the majority of women already in the workforce—do not appear to be going away anytime soon. The Congressional Budget Office estimates the U.S. labor force will grow roughly 0.5% per year from 2023-2033, about half the pace of the prior 30 years (Figure 8).

With labor supply growth likely to slow further, the advent of generative AI could be construed as a welcome development for an economy in which labor has become more scarce. Yet the potentially sizable jump in automation technology from generative AI ushers in the possibility for rapid changes in labor demand and with it fears of mass job loss. How might AI, and specifically generative AI, reshape the jobs market in the years to come?

### Part III: Figure 7

**Small Business Important Problems**

<table>
<thead>
<tr>
<th>Single Most Important Problem Facing Firms, 3-Yr. Mov. Avg.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labor Quality: Jul @ 23.5%</td>
</tr>
<tr>
<td>Inflation: Jul @ 18.6%</td>
</tr>
<tr>
<td>Taxes: Jul @ 15.5%</td>
</tr>
<tr>
<td>Regulations: Jul @ 9.5%</td>
</tr>
<tr>
<td>Poor Sales: Jul @ 6.3%</td>
</tr>
</tbody>
</table>

Source: NFIB and Wells Fargo Economics

### Part III: Figure 8

**Labor Force Growth**

<table>
<thead>
<tr>
<th>Year-over-Year Percent Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>CBO Forecast</td>
</tr>
<tr>
<td>Annual Labor Force Growth</td>
</tr>
<tr>
<td>5-Year Moving Average</td>
</tr>
</tbody>
</table>

Source: Congressional Budget Office and Wells Fargo Economics

### Feeling Exposed: Generative AI and Today’s Jobs

Despite still being a fairly new technology, researchers already have begun to explore the extent to which the application of LLMs could perform tasks currently done by today’s workers. The numbers often seem frightening for those worried about extensive job losses. By one estimate, 80% of workers could have at least 10% of their tasks affected by generative AI, while 19% could have at least half of their tasks affected. A recent McKinsey report puts the share of time spent on work activities that generative AI and other technology could automate at 60-70%.

What types of jobs appear to be most directly in the crosshairs? Each major wave of new technology has its own bent. The ability of software to automate routine information processing disproportionately depressed demand for middle-skill jobs during the 1990s tech build-out. Robotics have left a greater mark on physical jobs involving routine movements in the manufacturing sector. Generative AI is anything but routine. The ability of LLMs to interact fluidly with humans and create bespoke content on a wide range of topics could compete directly with knowledge workers and the “creative class,” previously viewed as more insulated from technological disruption.

A range of research suggests that generative AI raises the technology exposure of existing jobs most among higher-pay, “white collar” occupations typically held by more educated workers. For example, one recent paper finds 14 of the top 20 occupations most exposed to generative AI fall under the umbrella of postsecondary teachers, including foreign language teachers, history teachers and law teachers. Telemarketers, political scientists, mediators, judges and psychologists also make the list. Perhaps unsurprisingly, the least exposed occupations tended to be manual in nature, such as cement masons, roofers and welders. Similarly, McKinsey finds educators/workforce trainers at the top of the list of occupations to see automation potential rise due to generative AI, with business & legal, STEM and creative arts as other standouts. However, the substantial, generalized...
capabilities of generative AI point to nearly all occupations bearing at least some exposure to this form of technology.

Part III: Figure 9

**Average Standardized AI Exposure**

<table>
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<tr>
<th>Education Level</th>
<th>Weighted Occupational Exposure</th>
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<td>High school</td>
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<td>Some college</td>
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</tr>
<tr>
<td>Bachelor’s degree</td>
<td>0.21</td>
</tr>
<tr>
<td>Graduate or professional degree</td>
<td>0.15</td>
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</table>

Source: Brookings Institute, Webb 2019 and Wells Fargo Economics

Part III: Figure 10

**Change in Technical Automation Potential**

<table>
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<tr>
<th>Occupation</th>
<th>Percentage Point Difference, With Generative AI vs. Without</th>
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</thead>
<tbody>
<tr>
<td>Educator and workforce training</td>
<td>39</td>
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<tr>
<td>Business and legal profession</td>
<td>30</td>
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<tr>
<td>STEM professionals</td>
<td>29</td>
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<tr>
<td>Community services</td>
<td>26</td>
</tr>
<tr>
<td>Creatives and arts management</td>
<td>25</td>
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<tr>
<td>Office support</td>
<td>21</td>
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<tr>
<td>Managers</td>
<td>17</td>
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<tr>
<td>Health professionals</td>
<td>14</td>
</tr>
<tr>
<td>Customer service and sales</td>
<td>12</td>
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<tr>
<td>Production work</td>
<td>9</td>
</tr>
<tr>
<td>Health aides, technicians, and wellness</td>
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<tr>
<td>Property maintenance</td>
<td>9</td>
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<tr>
<td>Food services</td>
<td>8</td>
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<tr>
<td>Transportation services</td>
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<tr>
<td>Mechanical installation and repair</td>
<td>7</td>
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<tr>
<td>Builders</td>
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<tr>
<td>Agriculture</td>
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</tr>
<tr>
<td>Total</td>
<td>12</td>
</tr>
</tbody>
</table>

Source: McKinsey & Company and Wells Fargo Economics

However, exposure to AI technology is not necessarily interchangeable with displacement risk. Generative AI can complement rather than substitute for many existing jobs by freeing up time spent on certain tasks and allowing workers to focus on other activities that ultimately lead to more and/or higher quality output. The less time workers spend on rote, time-consuming, lower value-add activities, the more time they can allocate to higher value-added pursuits. Consider the time saved since advancements such as the GPS, Microsoft Office or internet search engines. In many instances, new technologies help individuals save time that can then be spent honing their crafts in other, more impactful ways.

The risk of generative AI becoming an outright substitute for workers becomes more pressing when it can perform nearly all the tasks of certain occupations. But as jobs that can be augmented become more productive, demand for those jobs can still sometimes grow. Such was the case with accelerated ATM adoption in the 1990s. The number of ATMs in the United States quadrupled between 1995 and 2010. Yet bank teller employment actually increased over this period as fewer tellers per bank branch permitted the opening of more branches and the automation of routine tasks freed up tellers to engage in other tasks, such as relationship banking.

In addition, other types of employment can increase as the presumed productivity boost raises real incomes. “Surplus” income can be spent in areas less exposed to automation, such as travel, dining out, house cleaning, beauty and personal fitness, thus supporting other areas of employment. 

**Generative AI can complement rather than substitute for many existing jobs.**
Part III: Figure 11

Job Growth in "Surplus" Income-Friendly Industries
12-Month Moving Average, Indexed to 1990

- Arts, Entertainment & Recreation: Dec @ 214
- Accomodation & Food Services: Dec @ 176
- Personal Care Services: Dec @ 176
- Total Private: Dec @ 142

Source: U.S. Department of Labor and Wells Fargo Economics

Furthermore, new types of jobs are likely to be created in the wake of wide-scale deployment of generative AI. It is easier to quantify the existing jobs that AI can perform than it is to imagine the new types of jobs that it will create. Researchers at MIT note that more than 60% of the jobs done in 2018 had not yet been "invented" in 1940. While switchboard operators and typists have almost completely disappeared, data scientists, solar panel installers and project management specialists have emerged and flourished.

Predictions thus far about mass net job losses stemming from automation have not held up particularly well. A 2013 paper by Oxford economists estimated 47% of U.S. employment was at high risk of being automated over the next decade or two. Instead, unemployment has hovered near its lowest level in five decades in recent years (excluding the brief spike around COVID lockdowns), and the employment-to-population ratio for prime-age adults (25-54) currently stands at a 22-year-high (Figure 12).

Speed of Adoption in a World with Frictions

Another reason that labor-saving technology has not led to rapid, mass job loss in the past is that it takes time for new innovations to diffuse. The public has been quick to try applications like ChatGPT, and its relative ease of use ushers in the possibility that generative AI could be widely adopted in quick fashion. There appear to be few barriers to entry in creating LLMs based on open source technology. As such, competitive pressures could keep usage fees low and entice commercial adoption.

That said, there are plenty of hurdles that could slow adoption. Regulatory guardrails could affect how quickly firms dive into AI, as policymakers may step in to address concerns about privacy or the potential for AI to create and spread false information. In some occupations particularly exposed to generative AI—education, community services and health—government is heavily intertwined in the services provided. But, governments are not exactly the most nimble when it comes to adopting cutting-edge technology (recall the stress on antiquated state unemployment insurance systems in 2020, for example), and they are particularly sensitive to putting people out of jobs. Pushback from existing labor could further slow adoption as the writers and actors strikes in Hollywood currently demonstrate. Difficulty in acquiring related physical capital such as GPUs, adjusting legacy information systems and finding workers qualified to implement generative AI into existing operations create additional barriers to rapid adoption of generative AI.

Conclusion: Is This Time Really Different for the Labor Market?

With major technological breakthroughs often taking decades to diffuse as we discussed in Part I of our series, it is still early days in determining definitively whether generative AI will turbo-charge productivity growth and, by extension, impart a shock on the labor market. That said, the capabilities of AI appear vast. The ability of LLMs to process hundreds of billions bits of data, generate original...
content, and interact almost seamlessly with humans makes it a serious contender for revolutionizing the ways many existing jobs are performed and the types of jobs the economy will bear in the future.

If generative AI marks a major breakthrough along the lines of the information technology revolution in the 1990s, history tells us that the macroeconomic impact should be an acceleration in real GDP, real incomes and overall employment. We doubt the disruption would be completely painless. Occupations in which the vast majority of tasks can be automated could, over time, disappear. Some remaining types of jobs could be less well paid or fulfilling, affecting income inequality and worker satisfaction. Additionally, not all workers may have the time horizon to re-train for occupations in which generative AI is complementary or for the new jobs sprung from this technology that have yet to be imagined. But there is some comfort to be had from the historical record, which shows that real incomes for the typical household have benefited from major technological advances and that prior doomsday scenarios of new jobs not being created quickly enough to offset disappearing occupations have not panned out.

Could generative AI be more disruptive to the labor market than our historical guideposts? There is certainly a tail risk of that, just like there is a tail risk of many things in macroeconomics. But making the widespread displacement of jobs the base case risks joining a long historical record of commentators who have rung the alarm bell about surging unemployment due to new inventions that seemed unbelievable to humans of the time. If the labor market could talk, it might echo Mark Twain's famous words: "reports of my death are greatly exaggerated."

Endnotes
ChatGPT Affect Occupations and Industries?" March 2023; Chui et al. 2023; and Eloundou et al. 2023. (Return)
14 - Felten et al. 2023. (Return)
16 - Autor 2015. (Return)
Part IV: Conclusions

Published on August 17, 2023

Summary

• Much of the conversation surrounding generative AI has focused on its potential impact on the labor market. But there is an important impact on productivity growth that is often overlooked in the commentary on AI. Generative AI has the potential to raise productivity growth and thereby growth in real per capita income.

• Another byproduct of stronger productivity growth is a rise in real interest rates. If, as we surmise, the productivity-enhancing effects of AI lead to stronger potential economic growth, then nominal interest rates could be higher in coming years than they were during the decade of the 2010s.

• Technological revolutions generally do not have marked effects on productivity growth immediately. Could generative AI have a more immediate effect on the labor market via significant displacements? Research suggests that generative AI raises the technology exposure of existing jobs the most among higher-pay, “white collar” occupations that are typically held by more educated workers.

• Generative AI can complement rather than substitute for many jobs, and AI may create new classes of occupations that are difficult to imagine now. The productivity-boosting effects of AI should lift aggregate real income, which should increase the demand for all types of goods and services, thereby increasing employment in those sectors.

• We generally are AI optimists in terms of its macroeconomic effects, but we acknowledge that it could have adverse microeconomic effects on certain individuals. Supportive public policy may be needed in coming years if generative AI has disruptive microeconomic effects that lead to social and political pathologies.
Stronger Productivity Growth: The Upside of AI

Artificial intelligence (AI) was starting to take root in the public consciousness in the years preceding COVID, but AI largely disappeared from the conversation when the pandemic led to economic upheaval. However, the release of ChatGPT in November 2022 has reestablished AI in the forefront of public discourse. Understandably, much of the conversation has focused on the labor market impact from generative AI, which is the subject of Part III of this series.

But there is an important impact on productivity growth—the subject of Part I—that is often overlooked in the commentary on AI. Generative AI has the potential to raise productivity growth via two major channels. Productivity growth, which is defined as an increase in the amount of goods or services produced per hour worked, is vitally important because it, along with growth in the labor supply, is one of the determinants of an economy’s long-run sustainable rate of growth. Moreover, productivity growth is the primary determinant of growth in real per capita GDP which, in theory, is equal to growth in real per capita income.

In short, the promise of AI is its potential to raise productivity growth and thereby living standards. That is not to say that every individual will necessarily realize an increase in their standard of living. Some individuals, especially those whose job could be displaced by AI, could suffer a decline in their level of real income. But, past episodes of accelerating productivity generally have been associated with rising real incomes for the typical household.

The first channel through which generative AI could lift overall productivity growth is via total factor productivity (TFP). The Bureau of Labor Statistics (BLS) defines TFP as “the joint influences of technological change, efficiency improvements, returns to scale, reallocation of resources, and other factors on economic growth, allowing for the effects of capital and labor.” Clearly, enabling workers with better technology should give them the ability to produce more goods or services per hour worked. For example, the widespread adoption of the internet and the networking of computers that occurred during the 1990s led to a marked rise in TFP growth in the second half of the decade (Figure 1). The overall rate of productivity growth, which was lackluster throughout the 80s and into the early years of the 90s, strengthened considerably in the late 90s.

The Tech Build-out of the 1990s as a Case Study for Capital Expenditures

Acceleration in capital expenditures is the second channel through which generative AI could lift productivity growth. As we noted in Part II of this series, spending on hardware and software rose strongly during the tech build-out of the 1990s, and this rise in the economy’s capital stock contributed to the acceleration in productivity that transpired at the time (Figure 1). The widespread adoption of generative AI would also require a significant amount of new spending on hardware and software. If the spending on hardware and software that will be needed in coming years to adopt
generative AI resembles the tech build-out of the 90s, then we estimate that this component of capital spending will rise roughly 50% above its recent trend (Figure 2).

A byproduct of stronger productivity growth is a rise in real interest rates. As we noted in Part II, the real fed funds rate averaged 3.7% between 1995 and 1999 (Figure 3), a period during which the Congressional Budget Office estimates that potential GDP growth averaged about 3.5% per annum. In contrast, the real fed funds rate was negative through most of the 2010-2019 economic expansion when potential output growth slumped to only about 1.8%. If, as we surmise, the productivity-enhancing effects of AI lead to stronger potential economic growth, then nominal interest rates (i.e., interest rates paid by consumers and businesses) could be higher in coming years than they were during the decade of the 2010s.

Part IV: Figure 3

![Real Fed Funds Rate](image1)

Source: U.S. Department of Commerce, Bloomberg Finance L.P. and Wells Fargo Economics

**AI Likely Will Not Transform the Economy Overnight**

Technological revolutions generally do not have marked effects on productivity growth immediately. As we discussed in our first report, the First Industrial Revolution commenced in Great Britain in the late 18th century. However, British productivity, and hence real per capita GDP in Great Britain, did not begin to accelerate noticeably until the mid 19th century (Figure 4). Mobile phones, personal computers and internet protocol were invented in the 1970s, but these technological breakthroughs did not have a significant impact on productivity growth until their widespread adoption in the 1990s. Similarly, there are a number of factors that could hold back rapid adoption of AI, as we noted in our first report. Mckinsey estimates that 50% of the work activities that are performed at present could be automated between 2030 and 2060. The midpoint of this range (2045) is still more than 20 years in the future.

Will Generative AI Be Accretive or Dilutive to Employment?

In sum, AI has the potential to raise aggregate living standards in the United States, but the effects may not be felt for years. Could generative AI have a more immediate effect on the labor market via significant displacements? As we noted in Part III, some researchers estimate that 80% of workers could have at least 10% of their tasks affected by generative AI, while 19% could have at least half of their tasks affected. Research also suggests that generative AI raises the technology exposure of existing jobs most among higher-pay, “white collar” occupations that are typically held by more educated workers (Figure 5).

However, exposure to AI technology is not necessarily interchangeable with displacement risk. Generative AI can complement rather than substitute for many existing jobs by freeing up time spent on certain tasks, thereby allowing workers to focus on other activities that ultimately lead to more and/or higher quality output. Furthermore, the income-enhancing potential of AI can spur the demand for jobs in areas less exposed to automation, such as travel, dining out, house cleaning, beauty and
personal fitness. Employment in the arts, entertainment & recreation industries, the accommodation & food services sector and the personal care services industry all outpaced overall job growth when the tech build-out caused productivity growth to strengthen in the 1990s (Figure 6). Additionally, new types of jobs, which have not been "invented" yet, are likely to be created in the wake of wide-scale deployment of generative AI.

Part IV: Figure 5

Average Standardized AI Exposure

<table>
<thead>
<tr>
<th>Education Level</th>
<th>Weighted Occupational Exposure</th>
<th>Exposure Based on Overlap Between AI Patent Capabilities and Occupational Tasks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than high school</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>High school</td>
<td>0.04</td>
<td>0.04</td>
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<tr>
<td>Some college</td>
<td>0.03</td>
<td>0.03</td>
</tr>
<tr>
<td>Bachelor's degree</td>
<td>0.21</td>
<td>0.21</td>
</tr>
<tr>
<td>Graduate or professional degree</td>
<td>0.15</td>
<td>0.15</td>
</tr>
</tbody>
</table>

Source: Brookings Institute, Webb 2019 and Wells Fargo Economics

Just as the productivity-lifting effects of AI that we discussed in Part I may not show up immediately, there could be hurdles that retard the potentially disruptive effects of generative AI to the labor market. Regulatory guardrails could affect how quickly firms dive into generative AI, and pushback from workers who could be adversely affected by AI could also impede rapid adoption. Difficulty in acquiring related physical capital such as GPUs, adjusting legacy information systems and finding workers qualified to implement generative AI into existing operations create additional barriers to rapid adoption of generative AI.

That said, the effects of generative AI on the labor market likely will not be completely benign. Some occupations could be automated over time, leading to economic pain at the microeconomic level. Income inequality might widen, and the fortunes of various industries could rise and fall. But, making the widespread displacement of jobs the base case risks us joining a long historical record of commentators who have rung the alarm bell about surging unemployment due to new inventions that seemed unbelievable to the humans of the time.

Conclusions

Generative AI is arguably the most important technological breakthrough that has occurred in recent decades. Sundar Pichai, the CEO of Alphabet Inc. (the parent company of Google), has even suggested that AI could be more profound than “fire or electricity.” Although AI may not be quite as revolutionary as Pichai envisions, it likely will have profound economic effects that could take a number of years, if not a number of decades, to play out fully. For starters, generative AI could lift growth in labor productivity via its effects on total factor productivity (TFP) and capital investment. Productivity acceleration, should it occur, would lead to stronger growth in real per capital income, at least on an aggregate basis.

We tend to be skeptical of dystopian predictions of widespread unemployment resulting from AI adoption in coming years. We readily acknowledge that some workers, especially those in occupations in which generative AI can perform most of the tasks, could be displaced. However, occupations that involve a significant amount of manual labor likely will not be highly exposed to potential AI displacement. Furthermore, generative AI can complement rather than substitute for many jobs. That is, AI can perform routine tasks, allowing workers to focus on higher value-added activities. Additionally, AI may create new classes of occupations that are difficult to imagine now. The
productivity-boosting effects of AI should lift aggregate real income, which should increase the
demand for all types of goods and services, thereby increasing employment in those sectors.

In closing, we generally are AI optimists, at least in terms of its macroeconomic effects. As we
pointed out in Part III of this series, history is rife with examples of groups that have opposed
technological change due to fears of widespread job losses. Time and again, however, aggregate levels
of employment and income have risen in the aftermath of the introduction of the new technology.
Of course, new technologies can be disruptive, which can cause detrimental microeconomic effects
to individuals that in turn can have social and political consequences. We have purposefully eschewed
discussion of the potential social and political consequences of artificial intelligence in this series
because we readily admit we do not have the expertise to address them. But, we acknowledge that
supportive public policy may be needed in coming years if generative AI has disruptive microeconomic
effects that lead to social and political pathologies.

Endnotes
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