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AI IS A GAME CHANGER FOR ECONOMIC GROWTH

HIGHLIGHTS

▶ The artificial intelligence (AI) revolution is a pivotal event that has the potential to significantly boost labor force productivity and potential GDP growth.

▶ AI may also render demographically based forecasts obsolete for long-term economic growth projections.

▶ The dividends of higher productivity could be substantial, including rising living standards, reduced inflation pressure, reduced federal deficits, and higher stock market returns.

THE AI REVOLUTION IS A PIVOTAL ECONOMIC EVENT

From time to time, things happen that serve as a humbling reminder to investors of the challenges in predicting the future. The Covid pandemic was one such instance, unleashing a torrent of fiscal, monetary, and supply-chain disruptions, culminating in unexpectedly steep inflation and interest rates.

We believe that the nascent revolution in generative artificial intelligence (AI) could signify another such pivotal event, in this case a very positive one, carrying far-reaching implications for labor markets, productivity, economic growth, and financial markets over the forthcoming decade and beyond.

Indeed, the AI revolution may render obsolete demographically based forecasts that have customarily provided a solid basis for long-term economic growth projections.[1] Such projections, which have been employed for decades by both policymakers and investors, will need to be revisited to account for AI as a new type of labor supply.

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THE POTENTIAL GROWTH EQUATION

Potential GDP growth projections form the foundation for long-term economic growth and capital market assumptions. The arithmetic is simple and based heavily on demographics: potential GDP is the sum of projected growth in the labor force and projected growth in productivity (output per labor unit). In essence, potential GDP growth — regarded by policymakers as the economy's "speed limit" — hinges on the number of workers and the efficiency with which they generate goods and services.

A prime illustration of this approach can be found in a recent report by the Congressional Budget Office (CBO) titled "The Budget and Economic Outlook: 2023 to 2033." This document, which serves as the bedrock of the Federal government's budget planning process, forecasts real potential GDP growth of 1.8% over the next decade.[2] The projection presumes potential labor force expansion of 0.4% annually and potential labor force productivity of 1.4% per year **(Figure 1)**.

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[1] Of course, there is another sense in which the AI revolution could mean the twilight of demographics if there is merit to the various "AI doom" warnings that have circulated among knowledgeable AI researchers. See, for example, "Pause Giant AI Experiments: An Open Letter" signed by Elon Musk and many other tech leaders calling for all AI labs to immediately pause for at least six months the training of AI systems more powerful than GPT-4. We will leave the very important AI safety debate to others for now to focus simply on the potential productivity implications of the deployment of the AI technology that already exists, while acknowledging that much more powerful and unpredictable AI technology could be coming soon.

[2] Congressional Budget Office, *The Budget and Economic Outlook: 2023 to 2033*, CBO Publication No. 58848, February 15, 2023.

FIGURE 1

Composition of the Growth of Real Potential GDP

Percent
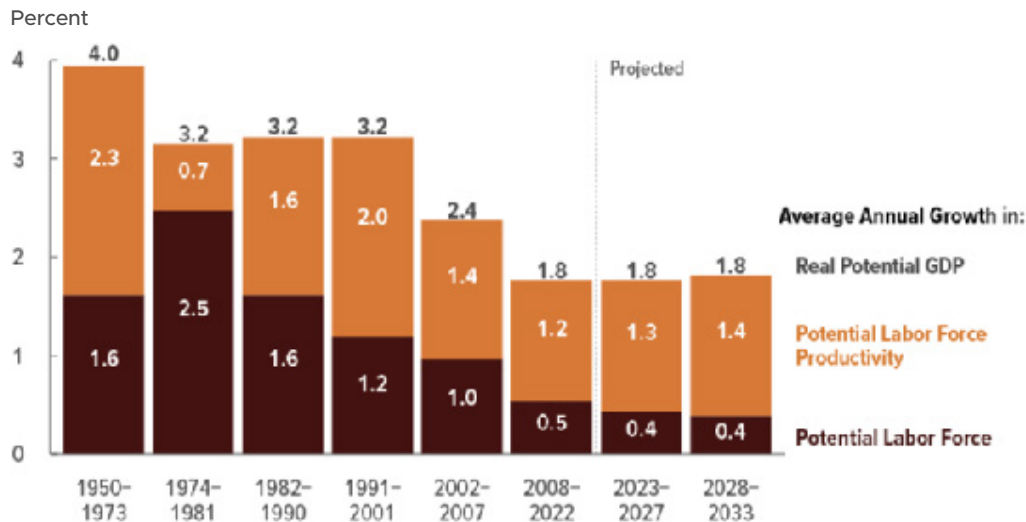
Source: Congressional Budget Office: "The Budget and Economic Outlook: 2023 to 2033," February 2023

The CBO projects that real potential GDP over the next decade will grow at a rate similar to its 1.8% growth rate since the 2007 – 2009 recession.

This estimate aligns with the recent history of real potential GDP growth since the 2007 – 2009 recession. Nevertheless, it falls significantly short of the 3% – 4% rates often witnessed between 1950 and 2001, when labor force and productivity growth were generally more robust. Labor force growth was at its peak in the 1970s as baby boomers entered the labor force in large numbers. Productivity growth exceeded 2% per year in the 1950s and 1960s, reflecting a post-World War II boom in infrastructure investment including the interstate highway system and extensive investments in airports and power grids. A second surge in productivity growth occurred in the 1990s reflecting the fruits of deregulation, trade liberalization, and investment in information technology.

Few currently dispute the plausibility of the CBO's cautious projection for potential GDP growth, as future labor force growth is virtually predetermined by low birth rates and immigration flows from years past, while productivity growth has typically fluctuated within a narrow range.

Similar frameworks underpin long-term economic growth projections by global institutions like the International Monetary Fund (IMF) or the World Bank (WB), which have warned about considerably slower future growth in key Asian economies such as China or South Korea due to formidable demographic headwinds.

AI'S POTENTIAL BOOST TO GROWTH

The recent breakthroughs in AI have been nothing short of remarkable, as evidenced by the media's intense coverage of the escalating competition among leading AI-centric companies such as OpenAI, Anthropic, Google, and Microsoft **(Figure 2)**. The enthusiasm ignited with the launch of OpenAI's ChatGPT last November, which enabled anyone with internet access to engage with a high-performance Large Language Model (LLM) possessing human-like reasoning and communicative skills. Within months, the platform attracted over 100 million users and a $10 billion investment from Microsoft, which subsequently unveiled "Bing AI" based on OpenAI's technology.

FIGURE 2

Media Frenzy on Artificial Intelligence:
Bloomberg AI Story Count, May 2013 – April 2023
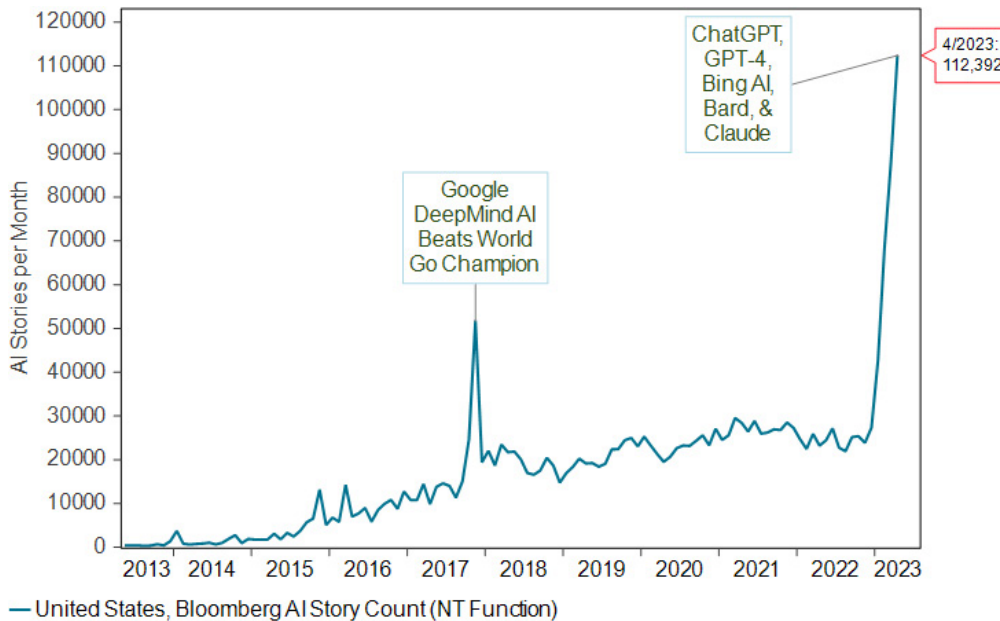
Sources: GW&K Investment Management, Bloomberg, and Macrobond

Media coverage of Artificial Intelligence (AI) has surged in 2023 based on the dissemination of a new class of Large Language Models (LLMs) with human-level cognitive abilities across many domains.

However, an even more striking development unfolded in March when OpenAI introduced GPT-4, their latest AI model. Rigorously assessed by researchers from OpenAI and Microsoft prior to its release, GPT-4 demonstrated human-equivalent or superior abilities across a broad spectrum of domains.[3] It could pass bar examinations, software engineering tests, medical licensing exams, and a variety of other intelligence assessments such as the SAT or GRE.

In essence, it appears that major digital assistants like Siri, Alexa, Cortana, and Google Assistant will soon receive substantial upgrades to their innate intelligence. Consequently, virtually every individual with a computing device will gain access to digital assistants boasting human-level cognitive abilities and the equivalent of multiple graduate degrees.

Rather than attempting to broadly survey this rapidly evolving field, we shall concentrate on GPT-4's established prowess in software development. As noted in Microsoft's technical review, "GPT-4 could potentially be hired as a software engineer."[4] This assertion stems from the AI's exceptional performance on LeetCode's Interview Assessment platform, which simulates coding interviews at major tech firms. GPT-4 resolved all questions from three interview rounds within a mere 10 minutes, compared to the 4.5 hours allocated to human applicants. The AI's scores consistently ranked within the top 10% among human candidates.

This development should prompt economists to ponder the implications of human labor force growth being supplemented by "full-time equivalent" AIs with human-level capabilities. Theoretically, millions of new labor force entrants could emerge as numerous AI "instances" are created, limited only by total computational resources. Given the current 480 million computing devices in the US (desktops, laptops, and mobile devices), there is considerable scope for accelerated growth in the augmented labor force, comprising both humans and AIs.

Now, let us examine the second component of the potential GDP growth equation: productivity or output per unit of input. If Microsoft's findings hold true, the AIs proved to be 27 times more productive than humans during the software engineering mock interviews (10 minutes for AIs versus 270 minutes for humans). This suggests that in industries where AIs can perform at or beyond human standards, a radical acceleration in potential growth is not only possible but probable.

Admittedly, a mere 4 million software engineers currently work in the US, constituting less than 3% of the total employed workforce of roughly 161 million. However, approximately 100 million knowledge workers exist in the US today, representing around 60% of the workforce. For the first time in history, novel technology holds the potential to automate a significant portion of the tasks performed by knowledge workers. The same arithmetic that applies to software engineers is likely to extend to numerous professions, resulting in a surge in the number of "full-time equivalent" AIs and, potentially, a leap in their productivity, or output per hour, as well.

Considering the cost dynamics surrounding cutting-edge AI technology, it has become increasingly clear that the affordability of AI usage is frequently underestimated. As AI expert Nathan Labenz recently observed, the GPT-3.5-turbo model costs a mere one cent for 5,000 tokens, equivalent to 10 pages of writing — a sum so trivial that consuming more than a dime's worth of content daily would be challenging.[5] This reflects a staggering 97% price reduction over a brief nine-month period.

> For the first time in history, novel technology holds the potential to automate a significant portion of the tasks performed by knowledge workers.

[3] OpenAI, GPT-4 Technical Report, v3., March 27, 2023, https://arxiv.org/abs/2303.08774.

[4] Sebastien Bubeck, et al, "Sparks of Artificial General Intelligence: Early experiments with GPT-4," Microsoft Research, March 2023, https://arxiv.org/abs/2303.12712.

[5] Nathan Labenz, "The Leaked Google Memo and OpenAI's Moats," The Cognitive Revolution, Substack, May 6, 2023.

Even the pinnacle of OpenAI's offerings, the high-performance GPT-4 model, can in seconds generate a full day's reading for a paltry $4.50. Looking ahead, Nvidia CEO Jensen Huang forecasts that, within a decade, AI will become "a million times" more efficient, driven by advancements in chip design, software, and other hardware components.[6] Consequently, it appears that the democratization of access to human-level cognitive abilities will be accelerated in the coming years, further underscoring the transformative potential of AI technology.

QUANTIFYING THE UNQUANTIFIABLE: AI'S POTENTIAL IMPACT ON PRODUCTIVITY

The inevitable question arises: What could the potential impact on US productivity growth be over the next decade? While "nobody knows" is an understandable response, Goldman Sachs' economists recently ventured to estimate AI's potential influence on economic growth, yielding some remarkable conclusions:[7]

➤ AI deployment could enhance annual US labor productivity growth by nearly 1.5 percentage points over a decade following widespread business adoption.

➤ The impact could potentially be almost twice as substantial, with a boost of 2.9 percentage points over the same period, assuming more potent AI effects.

➤ Approximately two-thirds of current jobs are susceptible to some degree of AI automation, with AI potentially substituting up to one-fourth of existing work.

➤ Extrapolating such estimates globally indicates that AI could render the equivalent of 300 million full-time jobs automatable.

To put into perspective the radical nature of these conclusions, note that their baseline productivity increase would effectively double the long-term CBO forecast of productivity and economic growth. The baseline would generate a long-term 3% economy reminiscent of the late 1990s or early 2000s boom times. The optimistic scenario could yield a long-term 4% – 4.5% economy, akin to the highest rates seen in the 1950s to early 1970s. Even swifter per capita growth is implied, as the rapid labor force growth of the past (approximately 1.5%) would be supplanted by accelerated productivity growth.

Goldman's scenarios are, of course, carefully caveated, reflecting uncertainty regarding the extent of tasks AI can automate and the pace of its deployment across the economy and globally. They also present a pessimistic scenario envisioning a mere 0.3 percentage point productivity boost, assuming less effective AI deployment **(Figure 3)**.
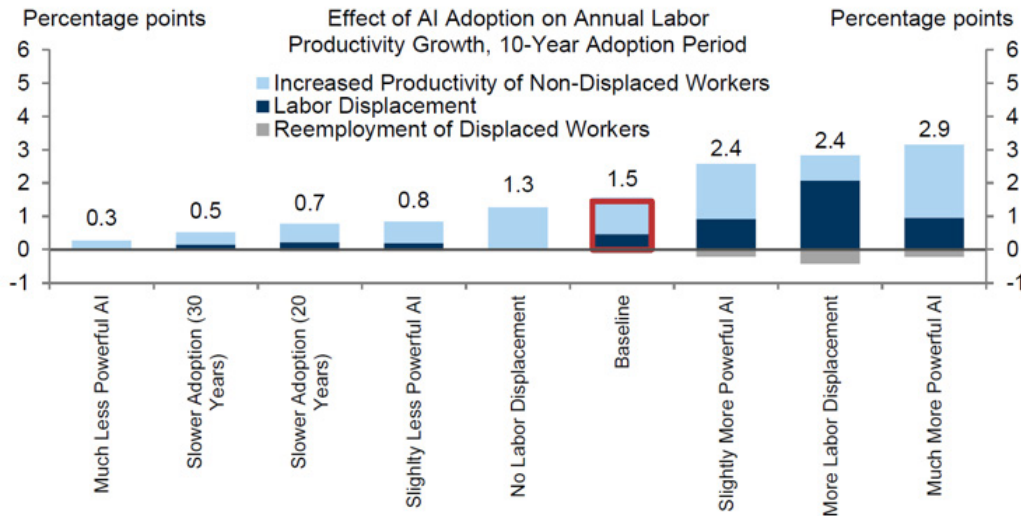
> The optimistic scenario could yield a long-term 4% – 4.5% economy, akin to the highest rates seen in the 1950s to early 1970s.

[6] Jonathan Vanian and Kif Leswing, "ChatGPT and generative AI are booming, but the costs can be extraordinary," CNBC, April 17, 2023.
[7] Joseph Briggs and Devesh Kodnani, "The Potentially Large Effects of Artificial Intelligence on Economic Growth," Goldman Sachs Economic Research, March 26, 2023.

FIGURE 3

Goldman Sachs' Scenarios for an AI Boost to US Labor Force Productivity

Percentage points   Effect of AI Adoption on Annual Labor Productivity Growth, 10-Year Adoption Period   Percentage points

- ■ Increased Productivity of Non-Displaced Workers
- ■ Labor Displacement
- ■ Reemployment of Displaced Workers

Scenario	Value
Much Less Powerful AI	0.3
Slower Adoption (30 Years)	0.5
Slower Adoption (20 Years)	0.7
Slightly Less Powerful AI	0.8
No Labor Displacement	1.3
Baseline	1.5
Slightly More Powerful AI	2.4
More Labor Displacement	2.4
Much More Powerful AI	2.9

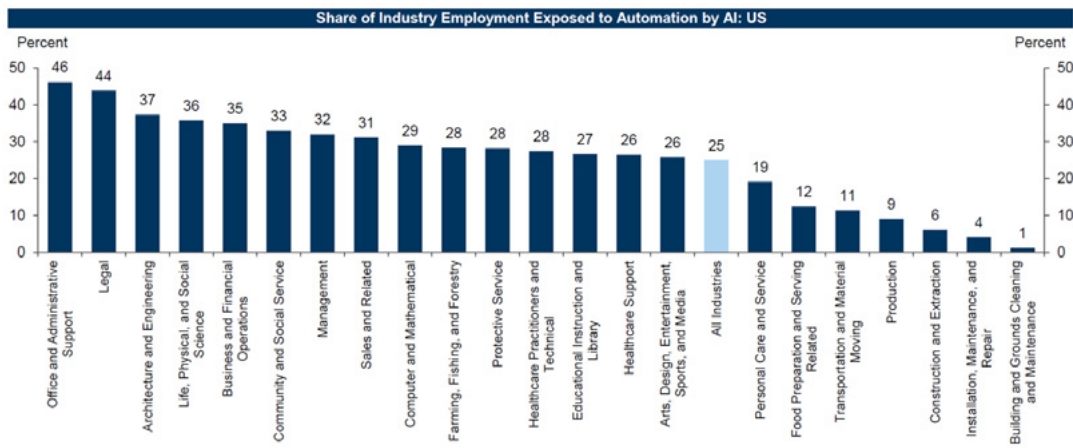Source: Goldman Sachs Global Investment Research

Goldman Sachs recently estimated that AI could boost US labor force productivity growth by 1.5 percentage points over a 10-year period, although the size of the boost will depend on AI's capabilities and adoption timeline.

Here is an intuitive way to think about the implications of Goldman's AI productivity scenarios: Imagine if the US had 14.5 million or 43.9 million more workers by 2033. That's how much extra output the new AI tools could create, using their baseline and optimistic scenarios. They say these tools could make workers 1.5 or 2.9 percentage points more productive each year, on top of the normal growth rate of 1.4 percent. Without these tools, the US would need a lot more people to produce the same amount of goods and services.

As speculative as such scenarios may be, Goldman's work is grounded in granular data on the task content of over 900 occupations in the US and 2,000 occupations in Europe. They subsequently estimated the proportion of tasks that AI could potentially undertake. This informed their conclusion that about two-thirds of US jobs could be partially automated by AI, with 25% – 50% of their tasks being replaced.

Overall, they estimated that one-fourth of current work tasks in the US could be automated by AI, with roles in administration and law being most affected, and jobs involving physical labor, such as construction and maintenance, being less impacted **(Figure 4)**. Their analysis of the euro area yielded similar findings.

FIGURE 4

One-Fourth of Current Work Tasks Could be Automated in the US

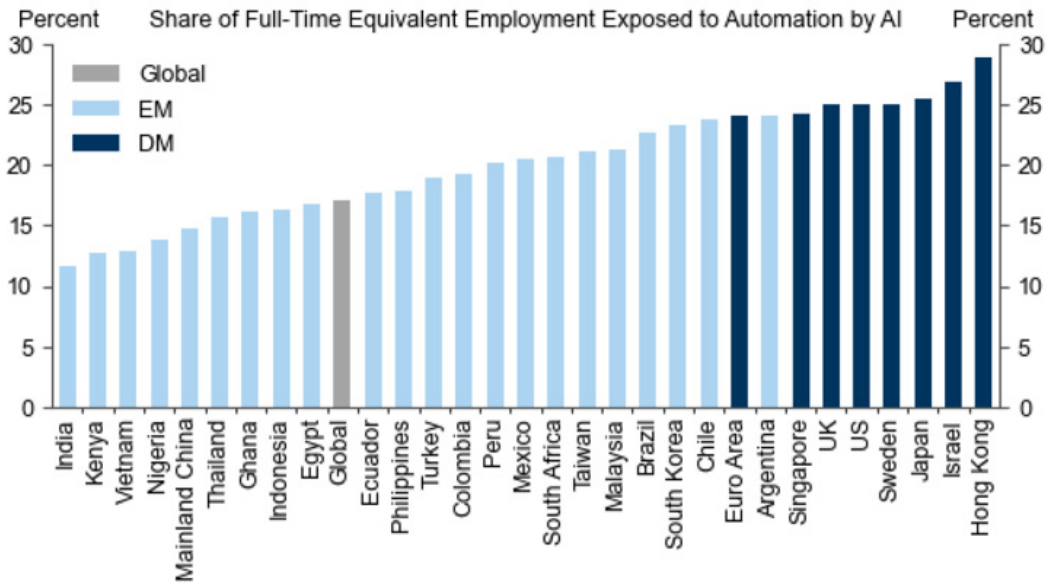Share of Industry Employment Exposed to Automation by AI: US

Source: Goldman Sachs Global Investment Research

Based on a granular database of occupational tasks that are exposed to automation by AI, Goldman estimates that one-fourth of current work tasks could be automated in the US.

Goldman's report also expanded this analysis globally, accounting for differences in industry composition across countries and presuming that AI would not disproportionately affect the large agricultural sectors in emerging market (EM) economies. Their global analysis proposes that fewer jobs in EMs are vulnerable to automation than in developed market (DM) economies, but that 18% of work globally could be automated by AI **(Figure 5)**.

FIGURE 5

Globally, 18% of Work Could be Automated by AI, with Larger Effects in DMs than EMs

Percent   Share of Full-Time Equivalent Employment Exposed to Automation by AI   Percent

Legend:
- Global
- EM
- DM

Categories (left to right): India, Kenya, Vietnam, Nigeria, Mainland China, Thailand, Ghana, Indonesia, Egypt, Global, Ecuador, Philippines, Turkey, Colombia, Peru, Mexico, South Africa, Taiwan, Malaysia, Brazil, South Korea, Chile, Euro Area, Argentina, Singapore, UK, US, Sweden, Japan, Israel, Hong Kong

Source: Goldman Sachs Global Investment Research

Due to the larger share of knowledge workers in DMs vs EMs, Goldman concluded that proportionately more work could be automated in DMs than EMs, with 18% of work globally subject to AI automation.

This is not to suggest that nearly one-fifth of global jobs will disappear due to AI. Although technology may supplant some tasks, it can also bolster productivity in other domains and create new tasks — and thus, new occupations. Goldman cites research demonstrating that 60% of today's workforce occupies roles that did not exist in 1940, implying that over 85% of employment growth in the past 80 years can be attributed to technology-driven job creation. Goldman's baseline scenario assumes that AI will replace a mere 7% of current US employment, support 63% of jobs, and leave 30% unchanged **(Figure 6)**.

This is not to suggest that nearly one-fifth of global jobs will disappear due to AI.

FIGURE 6

Replacement in Legal and Administrative Fields, Little Effect in Manual and Outdoor Jobs, and Productivity-Enhancement Everywhere Else

Share of Industry Employment by Relative Exposure to Automation by AI
- 0-10%: No Automation
- 10-49%: AI Complement
- 50%+: Likely Replacement
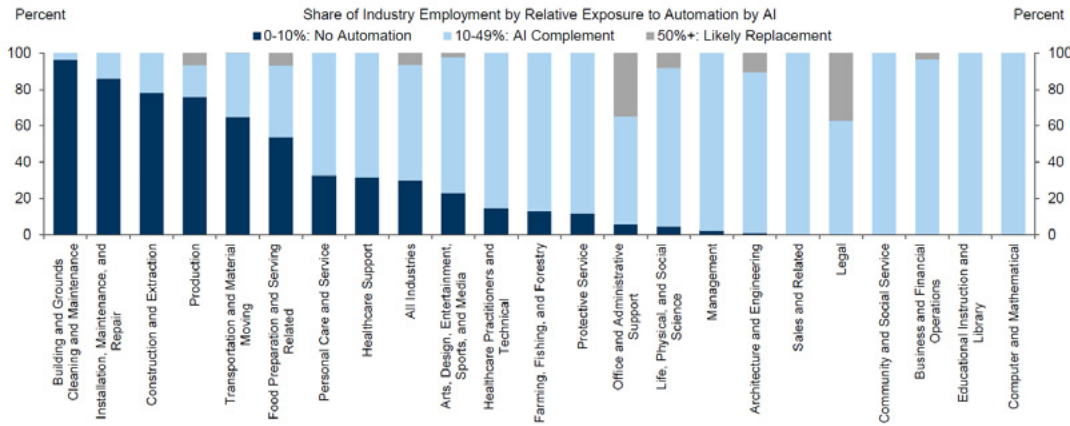
Source: Goldman Sachs Global Investment Research

Goldman's baseline scenario assumes that AI will replace about 7% of current US employement, support or complement 63% of jobs, and leave 30% unchanged.

Historically, when technology has eliminated certain jobs, new ones have typically been created to fill the void. For instance, as information technology advanced, new roles such as website designers, software developers, and digital marketing professionals emerged. Additionally, when these new jobs were established, job growth was stimulated in sectors like healthcare, education, and food services, as new workers had more money to spend on those services. This is not to imply that there will not be significant challenges and disruptions associated with a potential wave of AI-driven automation. The critical question is whether the productivity gains will outweigh the adjustment costs.

FOUR TYPES OF PRODUCTIVITY DIVIDENDS

Goldman's baseline scenario suggests that AI could deliver at least four types of productivity dividends, reshaping the economic and investment environment in the years ahead. First, a marked improvement in living standards can be expected. If productivity growth significantly surpasses labor force growth, GDP per capita could rise annually by 3% or more, evoking memories of the rapid expansion of US living standards during the 1960s and early 1970s.

> If productivity growth significantly surpasses labor force growth, GDP per capita could rise annually by 3% or more, evoking memories of the rapid expansion of US living standards during the 1960s and early 1970s.

Second, the swift implementation of AI may act as a powerful disinflationary force, guiding inflation toward the Federal Reserve's 2% target. Despite the current historic low in America's unemployment rate, the introduction of millions of AI agents with human-level skills could within a few years apply downward pressure on wages, especially for knowledge workers. Moreover, further exponential improvements in AI efficiency seem likely within a decade. This could lead to ongoing downward pressure on wages in many occupations which would prompt the Fed to maintain low interest rates to facilitate worker redeployment across industries. Against this backdrop, we expect there could be a reversal of the long-term trend for services inflation to outstrip goods inflation now that services industries are no longer immune to automation **(Figure 7)**.

> The swift implementation of AI may act as a powerful disinflationary force, guiding inflation toward the Federal Reserve's 2% target.

FIGURE 7

### For Many Decades, Services Inflation Has Been Greater than Durable Goods Inflation
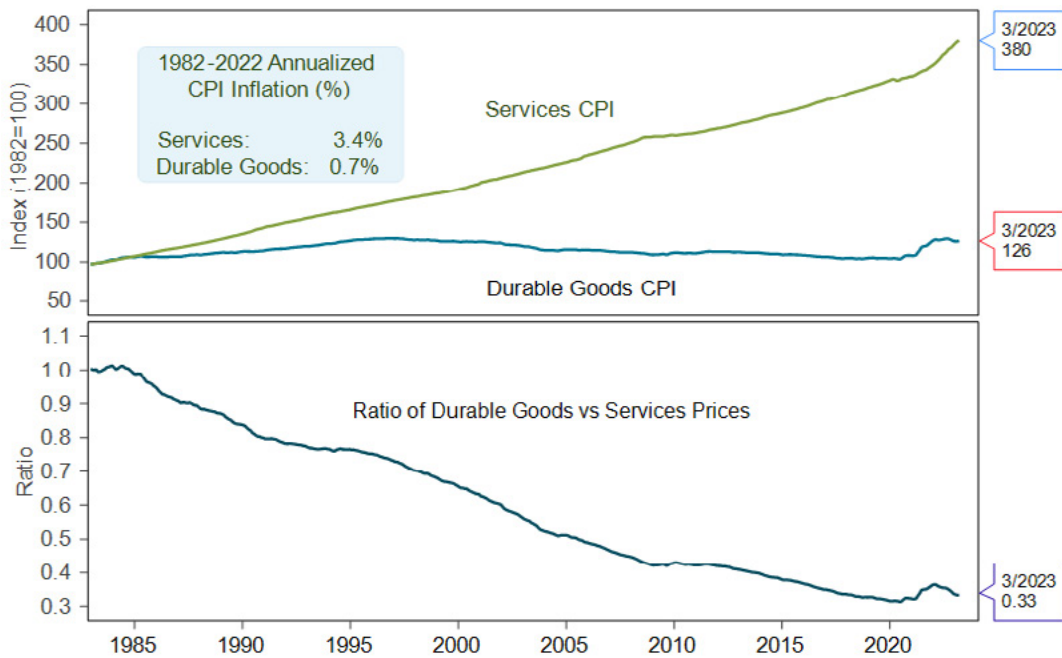
Sources: GW&K Investment Management, BLS, and Macrobond

With AI-driven automation likely to affect services industries in coming years, the long-term trend of services inflation outstripping goods inflation could be coming to an end.

Third, the realization of AI-driven productivity growth could mitigate concerns surrounding demographic challenges and future debt problems. A modest 0.5 percentage point increase in productivity growth over the next 10 years would result in a 4% higher GDP and $1.3 trillion lower deficits, according to the CBO's rules of thumb **(Figure 8)**.[9] Should Goldman's optimistic scenarios materialize, the influence of strong growth on deficit reduction and debt-to-GDP ratios could be substantially more significant.

FIGURE 8

Higher Economic Growth Is Key to the Debt Outlook:
Federal Debt Help by the Public as a Percent of GDP
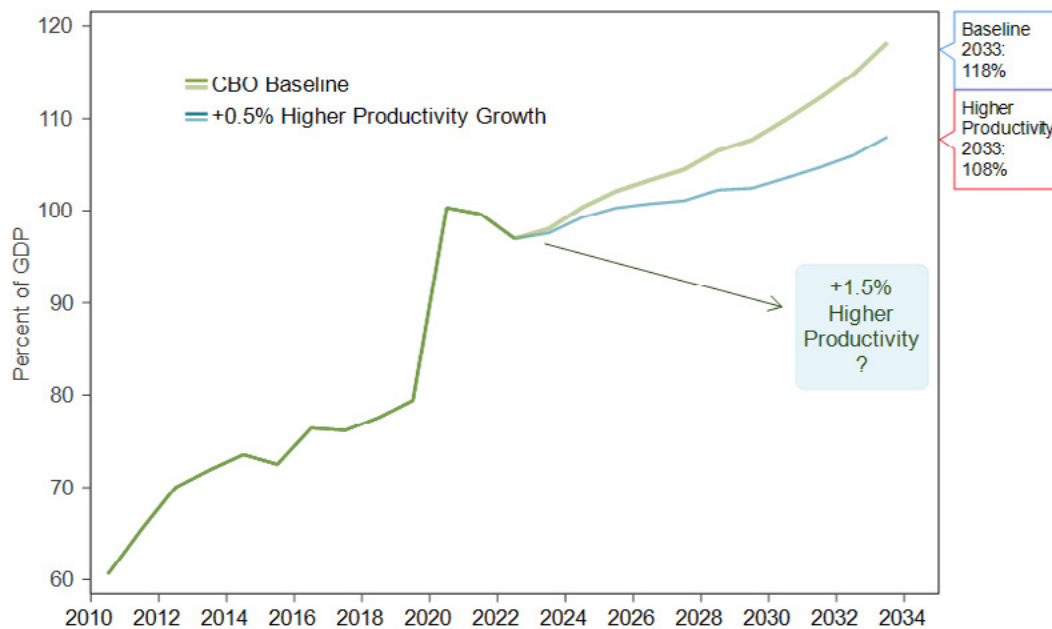
Note: GW&K calculations based on CBO February 2023 baseline and CBO April 2023 rules of thumb.
Sources: GW&K Investment Management, Congressional Budget Office, and Macrobond

A CBO model suggests that higher growth through a productivity boost of 0.5 percentage points would significantly reduce the federal debt burden. Goldman's baseline scenario suggests a far larger beneficial effect.

Fourth, investors are likely to benefit from heightened productivity growth, resulting in increased stock market returns. Long-term potential GDP growth projections inform financial economists' expectations for real returns on equities, as they offer a reliable basis for estimating future economic growth, corporate earnings, and payouts to investors.[10] The logic is straightforward: the higher an economy's growth potential, the greater the anticipated growth in corporate earnings and investor payouts, leading to increased returns for stock market investors.

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[9] Congressional Budget Office, "How Changes in Economic Conditions Might Affect the Federal Budget: 2023 to 2033," CBO Publication 58605, April 2023.
[10] An explanation of how long-term GDP growth projections are used as inputs to projections of future equity market returns can be found in AQR Portfolio Solutions Group's, "Capital Market Assumptions for Major Asset Classes," *AQR Alternative Thinking*, Q1 2023.

Furthermore, the AI-driven productivity revolution may give rise to additional benefits through rapid progress in AI-enabled technologies, such as biotechnology, robotics, and clean energy. Interestingly, OpenAI CEO Sam Altman's largest personal investment lies in Helion, a fusion energy company which aims to supply Microsoft with fusion energy by 2028.[11]

Without question, the growth in AI-driven productivity will pose challenges, as its extensive deployment creates waves of "creative destruction," generating winners and losers among companies and workers alike. The success of this transition toward widespread prosperity depends on the capacity of policymakers, business managers, and technologists to adeptly address these challenges.

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CONCLUSION: THE TRANSFORMATIVE POTENTIAL OF AI FOR ECONOMIC GROWTH

We believe it is hard to underestimate what a challenge the current AI revolution will pose to conventional thinking about the likely drivers of future long-term economic growth. Consider, for instance, a March 27 report by the World Bank, which posits that the global economy's "speed limit"— the maximum long-term rate at which it can grow without igniting inflation — is poised to plummet to a three-decade low by 2030.[12] Intriguingly, the 564-page report contains a mere five references to artificial intelligence, as opposed to sixty-five mentions of growth headwinds related to demographic factors.

If we are correct, traditional thinking on long-term economic growth forecasts will need to be jettisoned in the coming years as the AI revolution emerges as a catalyst for economic growth. The assumptions held by investors and policymakers regarding "secular stagnation" or enduring demographic impediments to growth in both developed and emerging market nations must be re-evaluated considering an unprecedented source of labor supply and augmented productivity.

Granted, much remains uncertain about the way the ongoing AI revolution will impact the global economy and society, and it will undoubtedly take time to unfold. Indeed, the productivity effects may not show up in scale for several years. However, there is no shortage of indications that the consequences will be far-reaching and transformative.

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[11] Catherine Clifford, "Microsoft agrees to buy electricity generated from Sam Altman-backed fusion company Helion in 2028," CNBC, May 10, 2023.
[12] World Bank Group, "Global Economy's "Speed Limit" Set to Fall to Three-Decade Low," Press Release, March 27, 2023.

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