Special Commentary — May 29, 2024

Do We Have Potential?: An Analysis of U.S. Potential Economic Growth

Part IV - Total Factor Productivity

Summary

- Growth in labor productivity is determined by growth in the capital stock, changes in labor "composition" (i.e., labor quality) and changes in total factor productivity (TFP, i.e., changes in technology and other processes). We focused on growth in the capital stock in the previous installment of this series, and we now turn to changes in TFP in this report.
- TFP, also known as multifactor productivity, measures the portion of output growth not attributable to capital and labor inputs, such as efficiency and process improvements. New technologies associated with the internet and the networking of computers led to robust TFP growth in the late 1990s and the early years of the 21st century. But TFP growth slumped in the immediate aftermath of the global financial crisis and has remained weak in recent years, helping to explain sluggish growth in overall labor productivity.
- There likely are a number of reasons why TFP growth has slowed, including a slower pace of technological diffusion after initial efficiency gains were realized. Yet TFP growth may be on the cusp of recovery amid a more widespread adoption of remote work and the budding AI-transition.
- For remote work to have a positive effect on productivity growth, it has to allow workers to produce more output *per hour worked*, not simply free up more working hours through decreased commuting time. Recent studies suggest employees who worked from home performed better and produced more per hour due to an improved ability to focus. With a larger share of Americans working more from home today than pre-pandemic, remote work could be supportive of TFP growth going forward.
- Early evidence also shows that AI can lead to efficiencies that increase the speed of task completion and the quality of output. AI tools generally may be better suited to complement some industries more than others, but if widely adopted, these tools can lift TFP growth.
- While these advancements appear supportive of firmer TFP growth, there historically tend to be a long lag between technological advancement and efficiency gains. It's uncertain how and when increased remote work and AI will lead to efficiency improvements that manifest in TFP gains, but we expect these innovations to have similar effects as the tech build-out of a few decades ago.
- In accounting for these lags, we suspect TFP growth will not reach its high watermark from the last productivity acceleration (1.9%) until the mid-2030s. A gradual ramp up to that point, however, implies that TFP growth could approach its long-run average (~1.2% per annum) by the end of this decade. Faster TFP growth in conjunction with the stronger rate of capital accumulation that we discussed in Part III positions labor productivity for faster growth in the coming decade.

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Do We Have Potential?: An Analysis of U.S. Potential Economic Growth

There Are Multifactors to Consider

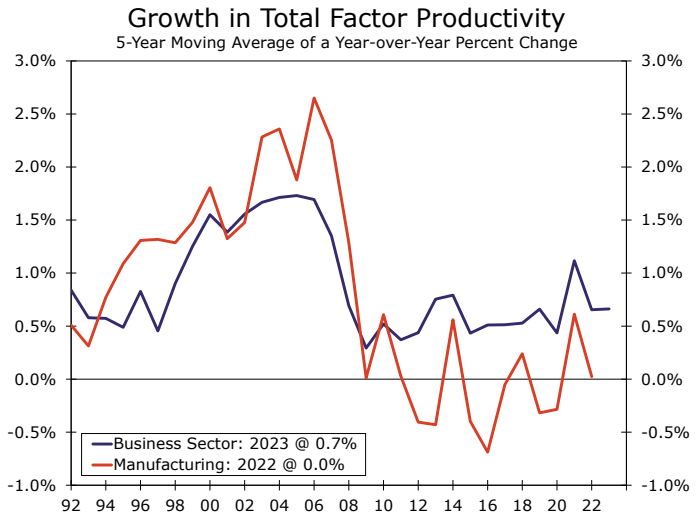
We noted in the first installment of this five-part series that an economy's rate of potential economic growth—the rate at which it can grow over a long period of time at a constant inflation rate—is determined by growth in the labor force and growth in labor force productivity. Productivity growth is itself primarily determined by two factors: growth in the capital stock and growth in total factor productivity (TFP), also known as *multifactor productivity*. The Bureau of Labor Statistics (BLS) defines TFP as "the portion of output growth that is not accounted for by the growth of capital and labor inputs and is due to contributions of other inputs, such as technological advances in production, the introduction of a more streamlined industrial organization, relative shifts of inputs from low to high productivity industries, increased efforts of the workforce, and improvements in managerial efficiency."[1] We addressed growth in the U.S. labor force in Part II, and we discussed growth in the capital stock in Part III. In this report, we turn our attention to TFP.

Economy-wide TFP growth was quite strong in the late 1990s and the early years of the 21st century as the business sector widely adopted the internet and the networking of computers (Figure 1). The combination of these new technologies with the associated acceleration in capital spending that was needed to adopt them, which we described in more detail in Part III, led to robust growth in the overall rate of labor productivity. However, TFP growth slumped, especially in the manufacturing sector, in the immediate aftermath of the global financial crisis (GFC), and it has subsequently remained weak. Consequently, the overall growth rate of labor productivity in the business sector averaged only 1.4% per annum between 2010 and 2023.

TFP growth was strong in the late 1990s and the early years of the 21st century, but it has slumped more recently.

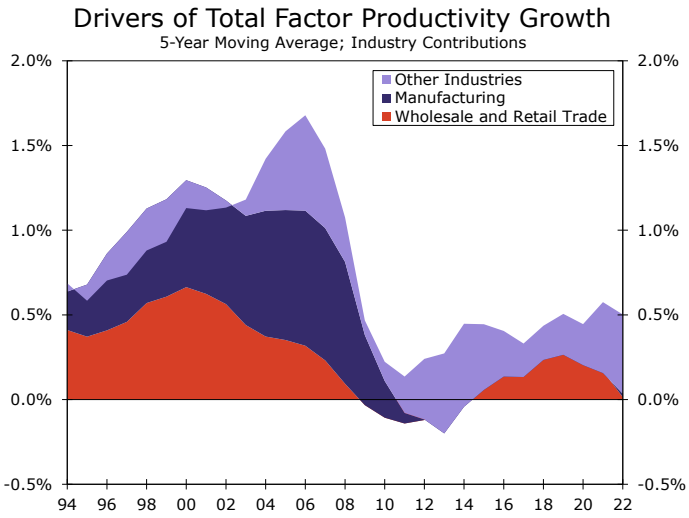
Trying to determine the exact reasons for the slowdown in TFP growth is difficult, because it is unobservable. It is simply measured as the residual of output growth after changes in labor and capital inputs have been measured. That said, researchers have offered some reasons that may explain the downshift in TFP growth over the past two decades. In surveying many papers that have been written in recent years, economists at the BLS note there is some evidence suggesting that the recent deceleration in TFP is not due to a slower pace of technological change.[2] Rather, some potential explanations include a slower pace of technological diffusion in the economy due to rising market power and concentration that has stifled competition. The International Monetary Fund (IMF) also finds little evidence of a slowing pace of technological progress. Rather, the IMF attributes the TFP deceleration to "a loss of efficiency or market dynamism over the last two decades."[3]

Figure 1



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

Figure 2



Source: U.S. Dept. of Labor, the Brookings Institution's Center on Regulation and Markets and Wells Fargo Economics

For instance, Moore's law translated to robust efficiency gains in the production of computer chips and information processing equipment in the 1990s and early 2000s.[4] This, along with the implementation of just-in-time inventory management, ultimately boosted the entire manufacturing sector's labor productivity growth.[5] After the GFC, technological advancements in transistors continued, but their contributions to labor productivity diminished as the diffusion of knowledge and best practices across

the sector slowed.[6] Furthermore, Bailey and Kane (2024) note that large retailers such as Walmart, Kroger and Costco drove efficiency gains in the retail and wholesale trade sectors in the early years of this century through procurement process improvements.[7] However, these effects have subsequently faded, and TFP growth in these sectors has slowed (Figure 2).

All told, TFP growth in recent years has fallen well short of the robust rates it registered during the 1990s and the early years of the current century. What is the outlook for TFP growth in coming years? Is the slow TFP growth rate of the post-GFC era destined to continue? Or is the American economy on the cusp of a TFP acceleration à la the 1990s?

TFP Growth Enhancers

Work From Home

There are some reasons for optimism. We discussed in Part II how work-from-home (WFH, a.k.a., remote work) could have a positive effect on labor force participation and thereby on potential economic growth via stronger growth in the labor force. But could WFH have a positive effect on productivity growth as well? Some observers contend that WFH raises the amount of output that workers can produce due to the elimination of commuting time. In this view, WFH raises productivity. But labor productivity is generally defined as output produced *per hour worked*. An individual who works remotely can potentially work, say, two hours more per day rather than commuting. In that case, the individual can produce more. But their output *per hour worked* does not necessarily rise. In order for a productivity gain to occur, the worker would need to produce more output *per hour worked.*

WFH, which is conducive to periods of "intense focus," can potentially raise TFP.

There is some evidence to suggest that WFH can raise output per hour worked. Bloom et al. (2015) report findings from an experiment that was conducted by a travel agency in China.[8] Some of the employees who worked in the agency's call center continued to work in the office five days a week while others were allowed to work from home four days per week with one day spent in the office. The authors report that "the performance of the home workers went up dramatically, increasing by 13% over the nine months of the experiment." Although nine percentage points of this improvement resulted from working more minutes, four percentage points came from an increase in the number of calls that the workers could handle per minute worked. The WFH individuals attributed this increase "to the relative quiet of home."

In another survey that included more than 30K American workers in 2020 and 2021, Barrero, Bloom and Davis (2021) estimate that WFH will raise output per hour worked by roughly 1%.[9] In a 2023 follow-up paper, the same authors note that individuals who perform analytical tasks are well suited for WFH.[10] The authors hypothesize that periods of "intense focus" that WFH affords individuals with analytical jobs may be behind the productivity enhancement. Although the number of days spent working from home has receded somewhat from its 2020 peak, a larger share of full-time American workers continue to work more from home than they did pre-pandemic (Figure 3). In short, wider adoption of WFH could strengthen productivity growth, specifically growth in TFP, albeit by a fairly small amount.

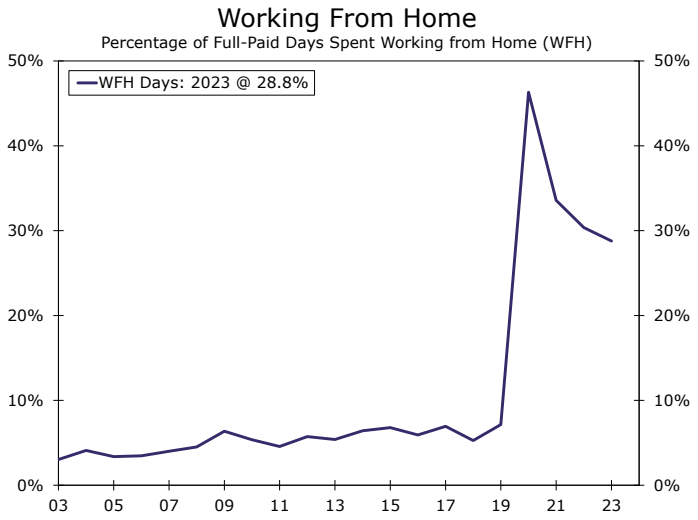
Artificial Intelligence

We discussed in Part III how the widespread adoption of automation and artificial intelligence (AI) will require a build-out in hardware and software that will lead to acceleration in the capital stock and thereby stronger growth in labor productivity. Recent research has found that AI may also come with a rise in efficiency and improvements to other processes that manifest in TFP gains. For example, Peng et al. (2023) found that software developers who had access to an AI programming aid could, on average, complete a programming task 56% faster than developers without access to the tool.[11]

Recent research has found that AI may also come with a rise in efficiency and improvements to other processes that manifest in TFP gains.

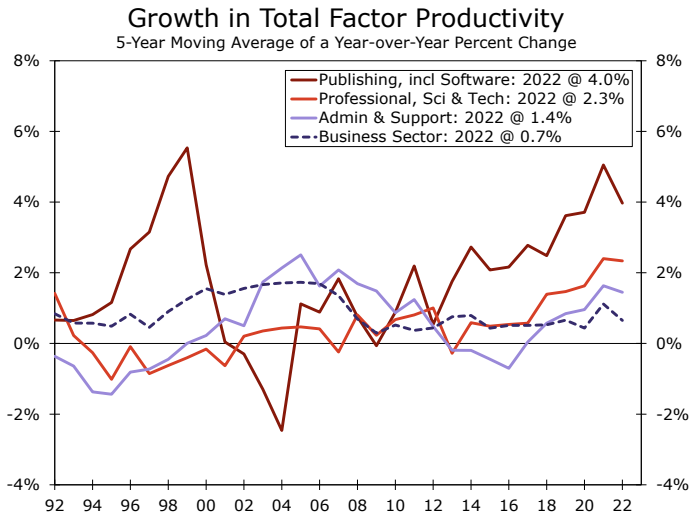
Noy and Zhang (2023) conducted an experiment involving writing tasks.[12] On a random basis, one half of the marketers, grant writers, consultants, managers and other professionals were given access to ChatGPT while the other half did not have access. The researchers found that the speed and quality of the writing assignment improved significantly in the ChatGPT group. Specifically, this group spent 40% less time on the assignment than the group without access to the AI tool, and they also found that quality improved the most among the least effective writers.[13]

Figure 3



Source: Barrero, Bloom and Davis and Wells Fargo Economics

Figure 4



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

Brynjolfsson et al. (2023) recently showed that the use of an AI-based conversation assistant at a customer support firm boosted productivity, measured by issues resolved per hour, by 14% on average.[14] Notably, the productivity improvement was much larger among new and low-skilled employees (up 34%), and there was a minimal change among experienced workers. Thus, the AI-tool helped new workers move up the learning curve much faster than normal because it was able to diffuse the best practices of tenured employees in real time. If widely adopted, such a development could lend itself to a pickup in TFP growth, as it would streamline employee training and improve employee effort.

These studies focused on firms in an array of labor-intensive service industries, such as software development, professional services and administrative & support services. As shown in Figure 4, TFP growth in these industries has outstripped the overall business sector's TFP growth since 2018. The studies suggest AI and amenability to remote work are potential drivers of these industries' TFP strength recently. In sum, a wider adoption of WFH and AI could boost the business sector's TFP growth in coming years.

While the evidence is supportive of firmer TFP growth, it is uncertain just how quickly these advancements will materialize. There tend to be long lags between technological advancement and efficiency gains that manifest in TFP, which we noted in a series of reports that we published on AI last year. For example, growth in TFP *downshifted* in the 1970s and 1980s despite the groundbreaking inventions of mobile phones, personal computers and internet protocol in the 1970s. It was not until the widespread adoption of these technologies in the business sector in the 1990s that total factor productivity accelerated anew. Indeed, researchers from the Federal Reserve Bank of St. Louis reported that early evidence suggests the diffusion of AI is following a similar timeline to that of personal computers and cloud computing.[15]

There tend to be long lags between technological advancement and efficiency gains that manifest in TFP.

Consequently, the process-improving component of AI may take a while to transfuse throughout the economy. While accumulation of AI-compatible hardware and software will boost overall labor productivity, proprietary data is often used in the development and deployment of AI tools. Heightened focus on data privacy over the decade has weakened the free flow of knowledge across the business sector and likely contributed to diminished TFP growth, despite the robust expansion in the net stock of intellectual property products.[16] Should this trend continue with AI, the boost to labor productivity from capital may be initially offset, at least in part, by softening TFP growth, all else equal.

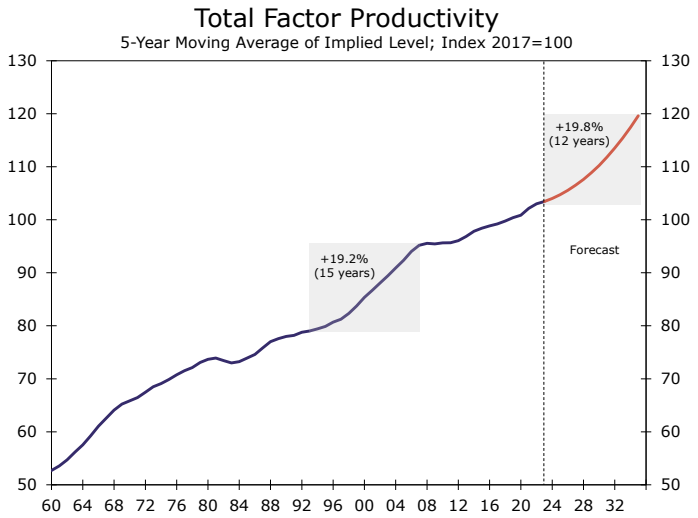
Look Ahead: TFP to Strengthen

There is a great deal of uncertainty regarding the timeframe in which process improvements related to WFH and the technological advancement inherent in AI will show up in TFP growth in the aggregate business sector. But to conceptualize our analysis, we assume that these effects on TFP growth will play out similarly to the tech boom of the 1990s. TFP growth can bounce around on a year-by-year

basis, so to get a sense of the underlying trend we smooth annual growth rates with a 5-year moving average. This underlying trend of TFP growth reached its high watermark of ~1.9% per annum in 2004-2005.

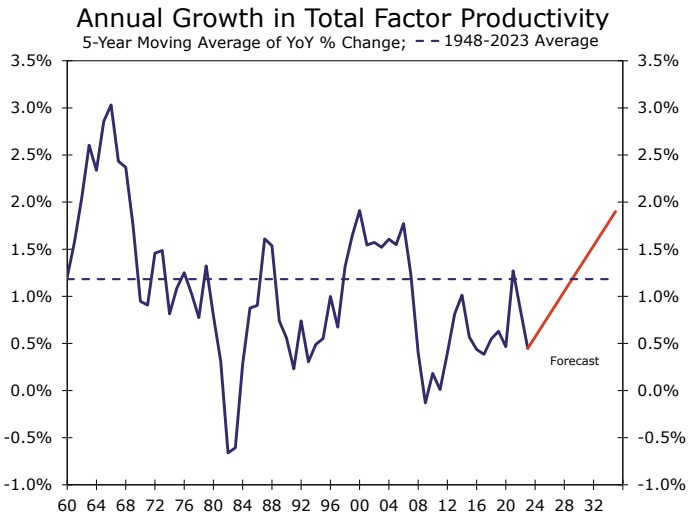
When thinking about the future, we allow the 5-year moving average of TFP growth to slowly ramp up to 1.9% per annum over the next *twelve* years to account for the lags that were noted previously. Under this scenario, the implied index of TFP will be 20% above its current level by 2035 (Figure 5), which is a fairly comparable gain to that experienced in the 15 years between 1992 and 2007. As shown in Figure 6, this scenario translates to the five-year moving average of TFP growth gradually ramping back up to its long-run average (1948-2023) of 1.2% by the end of this decade (2029). This pickup suggests that the contribution of TFP growth to the overall growth rate of labor productivity and potential economic output would be fairly in-line with its historical average over the next six years.

Figure 5



Source: Federal Reserve Bank of San Francisco and Wells Fargo Economics

Figure 6



Source: Federal Reserve Bank of San Francisco and Wells Fargo Economics

The annual growth rate of TFP averaged just around 0.8% between 2010 and 2019, helping to explain the weaker trend in labor productivity growth during the last economic expansion. Yet wider adoption of remote work and the rise of AI usage have the potential to lift TFP growth in coming years. Acceleration in TFP in conjunction with faster growth in the capital stock, which we discussed in Part III, positions labor productivity for a stronger pace of growth in the coming decade. In the next and final installment of this series, we will bring together our expectations for the growth rates in TFP, the capital stock and the labor force (Part II) to make some estimates about potential economic growth in the United States in coming years.

Endnotes

1 – See https://www.bls.gov/productivity/ for U.S. productivity data. (Return)

2 – "The U.S. Productivity Slowdown: An Economy-Wide and Industry-Level Analysis," U.S. Bureau of Labor Statistics Monthly Labor Review, April 2021. (Return)

3 - Cardarelli, Robert and Lusine Lusinyan, "U.S. Total Factor Productivity Slowdown: Evidence from the U.S. States," IMF Working Paper 15/116, International Monetary Fund, May 2015. (Return)

4 - Moore's law is broadly defined as the doubling in the number of transistors in a microchip every two years. Transistors are devices that amplify or switch electrical power. (Return)

5 - "Investing in Productivity Growth," McKinsey Global Institute, March 2024. (Return)

6 - Andrews, Dan, Chiara Criscuolo and Peter N. Gal. "Frontier Firms, Technology Diffusion and Public Policy: Micro Evidence from OECD Countries." The Future of Productivity: Main Background Papers. 2014. (Return)

7 – Bailey, Martin Neil and Aidan Kane, "How Will AI Affect Productivity?" Brookings Institution, May 2, 2024. (Return)

8 – Bloom, Nicholas, James Liang, John Roberts and Zhichun Jenny Ying, "Does Working From Home Work? Evidence From a Chinese Experiment," Quarterly Journal of Economics 130 #1, February 2015. (Return)

9 – Barrero, Jose Maria, Nicholas Bloom and Steven J. Davis, "Why Working From Home Will Stick," National Bureau of Economic Research Working Paper #28731, April 2021. (Return)

10 – Barrero, Jose Maria, Nicholas Bloom and Steven J. Davis, "The Evolution of Work From Home," National Bureau of Economic Research Working Paper #31686, September 2023. (Return)

11 - Peng, Sida, Eirini Kalliamvakou, Peter Cihon, and Mert Demirer, "The Impact of AI on Developer Productivity: Evidence from GitHub Copilot, arXiv," 2023, #1. (Return)

12 - Noy, Shakked and Whitney Zhang, "Experimental Evidence on the Productivity Effects of Generative Artificial Intelligence," *Science*, July 2023, 381, p.187–192. (Return)

13 - Quality was assessed by experienced professionals who worked in the same occupations. Evaluators assigned separate grades for writing quality, content quality and originality as well as an overall grade. Each piece of output was assessed by three evaluators, and the overall score was the average of each score. (Return)

14 - Brynjolfsson, Erik, Danielle Li, and Lindsey Raymond, "Generative AI at Work," National Bureau of Economic Research Working Paper #31161, November 2023. (Return)

15 - Kalyani, Aakash and Marie Hogan, "AI and Productivity Growth: Evidence from Historical Developments in Other Technologies," Federal Reserve Bank of St. Louis, April 2024. (Return)

16 - Corrado, Carol, Jonathan Haskel, Massimiliano Iommi, Cecilia Jona-Lasinio & Filippo Bontadini, "Data, Intangible Capital, and Productivity," University of Chicago Press, March 2022. (Return)

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