Aggregate Effects of the Adoption of AI

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AI is holding out the prospect of substantial productivity improvements. While the potential of AI may be large, it is uncertain how much of that potential will be realized and how fast it will occur. Recent estimates of the medium-term AI impact on labor productivity range from negligible to larger than the 1990s IT impact. But should AI meaningfully affect medium-term productivity growth, monetary policy is likely to respond by accommodating the increase in potential output. On the other hand, recalling the 1990s IT diffusion, one should not be too surprised that, even though AI is apparently everywhere, it hasn't yet noticeably improved one's experience with chatbots.

AI has received a lot of attention lately, especially generative AI that can create new content, such as ChatGPT for text. How will AI affect the productive potential of the economy? How will it affect labor markets? How soon can we expect AI adoption to show up in aggregate GDP growth? These are questions that are of interest for monetary policymakers to the extent that they affect the estimates of potential output growth and long-run interest rates in the economy.

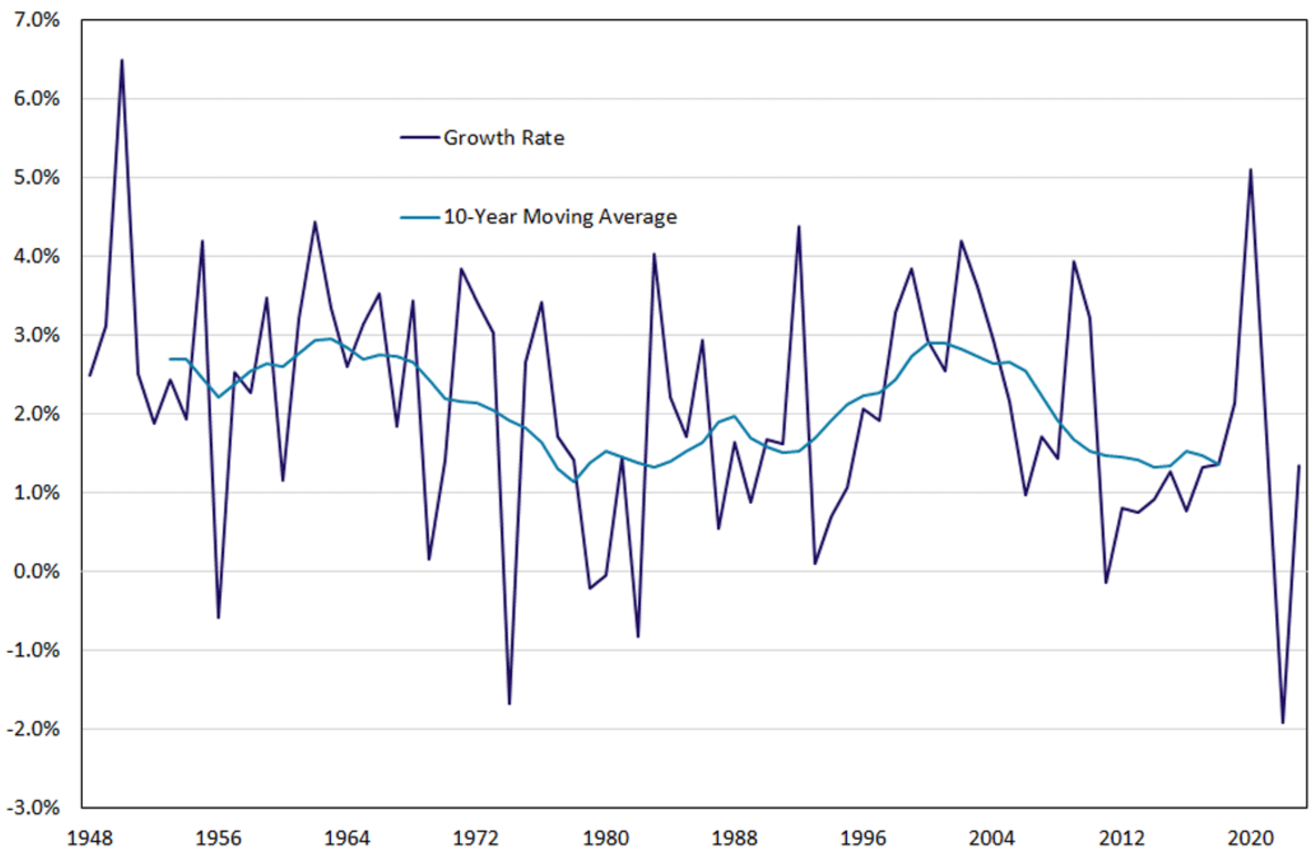
Being at the early stages of AI adoption, the answers to the questions above will of course be highly speculative. In this article, I focus on three recent studies that have tried to provide estimates of the impact of AI adoption on the U.S. economy's productivity:

- The 2023 article "Machines of Mind: The Case for an AI-Powered Productivity Boom" by Martin Neil Baily, Erik Brynjolfsson and Anton Korinek
- The 2023 report "The Potentially Large Effects of Artificial Intelligence on Economic Growth" by Joseph Briggs and Devesh Kodnami
- The 2024 working paper "The Simple Macroeconomics of AI" by Daron Acemoglu

These studies use a common conceptual framework, and they rely on an overlapping collection of primary research on the potential applications and benefits from AI. However, even within this common framework, the studies come to widely different conclusions on how much AI will potentially increase productivity over the next 10 years. These conclusions range from less than 1 percent to 20 percent, which would correspond to annual growth rates of 0.1 to 2.0 percent.

For perspective, labor productivity over the last 10 years — a period of relatively low productivity growth — has averaged about 1.5 percent per year. Labor productivity growth following World War II peaked in the late 1950s and late 1990s, with average annual growth rates of about 3 percent, as seen in Figure 1.[1] Thus, even if AI-induced growth adds to an underlying growth rate of 1.5 percent, the overall impact ranges from negligible to bringing growth close to post-WWII peaks.

Figure 1: Labor Productivity Growth in the US Non-Farm Business Sector



Source: Real output per hour of all persons employed in the nonfarm business sector (Bureau of Labor Statistics, downloaded from Haver Analytics) and author's calculations.

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A Framework to Evaluate the Impact of AI

The common conceptual framework of the studies I use starts with an estimate of the range of occupations potentially affected by AI. It then estimates how much AI will improve the labor efficiency in these occupations.

There is a limited number of studies on labor efficiency increases among early AI adopters.[2] For example, one study has found that coders can fulfill their tasks twice as fast with the support of AI, and another study found that the performance of novice call center employees improves by 30 percent.[3]

On one hand, one would expect early adopters of AI to pick low-hanging fruit and find the most immediate gains. On the other hand, however, AI adopters may well become better over time at finding efficient applications of AI. Based on the available evidence, AI applications will make overall labor about 30 percent more efficient on average. But how many occupations will benefit from the application of AI?

The Department of Labor maintains the O*NET database for occupations in the U.S. The database provides a verbal description of each occupation and a classification of tasks performed and of worker qualifications required. Several studies have classified occupations in this database as to whether AI can potentially perform some or all the tasks required. One study argues that about 80 percent of all occupations could see at least 10 percent of their tasks benefit from the application of AI.[4]

This provides the starting point for an estimate of potential AI applications. We next need estimates of the share of tasks amenable to the application of AI and the timeframe within which the potential can be exploited. Then, we need to weight the contributions of different occupations to aggregate labor, which is usually done using relative wages. Finally, we need to recognize that an increase in labor efficiency does not translate directly to an increase in labor productivity, since there are diminishing marginal returns to labor. As a first-order approximation, we frequently use the labor income share in value added as a measure of the labor elasticity of output. Depending on these adjustments, the three studies I listed argue that AI can potentially increase the effective output contributions of labor by 5 percent to 60 percent over the next 10 years.

Combining the potential labor efficiency gains with the potential occupational base to which they might apply, we get that labor productivity could increase between 1.5 percent and 18 percent over the next 10 years. This ranges from barely noticeable to substantial.

What Are Some Potential Qualifications?

Naturally, there are a number of qualifications that are important to note when estimating the potential impact of AI on labor productivity. The following discusses some significant qualifications regarding this exercise.

Labor Reallocation

A differential increase of labor efficiency across occupations will likely lead to a reallocation of labor towards occupations that become relatively more efficient. This indirect effect will further increase labor productivity. However, if we assume that the economy starts with an efficient allocation of labor across occupations, this will have only second-order effects.

Labor Complements vs Labor Displacement

We have assumed that the application of AI is complementary to labor. That is, we assume it enhances the effectiveness of labor and does not displace it. This is the opposite of the concerns expressed in recent years that automation is displacing medium-wage occupations that mostly perform routine cognitive tasks.

The three studies do not take a strong stance on the potential displacement of workers and/or occupations. If AI can completely substitute for the tasks performed by labor in an occupation, labor is likely to be displaced. This will result in a further increase of labor productivity. Whether this will lead to temporary or permanent employment reductions is an open question. On an optimistic note, labor productivity has more than quadrupled in the post-WWII period, while employment almost tripled.

Capital Accumulation

Once labor becomes more efficient, it becomes more attractive to pair it with additional capital. Thus, induced capital accumulation may lead to further increases in labor productivity. However, the studies on the efficiency gains from the application of AI to various tasks already include increased capital. In fact, in the National Income and Product Accounts, the development of AI should be represented as investment in intellectual property products. Thus, the additional productivity gains from induced capital accumulation may already be included in the current estimates for efficiency gains.

Impact on Baseline Labor Productivity Growth

The impact of AI on baseline labor productivity growth is not obvious. The estimates above assume a one-time permanent increase of labor productivity in a class of occupations, independent of other changes to labor productivity.

But labor productivity in the U.S. has been steadily increasing, even though the growth rate of 1.5 percent has been relatively low over the last 20 years. Will AI-induced productivity growth simply come on top of this underlying productivity growth? Will it reduce some of the underlying productivity growth because we are shifting to a new paradigm? Or will AI change the ability to innovate and not only result in a level shift of productivity, but a permanent change in the trend growth rate? We do not know.

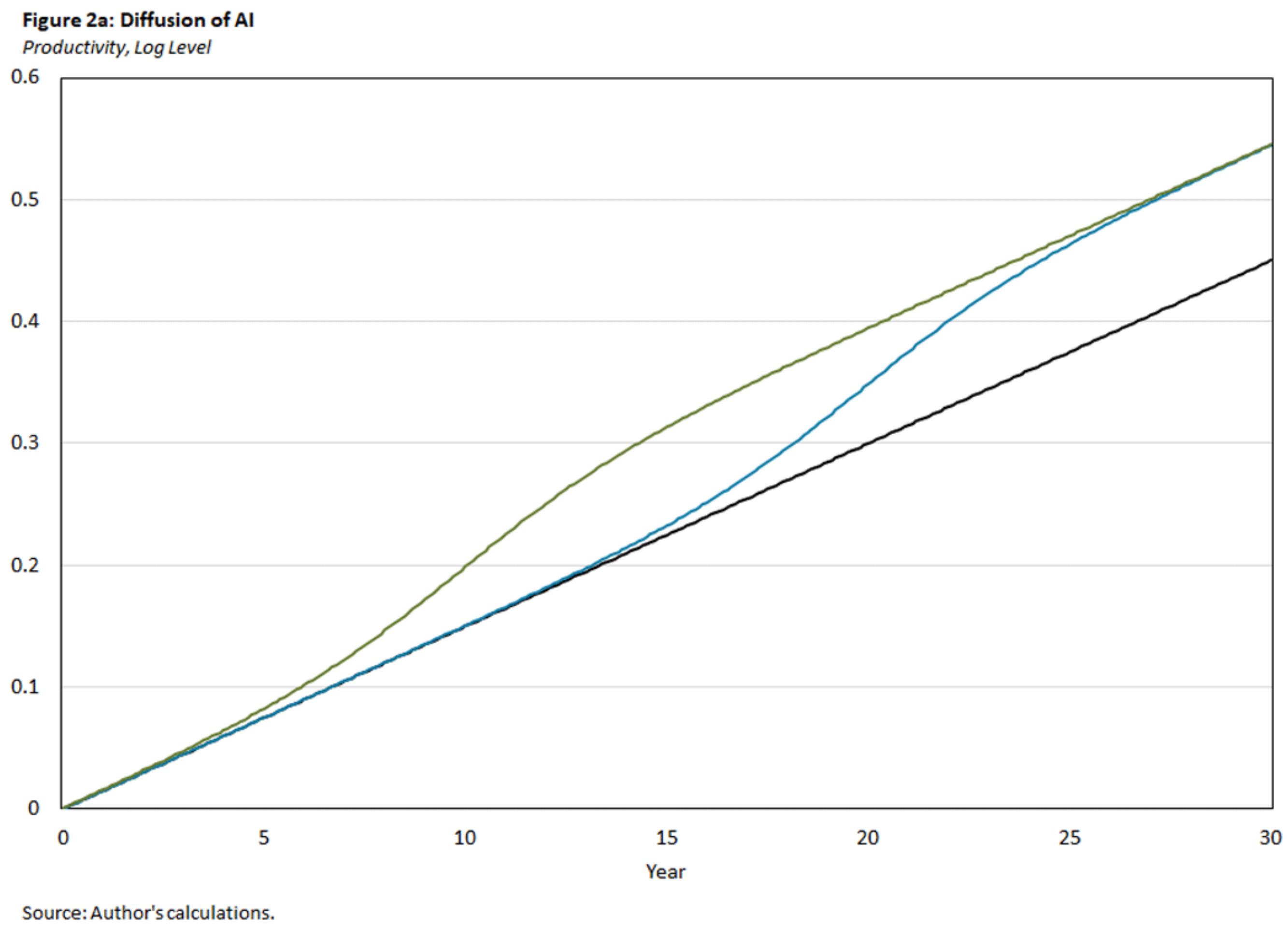
When Will AI Show Up in Aggregate Growth?

Not only is it uncertain by how much AI will eventually impact productivity, but it is also uncertain how fast its impact will show up in aggregate statistics. Consider again the two high-growth episodes in the U.S. economy — the late 1950s and the late 1990s — when average annual labor productivity growth was around 3 percent. There is no obvious single cause for the early high-growth period, though one reasonable story attributes it to the release of pent-up innovations in the U.S. consumer goods sector after being held back by low demand in the Great Depression and during World War II. The second high-growth period, however, is usually attributed to the widespread application of IT advances.

In either case, it took 10 to 20 years before the initial innovations resulted in widespread applications that showed up in aggregate labor productivity. I now illustrate the implications of delayed adoption for aggregate labor productivity using a simple diffusion model that has been applied in a variety of settings, including the spread of pandemics.

Think of the economy as chugging along at 1.5 percent labor productivity growth, and then AI appears. Assume that AI eventually increases labor productivity for a part of the labor force relative to the baseline productivity path, but that the application of AI slowly diffuses to that sector.

The two important parameters discussed above are the effective share of employment eventually affected by AI and by how much AI increases labor efficiency in the sector. We'll assume that the share affected by AI is 25 percent and that labor efficiency increases by a factor of 1.4. Thus, eventually average labor productivity will increase 10 percent relative to the baseline path, somewhere in the middle of the three studies noted above. This is the solid blue line relative to the purple line in Figure 2a. I would note that the implied AI-specific productivity improvement factor of 1.4 is higher than the average from currently available studies.



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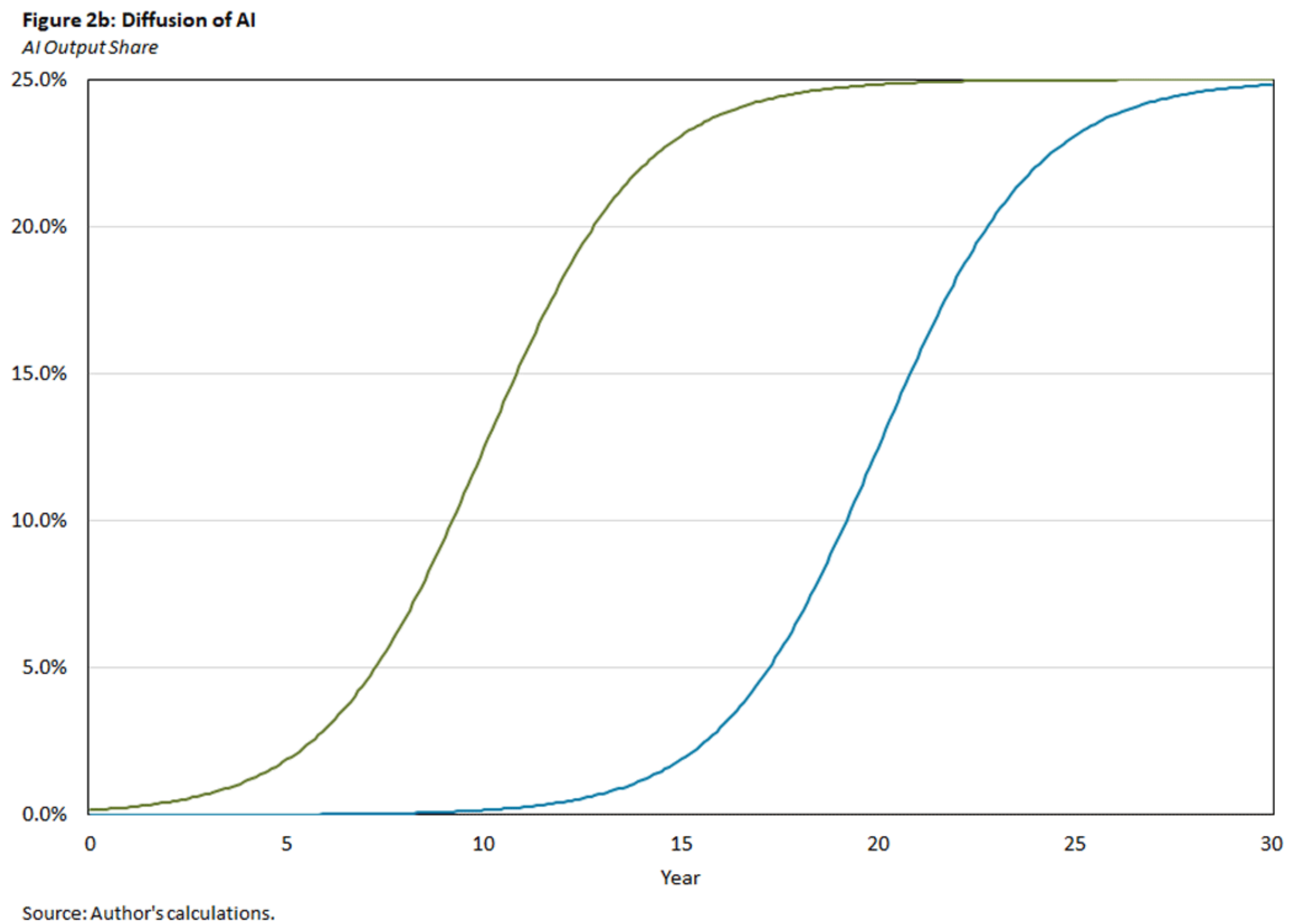
Now suppose that the application of AI gradually diffuses through the economy. The diffusion is such that the rate at which the share of AI adopters is increasing is proportional to the share of those who have not yet adopted AI. Thus, the growth rate starts out high and then declines over time. But initially there is only a very small share of AI adopters, so the base to which the high growth rate applies is small, and the aggregate impact is small.

Over time, as the share of AI adopters is increasing, the impact of new AI adopters is also increasing, and the aggregate growth rate is increasing until it reaches its peak when about half of potential AI adopters have adopted. From then on, the declining growth rate dominates, and aggregate productivity is declining. The solid blue line in Figure 2b plots the share of potential AI adopters over time. I assume that half of the potential improvements have taken place after 20 years. This is in line with the two growth episodes just discussed.



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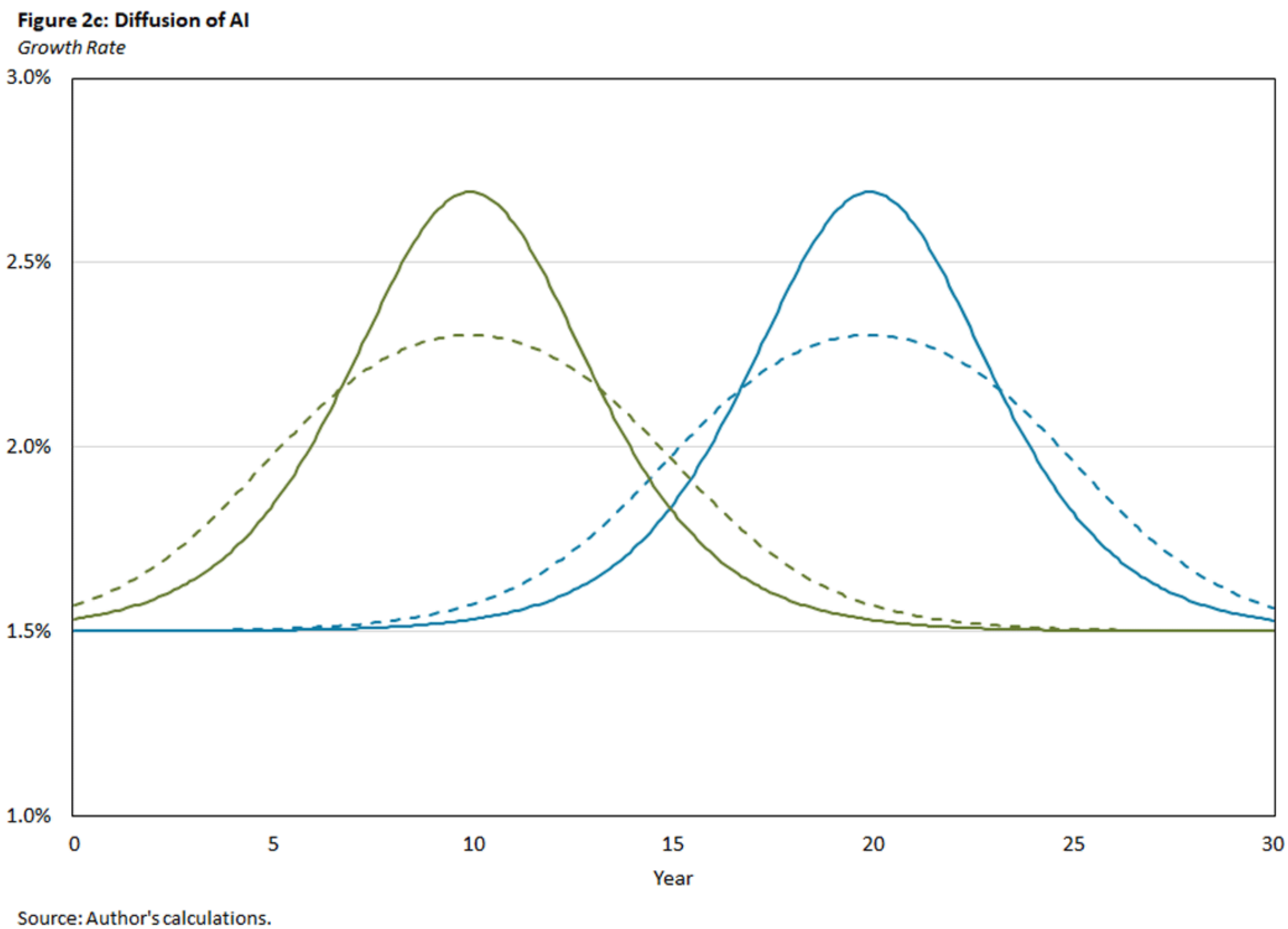
The solid blue line in Figure 2c plots the implied instantaneous aggregate labor productivity growth rate. Average labor productivity growth picks up noticeably after 10 years and reaches a peak of close to 2.7 percent when the AI-improved share of employment is 12.5 percent. The symmetric 10-year moving average of the growth rate (the dashed blue line) reaches a peak of about 2.3 percent, still below the two historical peak growth episodes.



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Now suppose that AI spreads faster in the economy. The green lines in the preceding figures represent a diffusion path where half of the potential AI improvements take place within 10 years, rather than 20 years. As you can see, the paths just shift to the left by 10 years — that is, peak growth now occurs after 10 years — but the magnitudes of the effects are the same.

What Does It Mean for Monetary Policy?

We should acknowledge that there is a huge amount of uncertainty about the impact of AI on the timing and magnitude of labor productivity changes. No matter how many anecdotes we have on particular AI applications, we have to see it in aggregate data to matter for monetary policy. To paraphrase Duke Ellington, it don't mean a thing if it ain't got that swing in aggregate labor productivity.

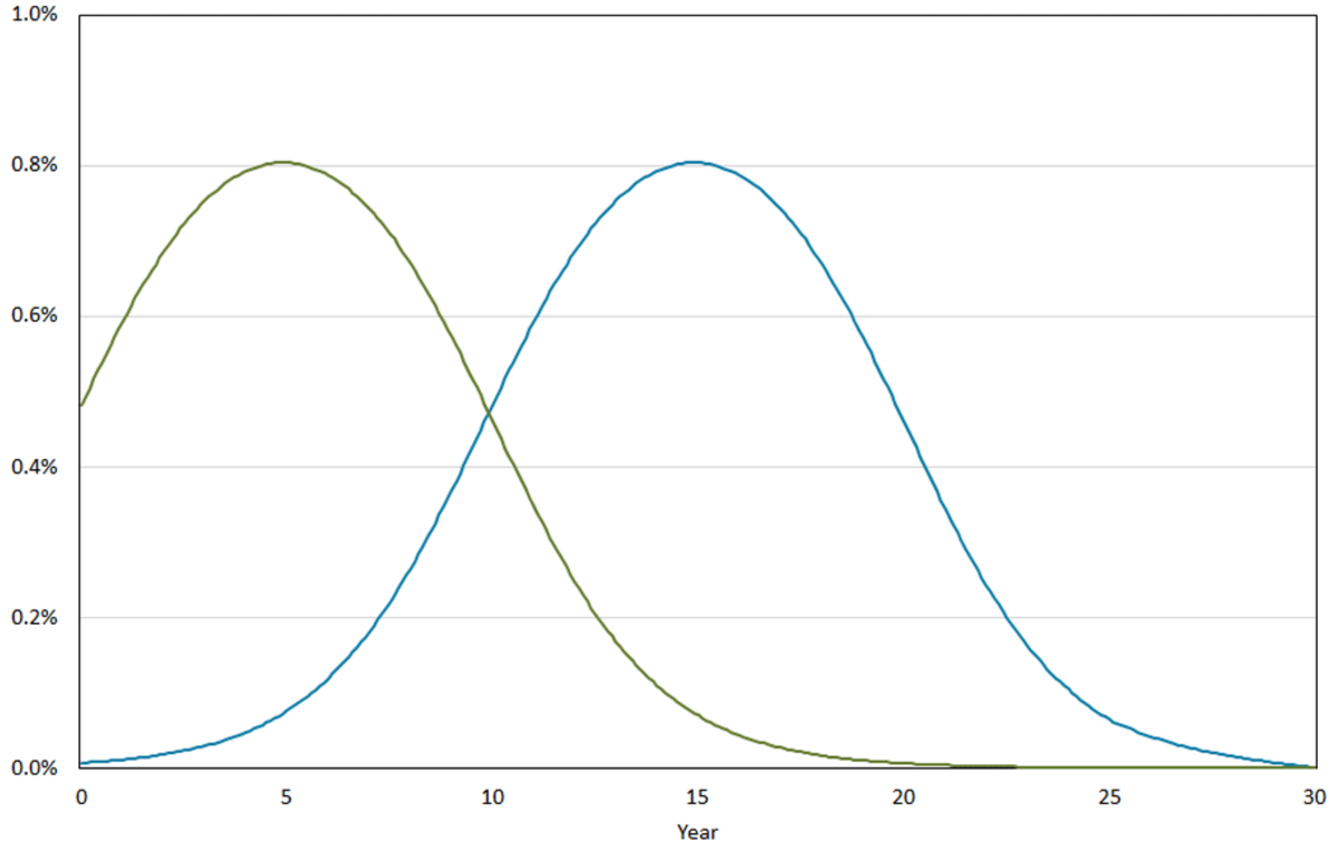
If there are no employment effects, labor productivity growth represents potential output growth or trend output growth. The usual position of monetary policy is to respond to deviations of output from potential output, not to changes in potential output, at least for as long as inflation is close to target. For example, productivity and output growth accelerated in the late 1990s. In response, the Federal Open Market Committee under then-chairman Alan Greenspan considered this to reflect an increase in trend growth rate of potential output and therefore did not counter with raising interest rates.[5]

At the same time, standard economic theory predicts that interest rates are related to expected consumption growth. If expected consumption growth increases — that is, future consumption increases more relative to current consumption — then interest rates should increase so that households willingly postpone consumption. Consumption is likely to increase with increased potential output, thus a higher growth rate of potential output should be associated with a higher equilibrium interest rate.

In a standard economic growth model, short-run interest rates move with the output growth rate. For a reasonable calibration of the model, the interest rate changes one for one with the growth rate. Thus, a 1 percentage point increase of the growth rate would be associated with a 1 percentage point increase of the short-run interest rate. But note that, for the baseline case when half of potential AI applications are adopted after 20 years, the growth rate only starts to increase noticeably after 15 years in the baseline setup, as seen in Figure 2c. Nevertheless, the short-run interest rate should increase 1.2 percentage points once the growth rate reaches its peak.

Long-term interest rates move less, but earlier. In Figure 2d, we plot the change for a long-term interest rate with a 10-year horizon (that is, the average of 10-year future short rates). While the short rate only moves with the contemporaneous growth rate, the long rate moves in anticipation of future growth rates and increases by 0.5 percentage points after 12 years. For the alternative case when AI adoption proceeds faster, the short rate increases earlier, and the 10-year interest rate increases immediately by 0.5 percentage points. We can think of the long rate providing an advance signal on future short rates.

Figure 2d: Diffusion of AI
10-Year Interest Rate Effect



Source: Author's calculations.

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In the context of recent policy discussions, the short rate associated with trend output/consumption growth represents r*, the interest rate that would be appropriate when there are no deviations of output from potential and inflation is at its target.[6] Thus, a persistent increase of r* due to an increase of trend output growth should lead to persistently higher policy rates. This argument was also made in the late 1990s in response to the perceived increase in trend output growth, but it did not carry the day then. This may simply reflect the difficulty for monetary policymakers to infer changes in underlying trends in real time when data are constantly revised, and the economy is buffeted by large temporary shocks.

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1 *Productivity growth (even for annual data) is highly volatile. To reveal any long-term trends, we therefore plot 10-year moving averages of the annual growth rates.*

2 *For the names of some of these studies, see the papers I'm reviewing in this article.*

3 *See the 2023 working papers "The Impact of AI on Developer Productivity: Evidence From GitHub Copilot" by Sida Peng, Eirini Kalliamvakou, Peter Cihon and Mert Demirer and "Generative AI at Work" by Erik Brynjolfsson, Danielle Li and Lindsay Raymond.*

4 *See the 2023 working paper "GPTs Are GPTs: An Early Look at the Labor Market Impact Potential of Large Language Models" by Tyna Eloundou, Sam Manning, Pamela Mishkin and Daniel Rock.*

5 *For a description of monetary policy in the late 1990s, see the 2002 paper "The Phases of U.S. Monetary Policy: 1987 to 2001" by Marvin Goodfriend and the 2010 paper "FOMC Learning and Productivity Growth (1985-2003): A Reading of the Record" by Richard Anderson and Kevin Kliesen.*

6 *See the 2023 article "The Stars Our Destination: An Update for Our R* Model" by Thomas Lubik and Christian Matthes.*

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