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AI is the New Macro: Implications for the Labor Market

AI is the science of making machines smart.

– Demis Hassabis, CEO of Google DeepMind, 2023

Generative AI is destined to be the key driver of equity markets over the next decade or so. We view artificial intelligence (AI) as the fourth wave of digital technology (after the PC, internet and mobile), with each stage having a progressively greater impact on the labor market, productivity, sector concentration, and free cash flow (FCF) generation. We briefly summarize these four implications below and then dive deeper into the first. We will be publishing papers on each of the other three in the coming months.

Four key implications

First, AI will be highly disruptive to labor markets. While jobs are not going to disappear, around 60% of tasks and occupations in the U.S. will be changed materially over the next two decades. That is, we expect overall employment and real wages to rise, but accompanied by dramatic shifts across vocations. Further, and different from previous tech shocks, high wage sectors are most exposed to AI.

Second, the diffusion of AI across the economy is likely to increase U.S. productivity by roughly 20% over next two decades. This includes increased efficiency by call center workers, taxi drivers, coders, writers, radiologists, and so on. Early estimates suggest around 60% of jobs will have their productivity increased by 30%.[1] Further, while most commentators emphasize efficiency gains, the bulk of value generated will come from the innovation

[1] "Machines of the mind: The case for an AI-powered productivity boom," by M. Baily (Brookings), E. Brynjolfsson (Stanford) et al, 2023.

and creative destruction AI unleashes, with new products and services that are fated to astonish and baffle us all.[2] Moreover, most of productivity benefits will accrue to larger firms, which exhibit a much higher tendency to adopt advanced technologies.[3]

Next, digital tech always features "winner-takes-most" dynamics and that will certainly be the case with AI, as prediction machines invariably scale.[4] To illustrate, Baily et al, emphasize that "The amount of compute used to train cutting-edge AI systems has been doubling every six months over the past decade." Huge fixed-cost investments combined with near zero marginal costs imply enormous economies of scale. This means the lion's share of value created is captured by a small number of companies and we are likely to witness increased concentration in most sectors. However, it is always the case that "titans rise and titans fall,' so not all of last decade's winners will remain above the precipice. And this is a good thing, as the displacement of seemingly entrenched incumbents, something the U.S. excels at, is critical for innovation to flourish and radiate across the economy.

Finally, business strategies for the digital age or AI era are capital-light, which is positive for margins, FCF, return on invested capital (ROIC), and shareholder yield.[5] This means companies and sectors with relatively high AI exposure are likely to significantly outperform over the medium-term.[6] Regarding country-level allocation, the diffusion of AI is more important than the number of patents or journal articles. This favors the U.S., with its unrivaled network of innovative titans, relative to China, Japan, or Europe.

What AI means to the labor market: Augmented intelligence

The remainder of this paper examines the labor market implications of AI, beginning with the observation that the occupations with the greatest exposure to AI are typically white collar, with high levels of formal education. On the other hand, those with the lowest exposure to AI feature physical skills that will remain beyond the aptitude of AI-enabled robots for the foreseeable future **(Figure 1)**.

FIGURE 1 – Occupations with particularly high or low AI exposure: Select examples.

Machines of the mind: Unlike previous tech shocks, AI will affect cognitive rather than manual work.

High AI Occupational Exposure	Low AI Occupational Exposure
Post-secondary teachers	Painters
Arbitrators & mediators	Roofers
Judges & magistrates	Drywall installers
Paralegal & legal assistants	Plumbers
Lawyers	Electricians
HR specialists	Carpenters
Procurement clerks	Welders
Purchasing agents & managers	Construction laborers
Reporters & correspondents	Steel workers
Technical writers	Mfg production workers
Loan officers	Heavy truck drivers
Insurance sales agents	Landscaping workers
Real estate brokers	Dishwashers
Personal finance advisors	Janitors & cleaners
Travel agents	Firefighters
Dieticians & nutritionists	Athletes

Source: E. Felten (Princeton) et al, "How will language modelers like ChatGPT affect occupations and industries," 2023.

[2] "AI, firm growth, and product innovation," by T. Babina (Columbia) et al, 2003.

[3] "New technologies, automation, and productivity across U.S. firms," D. Acemoglu (MIT), et al, 2023.

[4] "Prediction machines: The simple economics of AI," by A. Agrawal (U Toronto) et al, 2018.

[5] See our paper, "When "Bits" meet "Atoms": Implications of the second machine age for corporate profitability and traditional business models," 2018.

[6] The empirical evidence suggests this is already happening. See "Generative AI and Firm Values," by A. Eisfeldt (UCLA) et al, 2023.

For an alternative perspective, we can observe how AI exposure metrics vary with the skills underlying different occupations. Labor economists often characterize occupations by the degree to which they involve combinations of routine vs. non-routine, cognitive vs. manual, and analytical vs. interpersonal features. They find that occupations with higher AI exposure are more likely to involve non-routine cognitive analytical skills or routine cognitive skills, and less likely to involve different kinds of manual or interpersonal skills **(Figure 2)**.

Is being in a highly AI exposed occupation a good or a bad thing?

For employers it is unambiguously positive, as it increases opportunities for efficiency and innovation. For employees, it's a bit more complex. In some cases, being in a highly exposed occupation is challenging as the new technology acts as a substitute, allowing firms to replace workers. To provide a historical example, following WWII a lot of automation was introduced into coal mining. As a result, since 1949 the sector's productivity rose by an eye-popping 832%, but employment plummeted by 89%, according to the Energy Information Administration. Analysis by McKinsey suggests that occupations in a similar situation today include office support, customer service and sales, and food services, where AI will probably replace some workers.[7]

It is more common though for new technologies to act as a complement, that is augmenting labor demand through the creation of new tasks. Historically, general-purpose technologies (GPT), such as the steam engine or electricity, have, on net, created an enormous number of jobs as entirely new products, sectors and occupations emerge. AI is a GPT, and history strongly suggests it will likely have a similarly positive impact. McKinsey's analysis is especially constructive regarding the outlook for STEM professionals, creative workers, and business and legal professionals.

> We see generative AI enhancing the way STEM, creative, and business and legal professionals work .... Automation's biggest effects are likely to hit other job categories. Office support, customer service, and food service employment could continue to decline.
>
> – **"Generative AI and the future of work in America,"**
> **McKinsey, 2023**

FIGURE 2 – Cognitive and analytical skills are more exposed to AI than physical skills.
Occupational skills (x-axis) vs. generative AI exposure (vertical axis, converted into standard z-scores).
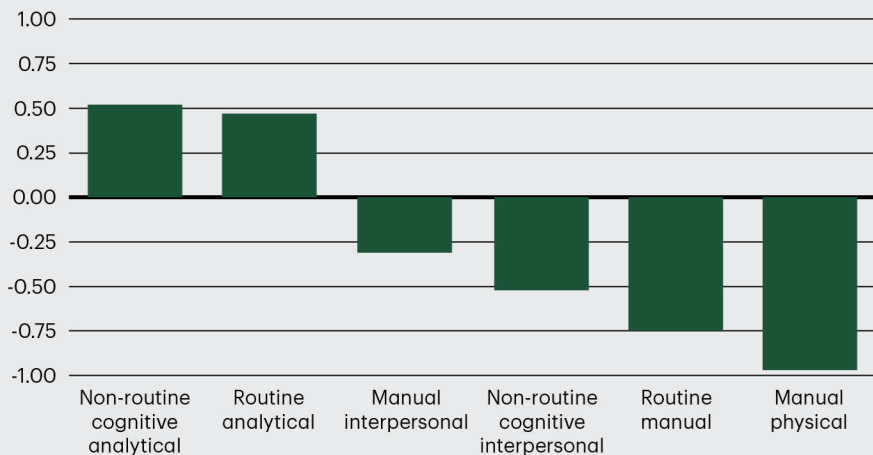
Source: "Generative AI and Firm Values," by A. Eisfeldt (UCLA) et al, 2023.

[7] "Generative AI and the future of work in America," McKinsey, 2023.

To add some nuance and illustrate how complicated tech dynamics can be, in certain cases an occupation benefits from a novel technology but then, a decade or so later, gets knocked back by an even newer development. Consider the case of bank tellers. As ATMs proliferated, the number of tellers actually more than doubled, from 195k in 1970 to 450k in 2010. The technology was complementary as banks opened more branches and tellers took on new tasks (such as selling mortgages and other financial products). However, this trend ended abruptly with the expansion of online banking a decade or so ago, which replaced tellers and resulted in a sharp decline in their numbers.[8]

Will wage polarization continue to increase or will AI be different and drive wage compression?

AI is likely to have a net positive impact on employment, as we argued above, but what are its implications for wage inequality? Previous technology shocks have primarily affected lower income individuals and exacerbated wage polarization.[9] And that certainly has been the case over the last four decades with digital technologies. However, some commentators have argued this time is different, as it appears AI will primarily impact high wage occupations, thus resulting in wage compression **(Figure 3)**. Although the early evidence on this debate is somewhat mixed, we have a high conviction view that the fundamental forces driving inequality have not changed, so this time is unlikely to be different.

As a bit of an aside, we've included below a quote by Larry Summers. He emphasizes that, since roughly the 18th century, IQ has been the most prized and highly rewarded personal attribute. However, with AI, average cognitive skills will probably become abundant and relatively cheap. The beneficiaries of this change are likely to include empathy, relationship skills, artistic creativity, and athletic exceptionalism. We don't have a strong view on this outlook but certainly do find it thought-provoking.

> **We've lived in a world that has been defined so much by IQ—by cognitive processing ... As that becomes more and more a commodity ... we are heading into a world that is going to be defined much more by EQ than IQ."**
>
> **– Larry Summers (Harvard)**
> **2023**

FIGURE 3 – There is a strong positive correlation between wages and exposure to AI.
Mean salary (USD '000, y-axis) vs AI occupational exposure (AIOE index, x-axis).
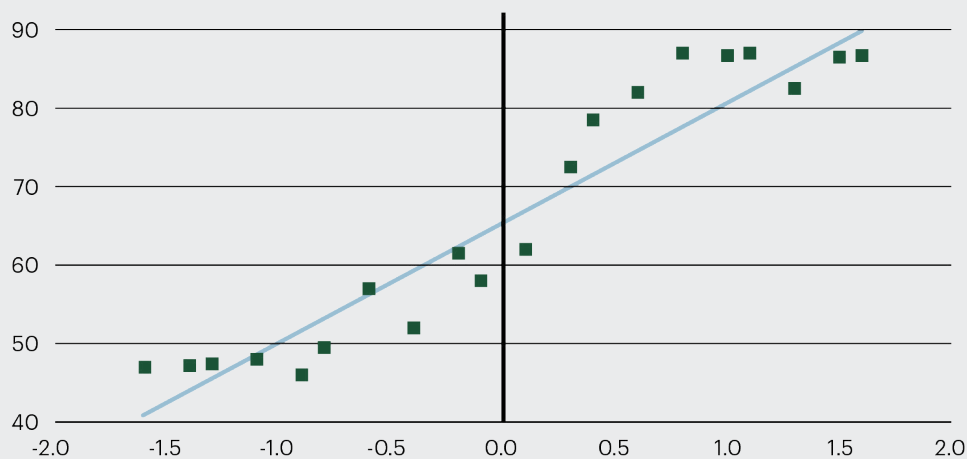
Source: E. Felten (Princeton) et al, "How will language modelers like ChatGPT affect occupations and industries," 2023. Note: Higher AIOE scores (x-axis) denote greater exposure. Occupations are grouped into 20 equal-sized bins based on AIOE score.

[8] "How computer automation affects occupations: Technology, jobs, and skills," J. Bessen (Boston U), 2015.

[9] "Power and progress: Our 1000-year struggle over technology and prosperity," D. Acemoglu (MIT) et al, 2023.

AI at work: Call centers

Having examined the outlook for employment and wages, we'll now discuss several case studies on the introduction of AI capabilities. The first example concerns the call center of a Fortune 500 software firm that specializes in business process software for subject matter experts and employees 5,000 agents. When the AI tool was first introduced, the positive impact on productivity occurred very quickly, within a month of implementation **(Figure 4)**. Further, less exerienced employees saw the greatest improvement (in fact, agents with more than a year on the job exhibited no improvement at all). Moreover, agent turnover declined 9% and customer satisfaction improved. This suggests that AI could prove complementary in this setting if agents are assigned new and more complex customer responsibilities.

Taxi drivers and AI NAVI

Our second example examines how the amount of time taxi drivers spend searching for customers changes when an AI-based navigation system is introduced. Overall, time spent searching declines significantly, especially for low-skilled drivers **(Figure 5)**.

FIGURE 4 – Call centers experienced an immediate 14% increase in productivity when an AI tool was introduced.
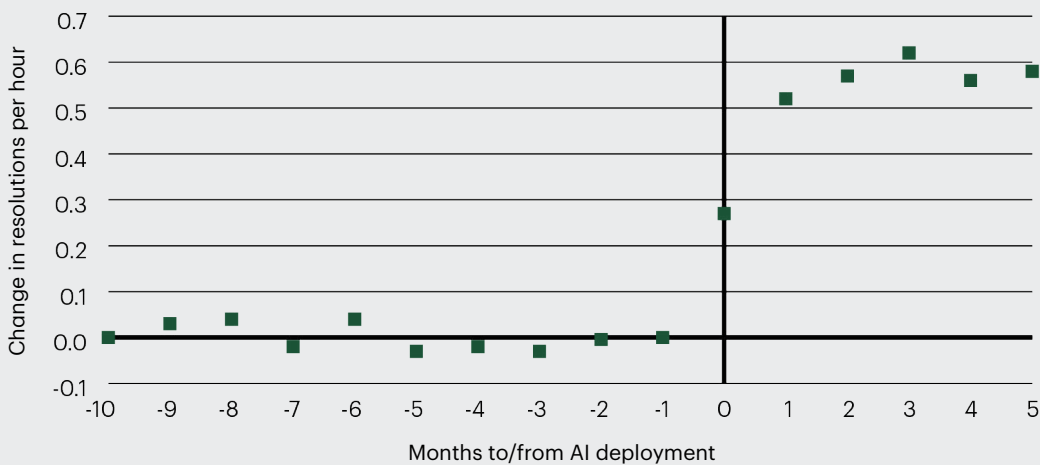
Source: "Generative AI at Work," E. Brynjolfsson (Stanford) et al, 2023.

FIGURE 5 – AI NAVI reduces search time by 5%, but all the benefit accrues to less experienced, lower skilled drivers.
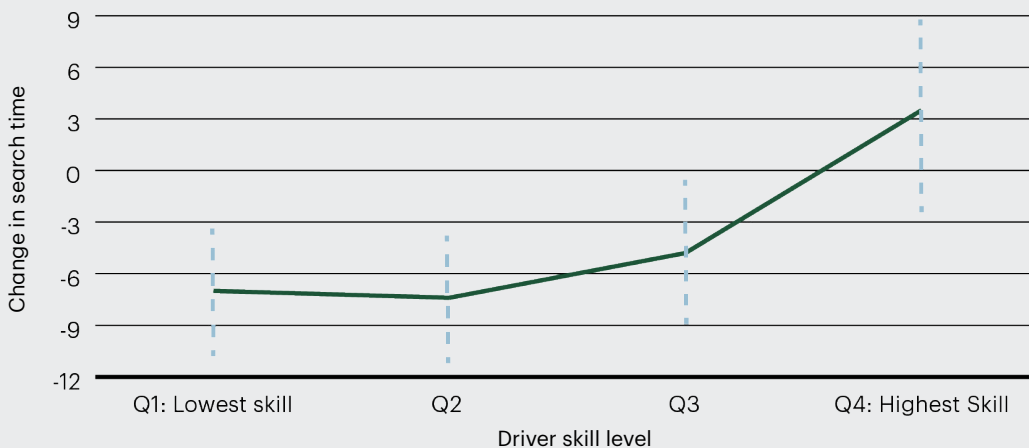
Source: "AI, skill, and productivity: The case of taxi drivers," by K. Kanazawa (U Tokyo) et al, 2022.

AI and content producers (writers, coders)

For our third case study, a recent paper examined the productivity effects of ChatGPT for mid-level professional writing tasks and found that the average time taken decreased by 40% and output quality rose 18%.[10]

Fourth, several studies have examined the impact of AI on coders. A typical finding is that "The treatment group, with access to the AI pair programmer, completed the task 55.8% faster than the control group."[11] The authors also emphasize that, for novice coders, tools like GitHub Copilot "help people transition into software development careers." This is a general result, found in studies across many different occupations, and suggests a key role for AI in accelerating career progression.

Will generative AI make you more productive at work? Yes, but only if you're not already great at your job.

The above heading is the somewhat tongue-in-cheek title of a recent article from Stanford's AI center. The sentiment is supported by the four case studies discussed above, as well as media reports of AI's passable college-level essays and famously flawed legal briefs. Overall, it appears that in many settings AI can augment basic abilities and increase the job productivity of less-skilled workers, allowing them to perform at levels previously achieved only by their more experienced colleagues.

As a second aside, we've included a quote below from two partners at the VC firm a16z. They argue that just as semiconductors reduced the marginal cost of compute toward zero, and the internet did

likewise for distribution, AI will reduce the cost of creating content toward zero. While we agree with the sentiment, we think it only applies to middling, garden-variety content. Truly exceptional code, writing, music, or videos will remain beyond the realm of AI for at least the next decade. In the meantime, prepare to be overwhelmed by mediocre content of every sort.

AI and health care

For our final example of AI implementation, we've chosen the health care sector, partially because adoption there lags behind most other industries. One reason is the paucity of structured, quantitative data versus the abundance of qualitative information, such as clinical notes and patients' reports.[12] However, severe financial pressures are building as health care spending soars. It represents an increasing and unsustainable portion of government expenditure, and McKinsey forecasts labor demand in the sector will increase by 30% over the next decade. This has created an urgent need to accelerate AI usage to improve productivity.

We'll now briefly discuss four examples. The first, a straightforward application, is HealthScribe, which transcribes conversations between doctors and patients, extracts medical information, and creates structured records of their appointments.

A second example is clinical decision support software, such as "Watson for Oncology" and DeepMind Health. They employ large language models (LLM) to extract clinical information from patient-specific data with the objective of aiding a doctor's judgement. Diagnosis is fundamentally a predictive process, which falls right in the wheelhouse of prediction machines like AI.

> **Just like the microchip brought the marginal cost of compute to zero, and the Internet brought the marginal cost of distribution to zero, generative AI promises to bring the marginal cost of creation to zero. ...the cost and time of generating content—everything from writing an email to producing an entire movie. ... we believe that a drop in marginal value of creation will massively drive demand.**
>
> **– "The Economic Case for Generative AI and Foundation Models,"
> Martin Casado et al (Andreessen Horowitz), 2023**

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[10] S. Noy (MIT) et al, "Experimental evidence on the productivity effects of generative AI," Science, 2023.

[11] "The Impact of AI on Developer Productivity: Evidence from GitHub Copilot," S. Peng (Microsoft) et al, 2023.

[12] "AI in US health care delivery," N. Sahni (Harvard) et al, New England Journal of Medicine, 2023.

Third, AI is increasingly used for image analysis, which includes reading MRIs, evaluating pathology slides, and interpreting ECGs. This is especially common in radiology, where 30% of practices had already adopted AI tools by 2020, a share that is probably over 50% by now. However, there are several challenges in combining AI predictions with human expertise.[13] To illustrate, Agarwal et al conclude, "AI assistance does not improve humans' diagnostic quality on average even though the AI predictions are more accurate than almost two-thirds of the participants in our experiment." This occurs because radiologists "under-weight the AI's information relative to their own and do not account for the correlation between their own information and the AI's."

Finally, AI has enormous potential to improve the hit-and-miss process of drug discovery. As The Economist notes, drugs can take a decade to emerge, cost billions of dollars and succeed only 10% of the time. Even a small improvement in speed and efficiency would be hugely valuable.[14] To illustrate the frenzied pace of activity, the FDA received over 100 drug and biological application submissions using AI/ML in 2021.[15] Further, 35% of US IPOs from 2020 and 2022 were biotech (vs. 34% tech), with the vast majority involving AI.

> **The optimal solution involves assigning cases either to humans or to AI, but rarely to a human assisted by AI**
>
> – **"Combining Human Expertise with AI: Experimental Evidence from Radiology," N. Agarwal (MIT) et al, 2023**

AI and the labor market: Investment implications

Advances in AI are ushering in an era of extreme uncertainty. It will be extremely disruptive to the labor market, with roughly 60% of tasks and occupations directly affected. Still, overall employment and real wages are likely to rise, as typically occurs with GPTs like AI. However, like previous waves of technology, we expect AI to drive further wage inequality.

Productivity, in economist Paul Krugman's famous formulation, "isn't everything, but in the long run, it's almost everything." On that note, the diffusion of AI is expected to increase U.S. productivity by 20% over next two decades. While this is a very rough guess, we can be more certain that a relatively small share will come from efficiency gains (doing things we already do, but with a bit less labor), with the lion's share generated by innovative new products and services, many of which will astound and befuddle us all.

Our forthcoming papers will examine productivity in more detail, and also explain why digital tech always features "winner-takes-most" dynamics. We expect increased concentration in most sectors, with a small number of companies capturing the vast majority of gains in value creation. Finally, business strategies for the digital age are capital-light, which is positive for margins, FCF, ROIC and shareholder yield. This is especially true for companies that establish themselves as global champions in the AI era.

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[13] "Combining human expertise with AI: Experimental evidence from radiology," N. Agarwal (MIT) et al, 2023.

[14] "Big pharma is warming to the potential of AI," The Economist, 2023.

[15] "Using AI & ML in the development of drug and biological products," FDA, 2023.

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