WHICH TASKS ARE COST-EFFECTIVE TO AUTOMATE WITH COMPUTER VISION?

By Maja S. Svanberg, Wensu Li, Martin Fleming, Brian C. Goehring, Neil C. Thompson

IN THIS BRIEF

- *Despite concerns over artificial intelligence's potential to replace human workers, previous literature has been unable to predict the pace of adoption.*
- *As an alternative, we present a new AI task automation model. It estimates three "end-to-end" factors: the level of technical performance needed to complete a task; the characteristics of the AI system required; and the economic choice of whether to build and deploy such a system.*
- *This paper focuses on the automation of computer vision tasks, where cost modeling is already well developed.*
- *We find that currently, only 23% of worker wages being paid for vision tasks would be economically attractive to automate with AI. Most computer-vision systems are cost-effective to deploy only when a single system is offered as a cloud-based service to be used across entire sectors, or even across the whole economy*
- *In the near future—perhaps in the next decade—the economics of AI could become more attractive by either cutting the cost of deployment or increasing the deployment's scale.*
- *The findings suggest that AI's displacement of jobs will be substantial, but also gradual. To mitigate the impact of unemployment, there is room for both policy and retraining.*

Machines will steal our jobs, is a sentiment heard frequently during times of rapid technological change. But is it true?

To be sure, this is a period of rapid change and anxiety. That's due largely to the emergence of generative artificial intelligence (AI) tools, such as ChatGPT from OpenAI, that are based on large language models (LLMs).

One recent study finds that about half of all tasks currently could be at least partially automated with LLMs (Eloundou et al., 2023). However, our research points out that the timing is essential. If the scale of automation were to happen rapidly, the disruption of the labor force could be enormous. But if it were to happen slowly, labor might be able to adapt. So the key question is not whether AI will automate tasks done by humans—it will for many jobs—but instead, how rapidly this automation will occur.

While a great deal of academic research has been published on AI automation and jobs, nearly all the predictions in these papers are vague about the timeline and extent of automation. That's because most researchers have failed to consider the technical feasibility or economic viability of AI systems when they discuss what's known as AI Exposure. One exception is a McKinsey & Co. report (Ellingrud et al., 2023) that estimates an AI adoption rate among businesses ranging from 4% to 55%. But with such an imprecise prediction, it's unclear what conclusions should follow.

To address important shortcomings of the previous AI-exposure models, we constructed a more economically grounded estimate of task automation. First, we surveyed workers to understand what performance would be required of an AI system. Second, we modeled the cost of building AI systems capable of that level of performance. And third, we modeled the decision of whether AI adoption is economically attractive to a business. The result of our work is the first end-to-end AI automation model.

THE FRAMEWORK

To estimate which tasks are economically attractive to automate with AI computer vision—which includes tasks such as checking product quality at the end of a factory assembly line—we developed a task-based approach based on two key topics:

- **Exposure:** For a specific task now done by humans, is it possible to build an AI model that could automate the task?
- **Economic attractiveness:** Is it more attractive economically for an AI system to automate a task than to have humans continue doing it?

To answer the question of exposure, we followed the literature on evaluating task descriptions for whether it might be possible for an AI system to perform them (Brynjolfsson et al., 2018). By contrast, answering the question of economic attractiveness was mostly new work. We discovered that the economics depend largely on the relative costs of AI and human labor. But while modeling the costs of human labor is straightforward, modeling the costs of AI isn't. For this reason, we reviewed the computer-science literature on AI training and inference.

And to gain additional data, we also performed 35 case studies.

A key concept for our work is *minimum viable scale*. This occurs when an AI deployment's fixed costs are amortized to the point that using the AI system, on average, costs the same as using human labor of equivalent capability. AI automation is cost-effective only when the deployment scale is larger than the minimum viable scale.

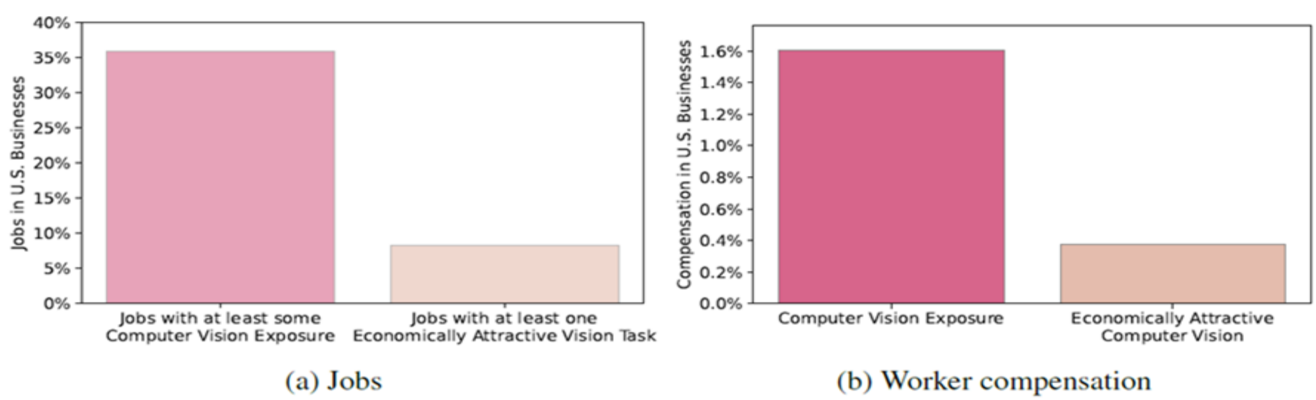
KEY FINDINGS

Results show that far more tasks can be performed by AI computer vision than would be economically attractive to automate. Specifically, we found that fully a third of all jobs in U.S. non-farm businesses (36%) have at least one task that could be exposed to computer vision. But we also found that only 8% of all jobs have at least one task that is economically attractive to automate (Figure 1a).

Another way to think of this: Of the 36% of jobs that have at least one task that could be automated with computer vision, just under a quarter (23%) also have a task for which this automation would be economically attractive.

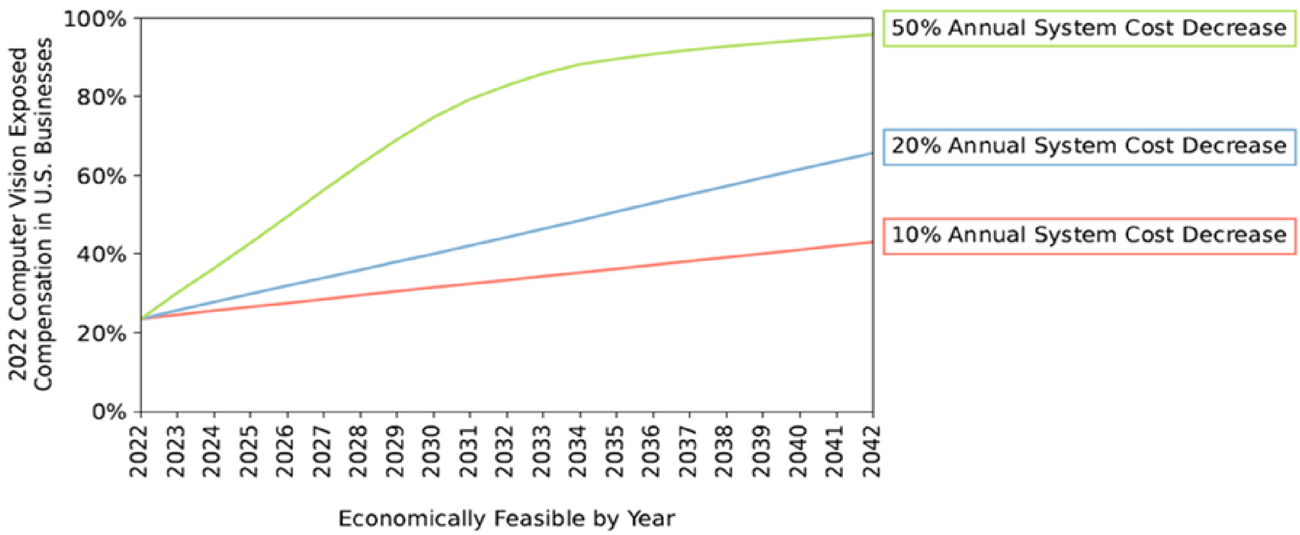
Since vision tasks represent such a small fraction of any occupation, a more relevant metric is *share of compensation*. To measure this, we first aggregated the human wages per task. We then compared and identified that cost as a percentage of U.S. labor compensation (rather than as a percentage of jobs). Using this measure, we found that vision tasks represent less than 2% of all U.S. non-farm compensation, of which only 0.4% are attractive to automate with AI (Figure 1b).

Figure 1. Comparison of AI exposure and firm-level economic attractiveness for computer vision.



The study's results are driven by the costs of deploying AI systems. For example, imagine that a small bakery is considering computer vision for a task now done by its human bakers, namely, visually inspecting ingredients to ensure they're not spoiled. In theory, the task could be done by a computer-vision system trained to detect spoiled food. But would it be cost-effective? Checking food quality represents only about 6% of a baker's duties, and the average annual salary for a baker is $48,000. So a small bakery with five bakers would have a potential savings with computer vision of $14,400 a year. (Calculated as $48,000 x 5 bakers x 6%.) Because these savings are far less than the cost of developing, deploying and maintaining a computer-vision system, an implementation would not be economically attractive for this bakery.

Figure 2. Timing of Economic Feasibility of Computer-Vision Automation if AI System Costs Drop



HOW AI COULD PROLIFERATE

Therefore, with today's technology, computer vision remains economically unattractive for many jobs and tasks. In the future, however, the economic attractiveness of AI could increase substantially in two important ways:

Scale: AI systems could increase their ability to automate more labor per system. This would likely be done with AI-as-a-Service business models, in which tasks traditionally done inside an organization are outsourced. Because the service providers would essentially aggregate labor costs for a given task across multiple firms, service models could greatly increase the attractiveness of automation economics.

Development costs: Technological advances could empower AI systems to be developed in new, less expensive ways, making these systems easier to justify economically. While some researchers predict this will happen quickly due to Moore's Law (Ford, 2015), we use the more recent estimate of a 22% annual price decrease (Hobbhahn & Besiroglu, 2022).

However, even with a 50% annual price decrease, it would not be until 2026 that half of all vision tasks have a machine economic advantage (Figure 2). At the other extreme, with an annual price decrease of 10%, the economic advantage wouldn't happen until after 2042.

IMPACT ON WORKER DISPLACEMENT

Policy discussions around AI center on three important questions: How many workers will be displaced by AI? How quickly? And how much retraining, social support and other interventions will this require?

Our results suggest that job loss from AI computer vision within the set of all jobs involving vision tasks will be smaller than existing job churn and that replacement of human labor by AI will be gradual, not abrupt. According to 2023 data from the U.S. Bureau of Labor Statistics, 22.5% of private sector jobs were lost annually between 2012 and 2019, on average. However, with substantial job creation, there was still a net average gain of 1.8% over the period.

So if the annual cost of computer vision was to drop by 50%, and if we assume that all firm-level vision tasks that can be done economically do get automated the same year, then the percentage of vision-task compensation lost every year will be 5% to 7% in the peak years. What's more, even without offsetting effects, the net job loss, including computer vision-related task displacement, would be around 3% to 5% of vision tasks annually. While this would be devastating for individual workers, it would by no means be an apocalyptic scenario.

One wrinkle is that AI could not only replace human workers, but also assist them—or even take on entirely new tasks. In one survey, 83% of executives said they believe AI will augment human labor rather than replace it (IBM Institute, 2023). Another study finds that only half of AI startups help customers reduce labor costs, while nearly all build products that enhance capabilities (Bessen et al., 2018).

The cost-effectiveness of AI models will likely play a large, important role in the technology's proliferation. In our study, more than three-quarters of vision tasks (77%) are not economical to automate with a computer-vision system that can be used only by a single organization. Instead, most computer-vision systems are cost-effective to deploy only when a single system is offered as a cloud-based service to be used across entire sectors, or even across the whole economy.

Many variables exist. The rate and scope of AI's adoption could be changed by either the cost of AI systems or the scale at which they're used. Deployments should become cheaper, improving the economic advantages of machines over human workers. And scale could be achieved either by a user organization getting larger via market share or by the formation of AI-as-a-Service operations.

However, even with rapid cost decreases of 20% a year, we find that computer-vision tasks will not become economically efficient for decades. The slower diffusion of AI implied by our model also lowers the amount of job displacement we should expect. This is certainly true for computer vision, where we find the rate of job loss to be lower than already experienced due to normal job churn.

The results point to a notably different path for AI automation than previously explored in the literature. We foresee a pace more in line with traditional job turnover. That slower pace should also allow for traditional policy interventions.

REPORT

Read the **full research report**.

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