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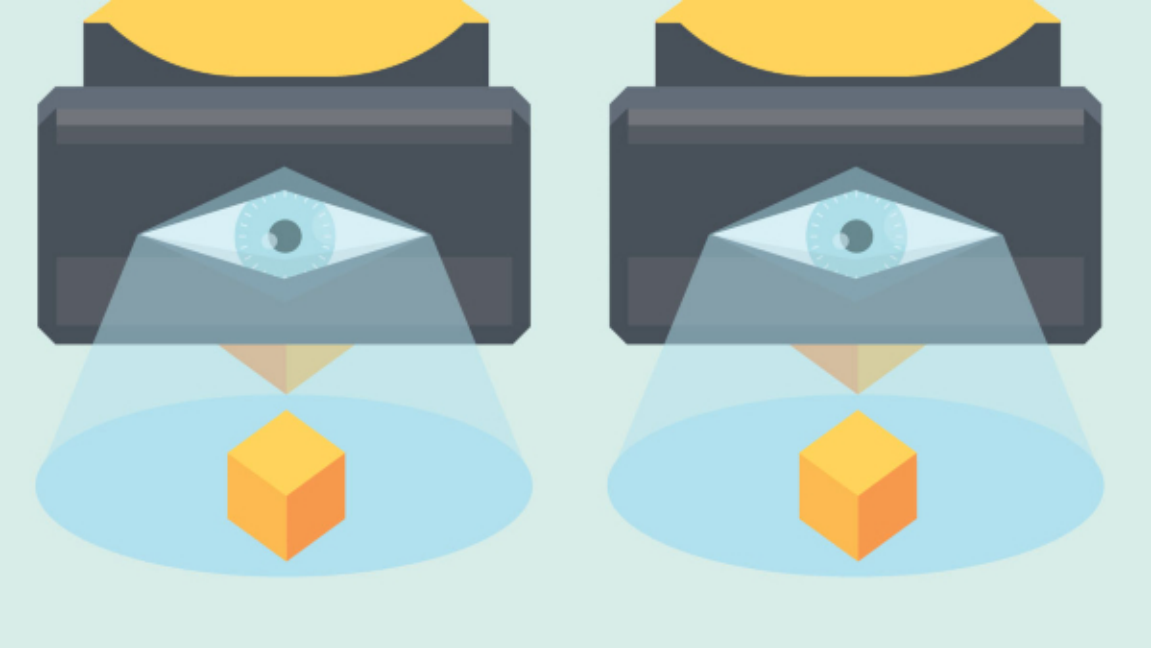


The relationship between technology and jobs is center stage in the policy and academic debate. The discussion reveals a fascinating, troubling contradiction. On the one hand, there is widespread fear that innovation will lead to a loss of jobs and rising income inequality — the "race against the machines" narrative. On the other, the slowdown in productivity growth across advanced economies has led some economists to argue that new innovations have no impact on growth.

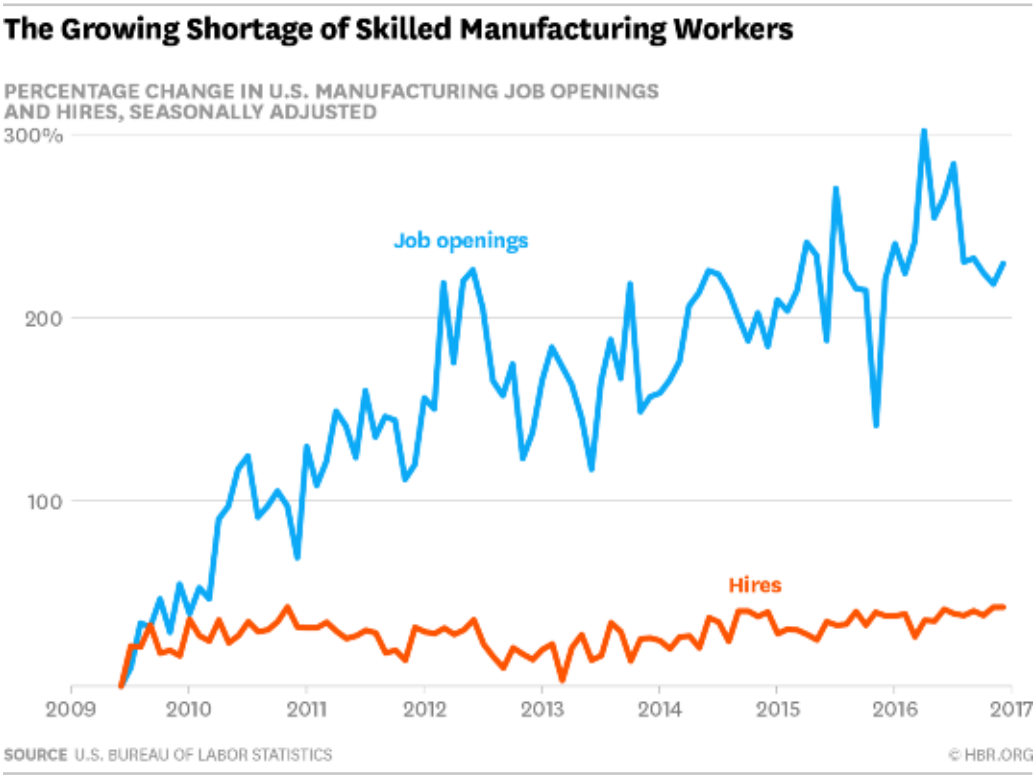
This debate has paid little attention to what we see as one of the most important waves of innovation. Upskilling technologies, a partnership between humans and smart machines, can augment workers' abilities, resulting in dramatically improved performance, greater safety, and higher worker satisfaction. One of the best examples of this type of partnership is the industrial use of augmented reality (AR) smart glasses in manufacturing, warehousing, and field service environments that overlay computer-generated video, graphic, or text information onto physical objects — for example, step-by-step repair instructions hovering over a machine part, visually guiding a worker through the job. As we'll show, wearable AR devices are now being used in manufacturing and industrial settings and can boost workers' productivity on an array of tasks the first time they're used, even without prior training. These technologies increase productivity by making workers more skilled and efficient, and thus have the potential to yield both more economic growth and better jobs.

The video below, for example, shows a side-by-side time-lapse comparison of a GE technician wiring a wind turbine's control box using the company's current process, and then doing the same task while guided by line-of-sight instructions overlaid on the job by an AR headset. The device improved the worker's performance by 34% *on first use*.

**VIDEO** AVAILABLE ONLINE
*TO VIEW, PLEASE VISIT THIS ARTICLE AT HBR.ORG*

Before we look further at AR applications in the workplace, let's take a step back and examine the macroeconomic issues that make machine augmentation of human performance so important. The U.S. and other advanced economies have suffered a severe drop in productivity growth since the great recession. In the United States productivity growth averaged just 0.5% per year from 2011 to 2016, compared to 3% from 1996 to 2005, according to the Bureau of Labor Statistics. This has led to subpar economic growth and stagnant wages, with momentous social and political repercussions not only in the U.S. but also in most of the developed world.

At the same time, as the chart below shows, U.S. manufacturing job openings are quickly outpacing the supply of qualified candidates, resulting in a growing gap in the industrial workforce. A 2015 Deloitte study estimates that there will be 3.5 million manufacturing jobs available over the next decade in the US, 2 million of which will go unfilled. This is a continuation of an existing trend.




Compounding the shortage is what numerous studies have pointed to: a growing skill gap between job requirements and the available labor pool. According to the U.S. labor department, a majority of manufacturing jobs now require partial or full college education, which is in stark contrast with the situation at the start of the 21st century, when the majority of manufacturing jobs were filled by workers with only a high school education. These are high-wage, high-productivity jobs, such as those done by advanced manufacturing technicians and electrical machine maintenance workers, that, if filled, could accelerate economic growth.

As advanced economies look to speed growth, they face the headwind of an aging population, which slows the rate of growth of the labor force. The solution to this problem is faster *productivity* growth, which requires higher worker skills. College education may be part of the solution, but increasing the proportion of college-educated people in the workforce will take time we don't have. Job retraining programs are faster, but have only been partially successful in addressing job market mismatches.

While factories increasingly employ the latest smart, connected technologies, human workers remain central to factory performance. Efficiently delivering information to them that enhances their performance is essential. Some efforts to this end have involved installing stationary PCs or tablets at workstations that, for example, provide warehouse workers with inventory data or allow repair technicians to check off completed steps during a maintenance call. But these solutions interrupt the workflow, constraining productivity.

There's been concern about machines replacing human workers, and certainly this is happening for some jobs. But the experience at General Electric and other industrial firms shows that, for many jobs, combinations of humans and machines outperform either working alone. Wearable augmented reality devices are especially powerful, as they deliver the right information at the right moment and in the ideal format, directly in workers' line of sight, while leaving workers' hands free so they can work without interruption. This dramatically reduces the time needed to complete a job because workers needn't stop what they're doing to flip through a paper manual or engage with a device or workstation. It also reduces errors because the AR display provides explicit guidance overlaid on the work being done, delivered on demand. Workers need only follow the detailed instructions directly in front of them in order to move through a sequence of steps to completion. If they encounter problems, they can launch training videos or connect by video with remote experts to share what they see through their smart glasses and get real-time assistance.

Like the wind turbine wiring case in the video above, a study conducted by Boeing showed that AR improved productivity in wiring harness assembly by 25%. And at GE Healthcare a warehouse worker receiving a new picklist order through AR completed the task 46% faster than when using the standard process, which relies on a paper list and item searches on a work station (view video here). Additional cases from GE and several other firms show an average productivity improvement of 32%.

We believe that AR technologies will be instrumental in closing the skill gap that is responsible for the shortage of skilled manufacturing workers. Because AR will allow more workers to do high-skill jobs, and improve their performance in this work, we are optimistic that industrial productivity will grow and that this will ultimately translate into higher wages.

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