A New Industrial Revolution?

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ARTIFICIAL INTELLIGENCE MAY RIVAL STEAM, ELECTRICITY, AND COMPUTING—BUT HISTORY SUGGESTS ITS FULL ECONOMIC IMPACT WILL TAKE TIME

With the Industrial Revolution, which began in Britain in the late 18th century, came the first wave of technology to transform the economic system. In the centuries that followed were further revolutions, each associated with new forms of technology. What lessons can we draw from this history about the rapid advance of technology in our own time?

Popular debates about today's new technologies fixate either on visions of a dazzling future of AI-powered scientific breakthroughs or on a dystopian future of obsolete workers struggling to survive alongside a wealthy technological elite. But the advent of railroads and steam-powered machinery in the 19th century and information and communications technology (ICT) in the late 20th century gave rise to hopes and fears just as far-reaching. Economics and history should, however, make us wary of extreme predictions about the technological future.

Basic economic principles imply a rosy view about the impact of technology on growth and living standards. By enhancing the productivity of workers, technology can raise the demand for labor, driving economic expansion and pushing up wages. This happy story is most accurate in light of material progress over the centuries. Waves of technology over the past 200 years have not led to ever-rising unemployment. If they had, there would now be a dwindling remnant of workers performing ever-fewer activities.

But within this broad pattern are significant complicating factors. A classic debate about past industrial revolutions centers on how quickly new technology has an effect.

General purpose technology

The First Industrial Revolution was economically significant because of the emergence of a new general purpose technology: steam power. Unlike better bread ovens, which simply make bakers more

Illustration by Mark Harris

effective, general purpose technology has many uses and increases productivity throughout the economy. Beginning in the late 19th century, the Second Industrial Revolution introduced another general purpose technology, electricity, and the third, beginning in the late 20th century, brought yet another, ICT. Industrial revolutions also bring about what's been termed the "invention of a method of invention." In the First Industrial Revolution it was about finding ways to bridge the gap between scientific knowledge and the creation of useful products.

Because it offers fundamentally new possibilities for the production of goods and services and has broad application across many fields, it's likely that AI constitutes a distinct general purpose technology. It also involves novel ways of coming up with ideas and so is itself a new method of invention. We may well be living through a fourth industrial revolution as groundbreaking as those that came before.

If new general purpose technology is fundamental to industrial revolutions, then how long does it take to have an effect? The economic historian Nicholas Crafts found that the impact of steam in the 19th century was slower and smaller than previously believed: The gains came only after 1830. This is because at first steam-powered sectors made up only a small fraction of the economy and so couldn't drive dramatic productivity growth. And reaping the full benefits of general purpose technology requires broad economic reorganization, which takes time. Steam power means moving workers into factories, electrification means revamping production lines, and ICT implies reshaping firms' administrative functions.

Solow paradox

This finding should allay an often-expressed disappointment with recent productivity performance. A pioneer of growth economics, Robert Solow, once commented that "you can see the computer age everywhere but in the productivity statistics." This "Solow paradox" points to the reality that despite the advent of computers and new communications technologies, productivity growth in the late 20th century seemed unspectacular at best. But if the experience of the First Industrial Revolution is any indicator, it's overly optimistic to expect an immediate payoff from new technology. Compared with the early impact of steam, the productivity gains from ICT are in fact historically unprecedented in their speed and magnitude. Clearly society has become better at harnessing the economic potential of new technologies.

Although over centuries economic expansion and higher living standards come from new technology—from advancements in the supply side of the economy—in the short term a host of factors influence growth. Some economists have blamed sluggish growth in recent decades on weak demand, particularly following the global financial crisis of the early 2000s. But it's been suggested that even the supply-side improvements underpinning the sustained economic growth of the past 200 years are now harder to come by. The economist Robert Gordon argues that innovations like electric lighting and running water, which had a significant impact on daily life and the economy during the 20th century, were technological low-hanging fruit—and that there are fewer of these left for the taking.

Does history suggest that AI could end this impasse? Despite dazzling recent advances, the technology is still at an early stage. This is almost certainly the case in terms of its practical application in the economy. AI's contribution to productivity has so far been modest, and some have already declared it a "productivity paradox." But as with steam, electricity, and ICT, harnessing the full potential of AI will take new kinds of organization and ways of working. If the ICT experience is anything to go by, then the AI productivity impact will be felt faster than the effect of earlier general purpose technology, even if it doesn't yield the spectacular growth some enthusiasts project.

Perennial fears

The second complicating factor when it comes to the impact of new technology involves how the productivity gains are distributed. Looking at the unfolding of the Industrial Revolution decade by decade rather than over entire centuries reveals a more complex and bleaker picture, one that has stoked those perennial fears of new technology and led to critiques of industrial capitalism. In the mid-19th century, Friedrich Engels noted the differing impacts of machines on workers in the early stages of the Industrial Revolution. The invention of the spinning jenny in the 1760s lowered the cost of yarn, making cloth cheaper and increasing the demand for it. There was a greater need for weavers, and their wages rose.

But later, the mechanization of weaving itself wrecked workers' standard of living. Engels observed in the hovels of Manchester, England, a distressed class of hand-loom weavers squeezed out by new machinery. With little alternative employment available, they barely survived on collapsing wages and 18-hour workdays as more and more of the woven goods they made were "annexed by the power-loom." In the factories themselves, men, women, and children toiled alongside machines for long hours in dangerous, unhealthy conditions. Machines and the factory system had blighted the lives of the working class, argued Engels.

The economic historian Robert Allen uses historical data to establish the basic pattern described by Engels. In the early decades of the Industrial Revolution, even as output per worker rose, real wages stagnated. Wages began to rise in line with productivity—as basic economic principles would predict—only after the middle of the 19th century. A shorter-term perspective than centuries, then, shows that new technology has complex and contradictory effects on living standards and wages.

In a series of recent studies, Daron Acemoglu and Pascual Restrepo model these various impacts. New technologies like steam-powered looms, industrial robots, and AI automate tasks that workers used to do, leading to a shedding of labor—the "displacement effect." This reduces the share of labor in national income and decouples wages from productivity.

Reinstatement effect

Other forces offset displacement. Weavers benefiting from the mechanization of spinning are an example of automation in one sector boosting demand for a related nonautomated task. But there's a more potent pro-worker effect that really got going in the second half of the 19th century: the "reinstatement effect." This happens when technologies generate new tasks that give human beings a comparative advantage over machines. During the 19th and 20th centuries, as steam engines, electricity, and computers transformed production, previously unimaginable jobs emerged: for engineers, telephone operators, machine technicians, software designers, and so on.

These various effects complicate the basic economic link between technology-caused productivity improvement and higher wages. If technology simply displaced labor, what would account for the famous stylized fact established by the economist Nicholas Kaldor in the 1960s—that the share of labor in national income had been relatively stable? On the other hand, if a new job emerged immediately for every worker who lost one to a machine, then technological unemployment and Luddite-type discontent would be impossible.

During the early phase of the Industrial Revolution, the displacement effect dominated, hurting workers; in the 20th century, the reinstatement effect became stronger, driving up wages and living standards. But since the late 20th century, real wages in many leading economies have been flat—another paradoxical aspect of the Information Age.

Acemoglu and Restrepo point out that many ICT and AI innovations have been aimed at automation rather than the creation of new kinds of tasks. This has exacerbated the problem of stagnant labor demand, slow wage growth, and rising inequality, raising fears about what an AI-dependent future might look like. They argue that there is even a danger of excessive automation directly hurting productivity. Instead they advocate the pursuit of labor-reinstating AI—for example, in education and health, where AI tools could help with individually tailored learning and treatment programs that would require more, not fewer, teachers and doctors.

Machine singularity

There's a bigger question. Given its potential to replace human creativity, is AI fundamentally different from earlier general purpose technology? Technologists talk of AI reaching "singularity," a point at which machines could improve and invent themselves, making humans redundant and eliminating labor reinstatement through the creation of new tasks.

Would such a scenario make economic comparisons with earlier eras useless? Maybe not. Even if AI did cross such a boundary, it would not necessarily translate into economic singularity—unbounded productivity improvement but human obsolescence. The economist William Nordhaus has devised empirical tests for the likelihood of such singularity and found that most of the conditions are far from being met. That's because much of the economy is physical, not informational, and is likely to remain so: For AI to completely take over, it would have to learn how to poach eggs, cut hair, and soothe crying toddlers at the day care center.

A big difference between the early 19th century and our own time is that we now have policy tools to influence the economy. It's well known that innovation has significant market failures. But choices about the path of AI are being left to corporations with little concern for the broader economic impacts policymakers and voters care about. Technology is a social choice that we can influence. Armed with the experience of earlier industrial revolutions, governments and regulators have both motive and means to guide technological development to ensure that its economic benefits are broadly shared—if they can find the political will to do so. F&D

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