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The Future of Work: Race with—not against—the Machine

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Will the revolution in digital and information technologies make us obsolete? Will jobs be lost and never replaced? Will wages drop to intolerable levels? History and economic theory and evidence suggest that in the long term, such fears are misplaced. However, in the short and medium term, dislocation can be severe for certain types of work, places, and populations. In the transition period, policies are needed to facilitate labor market flexibility and mobility, introduce and strengthen safety nets and social protection, and improve education and training.

The Fear: Are We Running Out of Jobs?

There is growing fear that recent and emerging breakthroughs in technologies such as artificial intelligence (AI) and robotics will lead to the wholesale replacement of human workers by machines and an era of mass joblessness and even wider income inequality. The U.S. magazine *Mother Jones* reports, "Smart machines probably won't kill us all—but they'll definitely take our jobs, and sooner than you think," while the British newspaper *The Guardian* argues, "Technology is hollowing out the middle class and creating a bifurcated economy." China's *Global Times* notes, "It is not entirely fantastical to suppose that under the rule of the robots, humans would be forced to beg for food since they don't have any jobs to do any more."

At least since the First Industrial Revolution in the 1750s, workers' jobs and livelihoods have been threatened by machines that can replace them. Facing this threat, the Luddites organized themselves to destroy weaving machinery in England in the early 1800s. More recently, taxi drivers from Paris to Mexico City to Bogota have blocked streets and at times resorted to violence to protest the advent of technology-enabled ride-sharing services like Uber. Losing our jobs because we have become obsolete as workers may be one of our greatest fears—and for good reasons: job loss has significant and long-lasting negative effects on future employment, earnings, consumption, health, and even life expectancy. For some individuals, mortality rates in the year after a job loss are up to 100 percent higher than would otherwise have been (Sullivan and von Wachter 2009).

These concerns have been echoed and studied in economics. In his prescient essay on the "Economic Possibilities for Our Grandchildren," Keynes (1930) predicted the decline of employment in the face of modern technologies and labeled it "technological unemployment." Leontief (1983) wondered whether workers would go "the way of the horses," replaced by machines.

In the United States and other developed countries, employment growth has followed a U-shape in recent decades, increasing for low- and high-skilled workers, but declining for middle-skilled workers, such as factory and clerical workers (Autor, Katz, and Kearney 2006; Goos and Manning 2007; Autor 2015b). This has resulted in both employment and wage polarization. While other trends like climate change, demographic change, and globalization have also affected jobs, a study of the United States found that those counties (jurisdictions below the state level) more "exposed" to robots have lost more employment than others (Acemoglu and Restrepo 2017).

There is also some evidence of U-shaped employment growth for many developing countries. However, for this group of countries, the overall evidence on the relationship between employment growth and the skills distribution is both more tentative and mixed. While the relationship has been U-shaped for countries as diverse as Malaysia, Poland, and Turkey, patterns for China and a range of other developing countries have differed (figure 1). This diversity is likely to be related to the interaction between local labor market conditions, including the skills distribution, and the technologies that are adopted.

The Past of Work: Have We Been Here Before?

One way to structure the economic history of developed countries over the last 250 years is to refer to three past Industrial Revolutions that occurred in the 1760s, the 1890s, and the 1970s. In turn, these revolutions can be characterized by the technological innovation that propelled them. Thus, the First Industrial Revolution used steam engines and factories to mechanize production; the Second used electricity, oil, and assembly lines to generate industrial production; and the Third used electronics and information technology to automate production.

All three past Industrial Revolutions led to large improvements in productivity. This in turn raised welfare in developed countries to levels previously unimaginable, in terms of both material living standards and leisure (since the 1950s, average hours per worker have been falling among OECD countries). Today, material living standards and leisure in developing countries lag far behind those in developed counties. Therefore, the effects of future productivity growth on welfare can be even more beneficial in developing countries than in developed ones.

Yet, productivity gains take time to materialize. In the case of electricity, the productivity boom occurred only in the 1920s, over 30 years after factory electrification, David (1990) documents. Brynjolfsson, Rock, and Syverson (2018) argue that the same has happened with information and communications technologies, which started in the 1970s but only in the 2000s have rendered a noticeable increase in productivity. In 1987, Solow famously said, "You can see the computer age everywhere but in the productivity statistics." This productivity pause is common to most technologies but is particularly pronounced for general-purpose technologies such as the steam engine, electricity, computers, and internet. Using them effectively requires a transformation of the production process that can take years, as well as substantial investment with no immediate payoff.

All Industrial Revolutions have also led to economic transformation and threatened employment. In the past 250 years, however, technological innovation has not produced mass unemployment (Gordon 2016). A specific good, type of work, or even

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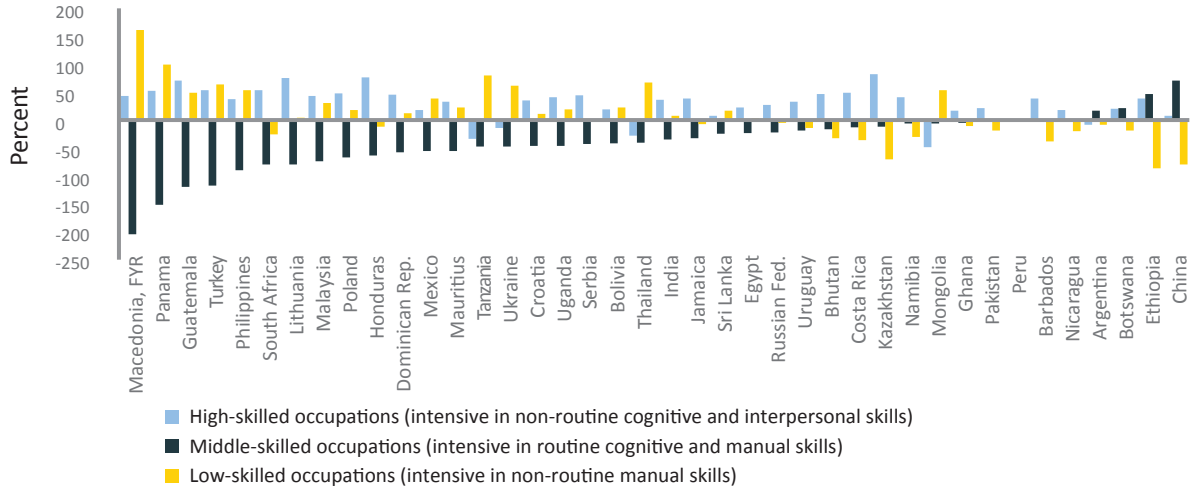
Figure 1. Annual Average Change in Employment Share, circa 1995–2012



Source: World Bank 2016.

a sector in the economy can dwindle and even disappear in the advent of new technologies. However, what is true for one sector, product, or job has not been true for the economy overall (Autor 2015b).

The example of farming in developed countries is instructive. In the United States between 1900 and 2000, farming went from being the main employer in the economy, with 41 percent of all jobs, to employing only 2 percent of workers, according to data from the U.S. Department of Agriculture. Over this century, productivity gains allowed agriculture to feed a growing population with fewer workers, while the rise of new economic activities created better-paying jobs and opportunities in cities for all workers. In developing countries, farming still plays a relatively more important role. Yet, even within this country group, its share among overall employment has been in a slow but secular decline. Among low and middle-income countries, employment in agriculture as a share of total employment fell from 53 percent to 32 percent from 1991 to 2016, according to the World Bank's World Development Indicators.

Although the positive labor effects of the past three Industrial Revolutions did materialize in the long run, there was a long period of time when wages and employment fell or remained stagnant even though new technologies were adopted and productivity increased. Allen (2009) dubbed this period "Engels' pause," after Friedrich Engels' essays on the British working class. "Engels' pause" lasted almost 80 years after the onset of the First Industrial Revolution and about 40 years after the Second. It caused labor disruption and social unrest (as insightfully illustrated in Charles Dickens' stories), and, arguably, even political revolutions, such as those sweeping through Europe in the 1840s.

The Future of Work: Is This Time Different?

No Industrial Revolution has exactly the same labor market effects as the preceding ones. Breakthroughs in artificial intelligence, robotics, and other technologies have led to claims that we are on the cusp of a new machine age that will dwarf previous waves of automation in terms of the scale, speed, and scope of the disruption it causes. A defining characteristic of the Fourth Industrial Revolution seems to be that while, previously, technology was increasingly able to perform routine manual and cognitive tasks, in the current digital and computing revolution, machines can also perform some nonroutine tasks that had been hitherto reserved to humans: the application of logic and information to provide a wide array of goods and services, from automated manufacturing and transportation to bookkeeping and judicial decisions (Brynjolfsson and McAfee 2011, 2014).

The disruption caused by the Fourth Industrial Revolution appears particularly palpable in developed countries, but there are also growing signs of it in the developing world. In the Philippines in recent years, for example, the business process outsourcing industry has become a major sector of economic activity and source of well-paying jobs, employing more than 1 million people. However, some companies in the industry have recently invested heavily in technology and, for instance, begun replacing call center agents by chatbots powered by artificial intelligence systems. While the impact of technological change is for the moment mostly evident on relatively low-skilled "process-driven" business outsourcing, there are widespread fears of more general impacts in the medium term.

This does not mean that machines will replace all labor or that wages will plummet across the board. Computers based on AI are remarkably effective in conducting specific tasks rather than replicating human intelligence. The early attempts to imitate humans in the 1970s derailed AI for decades. By contrast, the recent success of AI has been based on an algorithmic approach that uses neural networks and deep learning for well-defined and limited tasks. Human contribution is likely to remain the crucial ingredient—the "O-ring," as Autor (2015b) calls it. Through this illustration and his reflections on Polanyi's paradox ("our tacit knowledge of how the world works often exceeds our explicit understanding"), Autor (2015a, 2015b) has stressed the strong complementary between machines and humans.

The replacement of labor by machines takes time and depends on circumstances specific to a given context. Technological innovations tend to occur in developed countries, and their adoption in developing countries usually occurs with a time lag. Generally, labor is also much cheaper in developing countries than in developed ones. This further slows down the relative pace of adoption of new technologies in developing countries, which implies that in many of them concerns about the implica-tions of the Third Industrial Revolution still appear more urgent than those about the Fourth. However, even low labor costs do not stop technology adoption completely. For instance, Malaysia's Top Glove is one of the world's largest manufacturer of rubber gloves, with about one-quarter of global market share. As wages in Malaysia have gradually risen over the last 25 years,

the firm has remained competitive by gradually substituting foreign for domestic labor. However, as various factors have further increased the relative cost of labor, the company is now increasingly looking to automate.

A Framework to Assess the Impact of Technological Innovation on Jobs and Wages

Acemoglu and Autor (2011) and Acemoglu and Restrepo (2018) provide a helpful framework for assessing the employment and wage effects of technological innovation. According to this framework, there are broadly speaking two types of innovations: enabling technologies and replacing technologies. Enabling technologies expand the productivity of labor and lead to higher employment and wages. Modern examples are computer-aided design (CAT) and statistical software for economic and social analysis. Replacing technologies, in contrast, substitute for labor, making workers less useful and lowering their wages. Modern examples are industrial robots for car manufacturing and software for accounting and tax reporting.

The direct effect of replacing technologies is negative on wages and employment. However, these technologies can still have a positive effect in two main ways. First, the new technologies can generate complementary tasks. In the United States, for example, after automatic teller machines (ATMs) were introduced 40 years ago, the number of bank tellers, far from dwindling, doubled; tellers' function became more service- and information-oriented (Bessen 2015). Second, the productivity effects can be sufficiently large to create wealth and generate demand for other jobs (for instance, in tourism and hospitality).

The characterization of enabling and replacing technologies depends not only on the technical properties of the innovations but also on the workers' abilities and labor market conditions where they are implemented. The same technology can replace workers in some instances and enable workers in others: those well prepared with complementary skills would benefit the most from technological innovations. Therefore, an important challenge for policy makers, educational institutions, and households is identifying these complementary skills for future work. Labor market conditions, on their part, can affect how innovations impact employment and wages. Rigid labor markets would tend to adjust by shedding labor, while more flexible labor markets would adjust through wage reductions. Flexible labor markets can also induce workers' reallocation and mobility in the face of technological shocks, mitigating negative effects on both employment and wages. Identifying the main sources of friction in rigid labor markets (regulatory, search-and-match, behavioral frictions) can guide policy reforms.

What Policies Are Needed? What Can Countries Do?

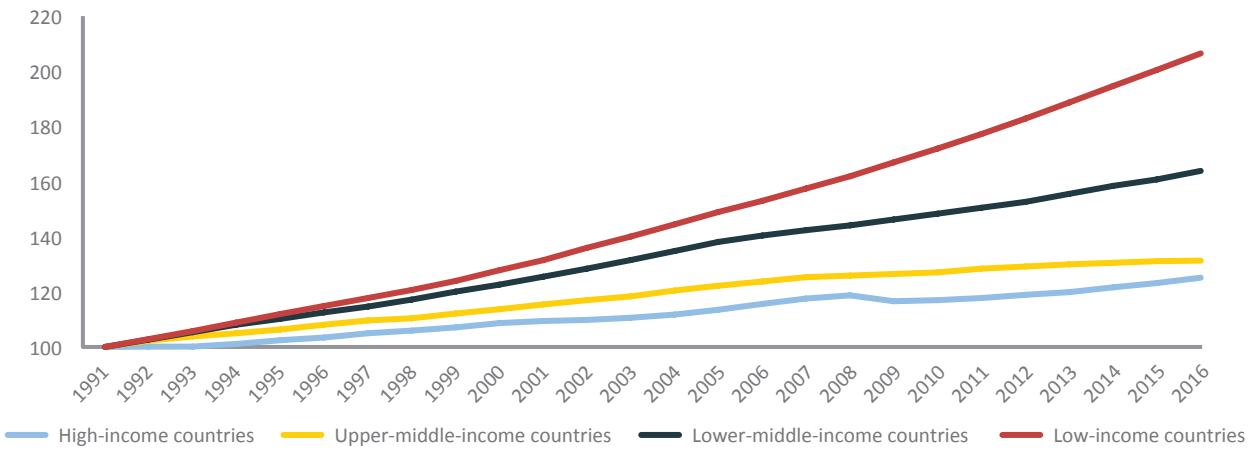
Today, more people are employed than ever before (figure 2). In the long run, new tasks and new jobs will be created that are difficult to envision now (in the same way that even the most knowledgeable and imaginative observer at the beginning of the 1900s would not have guessed how workers leaving agriculture would be employed in the following decades). At the same time, many of the current technological advances widen inequality. The returns to tasks complementing new technologies have grown dramatically, but many low- and mid-skilled jobs are at risk of being replaced by automation. The prospect of an "Engels' pause" is, moreover, looming in the horizon. This raises the question how to mitigate, if not avoid, the negative effects of technological change.

Technological change promises tremendous gains in productivity and welfare. Therefore, "neo-Luddite" policies that aim to stop or delay the Fourth Industrial Revolution appear misguided. Instead, the main policy question is how to maximize the potential social gains from technological change. This calls for policies that facilitate labor market flexibility and mobility, introduce and strengthen safety nets and social protection, and improve education and training.

Policies that make labor unduly expensive induce the adoption of labor-replacing technologies. Labor market reform should be directed at facilitating labor flexibility and mobility, including international migration. Recent evidence for the United States, for instance, suggests that immigration reduces the negative effects of technological change on the employment of native workers at the lower end of the wage distribution. This is because an inflow of immigrants specialized in manual tasks attenuates the downgrading of native workers' jobs and wages induced by technological change (Basso, Peri, and Rahman 2017). Getting the basic business environment right for firms to invest and hire workers and reducing market failures hindering startups can similarly help capture the gains of technological change. The policy principle should not be to protect jobs that are becoming outdated and unproductive due to technological change but to protect people (as the Danish flexicurity approach to labor market exemplifies; World Bank 2013).

A more dynamic labor market requires better social protection to be both feasible and desirable. Safety nets–including cash

Figure 2 . Total Employment, 1991–2016 (1991=100)



Source: Authors' calculations based on World Bank World Development Indicators.

transfers to the poor and unemployed—are essential to support workers (and their families) who may become displaced or replaced when new technologies are implemented. Evidence from around the world shows that well-targeted and well-designed safety nets make a substantial contribution to the fight against poverty and inequality, both in the long run and in the adjustment to technological and other large shocks (World Bank 2013, 2018).

In the long run, broader redistribution policies—such as better and more inclusive public goods, social insurance at least partly decoupled from traditional wage employment, redistribution of capital market shares, earned-income tax credits, and even a universal basic income—may be desirable to make sure that the technological dividends are spread around the population, making everyone an "owner" of the current and potential technologies (Freeman 2015).

Not less important, educational reform—emphasizing scientific, mathematical, and communicational abilities, as well as softer skills such as perseverance, flexibility, creativity, adaptability, and team work—is crucial to develop the complementary skills that workers need to benefit from all types of machines and technologies. Complementing fundamental education with active labor market policies, workforce training, and other opportunities for lifelong learning can encourage workers to stay engaged and continue to participate in changing labor markets (Card, Kluve, and Weber 2018; OECD 2017).

Having the right skills can transform "replacing" technologies into "enabling" technologies for workers. The "high school movement" in the United States in the early 1900s (which mandated and facilitated children's stay in school until 16 years of age) was a large investment that prepared several generations to benefit from the structural transformation away from farming and the concomitant Second Industrial Revolution. More recently, the share of China's labor force with at least upper secondary education increased from 6 percent to 29 percent from 1980 to 2015. In parallel, the share of the country's labor force with tertiary education increased from 1 percent to more than 12 percent, while the share of employment in the private sector jumped from virtually zero in 1978 to more than 83 percent in 2014. The resulting improvements in human capital and more efficient allocation of labor facilitated effective technological adaptation and economic transformation. It can be considered a key factor behind China's economic success since 1978 (Li et al. 2017).

The main principle underlying these policies is that technologies and markets do not produce outcomes; people and institutions do. The comparison with natural resource wealth is informative: depending on public institutions, it can lead to substantial increase of social welfare or to waste and plutocratic gains.

Conclusion: Race with—not against—the Machine

Keynes' essay on the "Economic Possibilities for Our Grandchildren" was ultimately optimistic, a voice of hope, as the world economy was about to plunge into the Great Depression. He predicted that technological unemployment would be a temporary phenomenon. In the long run, technological innovation would bring about higher incomes and quality of life, including more leisure. Even in light of the challenges brought about by the Fourth Industrial Revolution, this prediction is attainable for the entire population and not only for a privileged few—but only if public institutions promote equality of opportunities, generate an educational system that favors flexible skills and creativity, and use redistribution policies to share the proceeds of technological gains. With proper public institutions, instead of raging or racing against the machine, we can race with the machines toward a better future.

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