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IS THIS TIME DIFFERENT? WHAT HISTORY SAYS ABOUT MACHINES' IMPACT ON JOBS

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Introduction

Throughout history, a familiar story has played out in societies undergoing rapid technological change. On one side, doomsday predictors have warned that laborsaving machines will make jobs obsolete and fuel social unrest. On the other side, utopians have preached a machine-powered era of abundance and leisure. Both sides have always thought that "this time is different" and that the world would never be the same. In a sense, both sides have been right (though not to the extremes predicted). Technological innovation has made workers more productive overall but has also displaced workers and periodically fed social unrest. Importantly, each wave of innovation and adoption has changed the nature of work and the relative value of workers' skills in unique ways.[1]

Like prior generations trying to prepare for an uncertain future, current workers and policymakers are wondering how the rise of computers and robots – which can seemingly beat humans at any task from detecting tumors to driving – will change the nature of work. The stakes are particularly high for older workers, who increasingly need to work until their late 60s to afford to retire. This *brief* is the first of a three-part series investigating the impact of the current wave of automation on the job prospects of older workers. To place this automation wave in context, this *brief* reviews the literature on the effect of laborsaving technology over the past two centuries.[2]

The discussion proceeds as follows. The first section explains how technology expands the economic pie. The second section describes how machines change the level and type of labor that is in demand. The third section focuses on the painful transitions that some workers have faced because of machines, and the fourth section compares the changes taking place today to past waves to assess whether this time is, in fact, different. The final section concludes that changes today, while qualitatively different from the past, are comparable in scope. It seems reasonable to expect that – at least for a few more decades – machines will continue to make some skills more valuable than others without making human skills obsolete.

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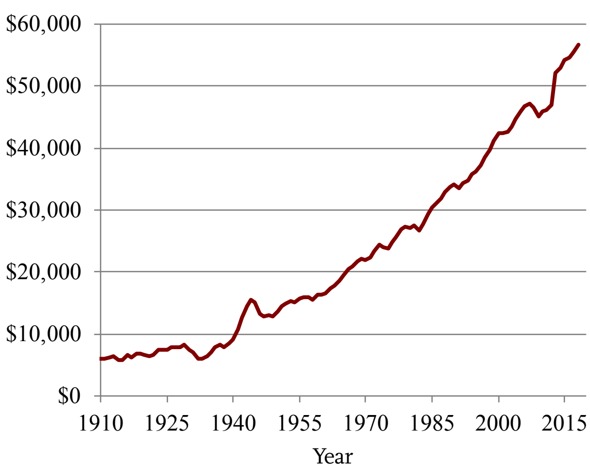
A Bigger Economic Pie

From Stone Age tools to robots, technology – or knowledge that can be used to solve practical problems – has been a powerful force shaping civilization. While technology can have a dark side – like making machines of war more deadly – it has also led to economic abundance. And one of the drivers of abundance has been laborsaving technology (simplified to "machines" in this *brief*). From the power looms of the 1800s and automatic bottling machines of the 1900s to the computerized banking systems in the late 20th century and robotic auto plants of today, machines have dramatically improved living standards (see Figure 1).

Figure 1. U.S. GDP Per Capita, 1909-2018, in 2018 Dollars



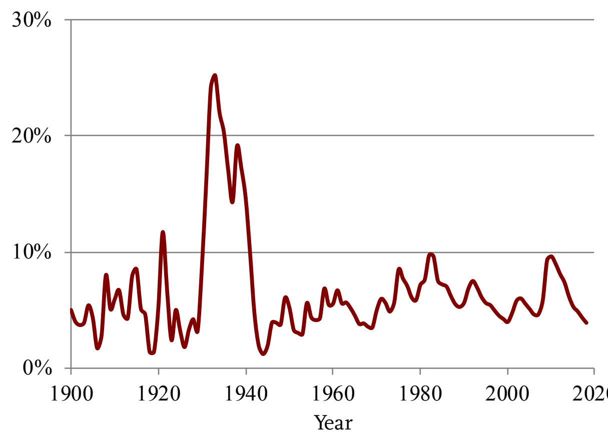
Sources: Authors' calculations from Kendrick (1961); U.S. Bureau of Economic Analysis (2019); and U.S. Census Bureau (2019).

Machines expand the economic pie by increasing total factor productivity, i.e., the amount that can be produced from a given level of inputs. In other words, machines enable people to produce more with less human input, resulting in more goods or leisure time. Importantly, when some of the saved effort is invested in developing new technology, machines can fuel a sustained increase in living standards, as they have over the past 200 years.[3]

A Different Mix of Jobs

A paradox of machines is that, despite all the production they assume, the vast majority of willing workers are still able to find a job in the United States today (see Figure 2).[4] Economists explain this paradox by arguing that, over the long term, businesses take advantage of the skills of the available labor pool to create the most cost-effective production processes. As long as humans can do some things better than machines, they reason, demand for labor will continue to exist.[5]

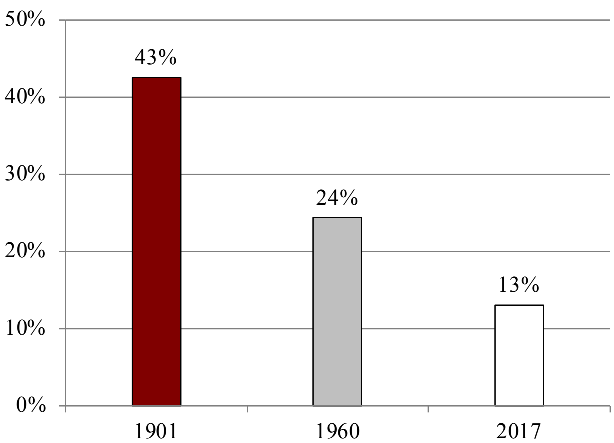
Figure 2. U.S. Unemployment Rate, 1900-2018



Sources: Authors' calculations from U.S. Census Bureau (1975); and U.S. Bureau of Labor Statistics (2019).

Economists have also identified more concrete ways in which machines can add jobs.[6] One way is obvious: machines need to be created, maintained, and operated by humans (think of the lucky tractor operator enviously watched by displaced farm workers in *The Grapes of Wrath*). Less obvious are the jobs created when machines make goods and services cheaper, so consumers can buy more with the same amount of money. For example, people spend less than 15 percent of their budgets on food compared to more than 40 percent in 1901, which leaves more income to buy other items (see Figure 3). Lower prices can also lead to increased demand for labor elsewhere in the production chain – for example, cheaper machine-harvested cotton increased demand for spinners to turn the cotton into fabric in the 1800s.[7] Greater demand for goods, in turn, can increase overall wages by increasing the economy-wide demand for labor, feeding a cycle of increased production, consumption, and income under the right circumstances.[8]

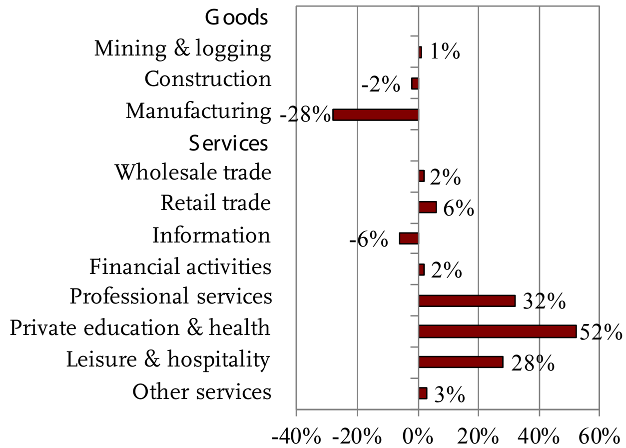
Figure 3. Percentage of Total Expenditures Spent on Food in U.S., 1901, 1960, and 2017



Sources: U.S. Bureau of Labor Statistics (2006, 2018).

Perhaps the most powerful way in which machines can help create jobs is by reducing the cost of innovation in science, technology, and the development of new products and services.[9] Many innovations start out being labor-intensive – for example, early automobiles were crafted by hand and new types of batteries are similarly hand-built today – and become less labor-intensive as production processes become routine, scaled-up, and mechanized.[10] Intuitively, laborsaving machines free up the labor necessary to progress through the early stages of a product's life – if producing food and shelter required all the labor available in an economy, who could spare the time to invent smartphones?[11] This cycle of job destruction and creation has produced a labor force where, over the long run, workers have generally found jobs – albeit jobs that largely did not exist 100 years ago (see Figure 4). However, it is important to note that no economic principle requires job creation to match or exceed job displacement due to automation, especially in the short run.[12]

Figure 4. Change in U.S. Employment since the End of WWII, by Industry



Source: U.S. Bureau of Labor Statistics (2016).

Painful Transitions

While machines have led to a bigger economic pie in the long run and have usually coexisted with a growing market for human labor, they have not always been welcomed. In fact, resistance to machines has been a constant theme; one example is the commonly cited instance of textile makers destroying spinning machines in the 1800s (the Luddites).[13]

Resistance to machines is rooted in workers' anxiety about their job prospects. And a lot is at stake. Workers rely on jobs not only for their economic livelihood – as a way to get their "share of the pie" – but also to fulfill a variety of psychological needs, including a sense of belonging, status, interpersonal contact, and purpose.[14] And machines – by displacing some humans in the production process and changing the nature of jobs not displaced – can threaten both the monetary and psychological rewards from employment.

Once a machine is introduced into a workplace, it immediately reduces the need for some types of human labor, and the workers engaged in that labor can face layoffs. Compared to layoffs driven by competitive pressure or changes in consumer demand, machine-driven layoffs can be especially painful. Since machines can be adopted across industries and occupations, workers can discover that the skills they had invested in are no longer in demand *anywhere.* For example, glassblowers who had spent decades honing their skills found a rapidly shrinking market for such skills in the early 1900s as manufacturers adopted automatic bottle-making machines.

While workers displaced by machines might be able to cope for a while by moving to employers who are late-adopters of the machines, workers ultimately face an unpleasant choice: either invest in skills that command a premium, or compete against a growing pool of unskilled workers for menial jobs. Neither transition is painless. One involves a serious investment in training to enter a new career, often as an entry-level worker. The other involves a loss of financial security and status. Both transitions involve leaving one's existing community of coworkers and creating a community and identity centered around a new occupation, often in another city or region.[15]

By the early 1900s, economists had recognized that several factors determine how much machines could harm workers, including: 1) the rate at which machines displaced vs. created jobs; 2) the types of jobs displaced vs. created; and 3) the ease with which displaced workers could move to new jobs.[16] Two historical periods of rapid machine adoption illustrate how these factors can lead to very different outcomes for workers. In the early 1800s, wages stagnated for over four decades in the United Kingdom (even as per capita income grew dramatically) as craftsmen and cottage-industry workers in the countryside were displaced by machines in the city. Wage growth picked up only after widespread migration from the countryside to cities and after the introduction of compulsory public education (among other factors). While this phase was short-term in the historical sense, a whole generation of workers suffered as the economic, political, and social systems adapted to the industrialization of production. On the other hand, after World War II, even though machines wiped out many jobs in farming in the United States, employment and wages grew steadily due to a seemingly endless demand for new manufactured goods and emerging services.[17]

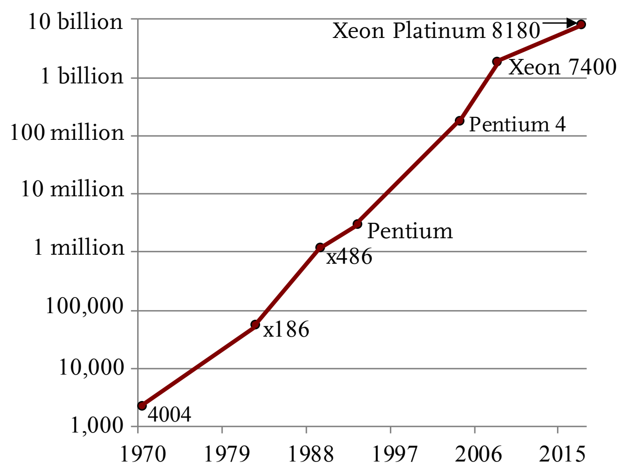
Is This Time Really Different?

Machines have been displacing workers for over 200 years. But, as in the past, many writers today claim this time is different.[18] Their arguments can be summarized as follows: machines are being introduced at an ever-increasing rate and rapidly encroaching on abilities thought to be exclusive to humans. As a result, jobs will be eliminated faster than new ones can be created, and the new jobs will require skills that unemployed workers do not possess. In the long run, machines will be so capable that most humans will have no advantage over them, leading to the end of work as we know it.

Is the Rate of Change Faster?

Those arguing that technology is advancing more rapidly often show graphs of computing power, which has doubled every few years since the introduction of electronic transistors (see Figure 5). Other metrics showing exponential technological growth include increases in spending on research and development and the number of patents awarded.[19] The stock of technology is certainly high today, even compared to periods of rapid industrialization: One study estimates that half of all tasks currently performed by humans could, in theory, be done by machines by 2030.[20]

Figure 5. Number of Transistors per Intel Chip, 1970-2017, Log Scale



Source: Intel (2019).

Invention is just one side of the equation, however; adoption is the other. Just because technology exists does not mean it will be viable. And just because it is viable does not mean it will be immediately adopted. Historically, technology has required extensive trial-and-error and changes in production methods, regulations, or consumer preferences before promised productivity gains have been realized.[21] For example, the cotton gin did not reach its potential until the development of a new breed of cotton more suitable to machine picking.[22]

Unlike the recent growth in the stock of available technology, the rate of adoption has not changed significantly.[23] Job displacement rates, which are affected not just by the rate at which machines are adopted but also their power to displace labor, have also not approached historical highs nor are they projected to do so (see Table 1).[24] If history is a guide, adoption rates, governed by human inertia, vested interests, and institutions, will continue to act as a speed limit in the face of potentially accelerating change.

Table 1. Historical vs. Projected 15-Year Job Loss Rate, by Industry

Industry	Start of 15-year period	Share of economy	Change in full-time employees
Agriculture	1962	4%	-46%
Manufacturing	1995	13	-38
Services (food & lodging)	*2016*	*10*	*-30 (projected)*

Source: Manyika et al. (2017).

Do Today's Machines Pose a Unique Threat?

Some writers argue that the difference this time is the far-reaching abilities of current machines. Computers appear to have an advantage in tasks that require certain *cognitive* abilities – like storing, processing, and transmitting information – while rapidly gaining ground in others – like pattern recognition and prediction (e.g., detecting tumors). If machines become better at tasks that rely on brainpower (having easily eclipsed humans and animals in brawn), will humans have a comparative advantage in *any* domain?[25]

While impossible to dismiss, predictions of the end of work are not new. Karl Marx predicted the end of work as the logical end-state of capitalism over a century ago, and computer scientists in the 1950s (most notably Alan Turing) predicted that machines would be able to carry out any task done by humans. Yet decades later, people are still picking strawberries by hand, and the unemployment rate is under 5 percent. That said, the range of tasks that machines perform has steadily expanded, and they now have the potential to displace workers from any activity that involves executing an explicit set of procedures ("routine work").[26] Even with recent gains in the ability of machines and the exponential rate of growth in their abilities, it is probably safe to assume for the purpose of this series – which focuses on job prospects for older workers – that many traditional types of jobs will continue to exist in the near term.[27]

Conclusion

Since the Industrial Revolution, laborsaving machines have helped generate enormous growth in productivity with widespread benefits for society. As part of this process, machines can require painful short-term transitions as workers displaced by automation scramble to adapt to a changing labor market. Historically, though, workers have eventually learned new skills for jobs in growing industries and most people who wanted a job have found one.

Individuals today may fear that this time will be different due to today's increasingly capable robots that can do a range of activities previously handled by humans, like driving, serving coffee, and detecting cancer.

Against this backdrop, the remaining two *briefs* in this series will look at older workers. One will assess how older workers have fared since 1980. And the other will explore how emerging technologies might affect their job prospects over the next two decades.

Endnotes

1 One way to see history repeat itself is by comparing Barnett (1926), who discusses the introduction of machines like the linotype and automatic bottle-maker, to Forslin, Sarapata, and Whitehall (1979), who describes the introduction of robots in auto-plants, and to a recent report by the National Academies of Sciences, Engineering, and Medicine (2017), which addresses the potential impact of recent advances in information technology. In each period, technology has introduced new goods and services and enhanced the quality of existing ones. This *brief* will focus on the labor-market effects of technology rather than the effect of technology on the quality, cost, or availability of goods and services.

2 While laborsaving machines have been displacing workers since the start of the Industrial Revolution over 200 years ago, studies on the U.S. job-market impact became common only after the 1930s (and these studies continue today). For example, the Work Projects Administration's National Research Projects initiative published over 30 reports analyzing the effect of technology on work starting in the late 1930s (e.g. Gourvitch 1940), and the National Academies of Sciences, Engineering, and Medicine released a report in 2017.

3 See Landes (1969) for a thorough narrative of the Industrial Revolution.

4 Although this outcome has not always been the case (e.g., "Engel's pause" in the United Kingdom during the early 1800s and the Great Depression in the United States during the 1930s).

5 See Acemoglu and Restrepo (2017) for a detailed model.

6 See Autor (2015); Autor and Salomons (2018); and Acemoglu and Restrepo (2019) for more on this topic.

7 Landes (1969).

8 See Landes (1969) for a detailed narrative of the Industrial Revolution from the 1800s to the 1960s for numerous examples of this dynamic.

9 As documented in Acemoglu and Restrepo (2016), from 1980-2010, the introduction and expansion of new tasks and job titles explains about half of employment growth.

10 See Jaffe (2019) for an illustration of this dynamic in play today.

11 Technically, machines increase the accumulation of capital, which can then be invested in developing new products.

12 Shiller (2019).

13 Another example is that, after the introduction of stone-planing machines in the 1920s, stonecutters often refused to work on sites that had introduced these machines (Barnett 1926). Resistance also continues today, with people vandalizing self-driving cars in Arizona (Romero 2018).

14 See (Shiller) 2019 for a poignant description of the broad effects of job displacement.

15 It is important to note that the labor force impact of machines is not predetermined by the nature of the machine. Cultural, economic, and social conditions and institutions such as labor unions can play an important role in how machines affect labor – see Forslin, Sarapata, and Whitehall (1979) for an example of how robots in auto plants had varying impacts on workers in 15 countries.

16 Barnett (1926). See Acemoglu and Restrepo, (2019) for current thinking.

17 Goldin and Katz (2007) highlight the role of education.

18 For example, Ford (2015); Kaplan (2015); Brynjolfsson and McAfee (2014); and Rifkin (1995).

19 The average time from conception to commercialization during 1885-1919 was 37 years; during 1919-1938, it was 24 years; and, during the post-war period, it was 14 years. This metric refers to the gains in cognitive phase, or the interval between basic discovery and the start of commercial development.

20 Manyika et al. (2017).

21 Because introducing machines can be costly and risky, companies have been more likely to invest in them when they are building production capacity to meet new demand or when they are facing competitive pressure (Landes 1969).

22 See Rifkin (1995).

23 Barnett (1926) states, "when machines were widely available, they were implemented widely within 10 years." Manyika et al. (2017) estimate 5-15 years for 50-percent adoption of new technology over the past few decades, with no increase in trend.

24 See Manyika et al. (2017). Acemoglu and Restrepo (2019) argue that job displacement did accelerate in manufacturing over the past decade.

25 The fate of horses after the introduction of the automobile is often cited as an example by those alarmed by automation. But one can take comfort in the fate of dogs and cats, which continue to serve a purpose even after their economic value has become irrelevant.

26 Since many middle-class, white-collar jobs are administrative (i.e., involve carrying out explicit procedures), they have been among the first to be automated. And because those jobs required training, they often paid well enough to support middle-class lifestyles. Over the past 20-30 years, economists have documented a steady erosion of white-collar jobs, with a growing gap between the wages and employment prospects of workers (Autor 2010, 2019).

27 However, the decline in the labor force participation rate among prime-aged unskilled men in particular should be a serious concern (Krause and Sawhill 2017).

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