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WHY ARE THERE STILL SO MANY JOBS? THE HISTORY AND FUTURE OF WORKPLACE AUTOMATION AND ANXIETY

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There have been periodic warnings in the last two centuries that automation and new technology would wipe out large numbers of middle-class jobs. In the early 19th Century, for instance, a group of English textile artisans, known as Luddites, famously protested the automation of textile production by seeking to destroy some of the machines. A century later, concern rose again over "The Automation Jobless," as they were called in the title of a *Time* magazine story of February 24, 1961.[1]

In 1964, President Lyndon B. Johnson even empaneled a Commission on Technology, Automation, and Economic Progress to confront the productivity problem of that period—specifically, that productivity was rising so fast it might outstrip demand for labor. The commission ultimately concluded that automation did not threaten employment, but that didn't permanently close the case.

Employment displacement concerns have recently regained prominence. For instance, in their widely discussed book, The Second Machine Age, MIT scholars Erik Brynjolfsson and Andrew McAfee offer an unsettling picture of the likely effects of automation on employment.[2]

While we can say with certainty that the past two centuries of automation and technological progress have not made human labor obsolete—the employment-to-population ratio actually rose during the 20th-Century, even as women moved from home to market—past interactions between automation and employment cannot fully predict the future. At the same time, there is no fundamental economic law that guarantees every adult will be able to earn a living solely on the basis of sound mind and good character. The emergence of greatly improved computing power, artificial intelligence (AI) and robotics raises the possibility of replacing labor on a scale not previously observed. If this should occur, the primary challenge we will face is one of income distribution: How do we ensure that the largest number of people gain from the surge in productivity?

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POLARIZATION OF THE LABOR MARKET

Automation does, indeed, substitute for labor—as it is typically intended to do. However, automation also *complements* labor, raises output in ways that lead to higher demand for labor, and interacts with adjustments in labor supply. Too often expert commentators tend to overstate the extent of machine substitution for human labor and ignore the strong complementarities between automation and labor that increase productivity, raise earnings and augment demand for labor.

THE PRIMARY CHALLENGE WE WILL FACE IS ONE OF INCOME DISTRIBUTION: HOW DO WE ENSURE THAT THE LARGEST NUMBER OF PEOPLE GAIN FROM THE SURGE IN PRODUCTIVITY?

IN THIS RESEARCH BRIEF

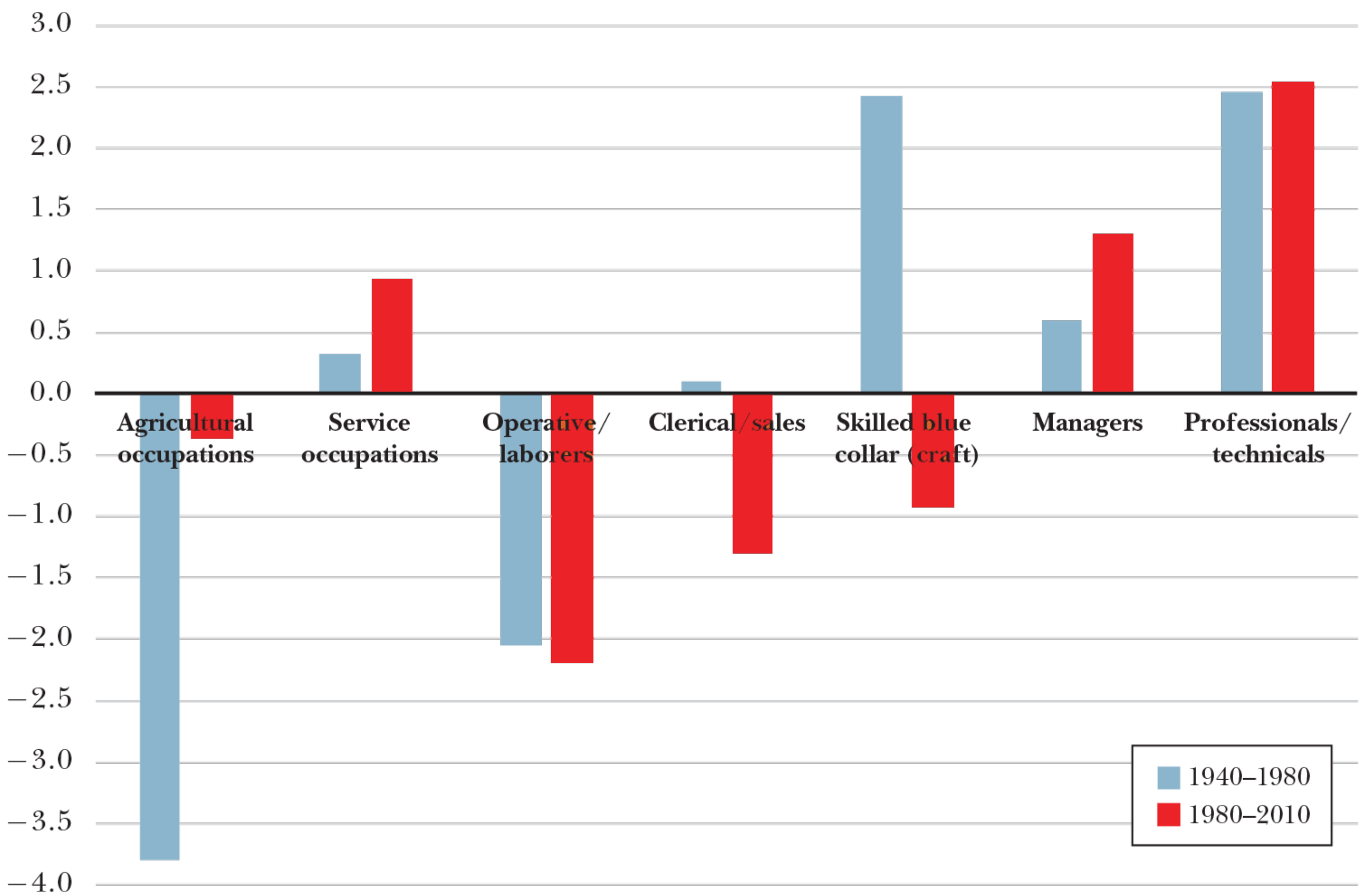
- Automation can complement human labor as well as substitute for it, increasing productivity and spurring labor demand. Focusing only on what is lost misses this complementarity.
- Automation may eliminate large numbers of job tasks yet increase the number of jobs.
- Not all jobs are good jobs. A polarization of the labor market is squeezing out mid-level wage earners and widening the gap between those at the top and those at the bottom.
- The emergence of greatly improved computing power, artificial intelligence (AI) and robotics raises the possibility of replacing labor on a scale not previously observed.
- History suggests that automation is not the enemy of employment. But it may pose a greater challenge for income distribution.

POLARIZATION OF THE LABOR MARKET (CONT.)

Without a doubt, when a computer processes payroll, alphabetizes a list of names, or tabulates the age distribution of residents in a census district, it is replacing a human task. Whether the technology is a tractor, assembly line or spreadsheet, the goal is to substitute mechanical power for human musculature, machine-consistency for human handiwork, and digital calculation for slow and error-prone workers. In particular, it allows computers to substitute for workers in performing routine, codifiable tasks while amplifying the comparative advantage of workers in supplying problem-solving skills, adaptability and creativity. The frontier of automation is rapidly advancing, yet the challenges to substituting machines for workers in tasks requiring flexibility, judgment and common sense remain immense. In many cases, machines both substitute for and complement human labor. Focusing only on what is lost misses a central economic mechanism by which automation affects the demand for labor: raising the value of the tasks that workers uniquely supply.

The biggest change as new technologies emerge is not a reduction in the number of jobs created, but the types of jobs available and what those jobs pay. Reflecting in part the forces of machine substitution for human labor in routine codifiable tasks, there's been a "polarization" of the labor market in which wage gains went disproportionately to those at the top and at the bottom of the income and skill distribution, not to those in the middle.

POLARIZATION IN THE U.S. LABOR MARKET: AVERAGE CHANGE PER DECADE IN OCCUPATIONAL EMPLOYMENT: 1940-1980 AND 1980-2010



Source: Katz and Margo (2014)

COMPLEMENTARY AUTOMATION AND HUMAN WORK

Why hasn't automation already wiped out employment for the vast majority of workers? This is due to an economic reality that is as fundamental as it is overlooked: *Tasks that cannot be substituted by automation are generally complemented by it.* Most work processes draw upon a multifaceted set of inputs—labor and capital; brains and brawn; creativity and rote repetition; technical mastery and intuitive judgment; perspiration and inspiration; adherence to rules and judicious application of discretion. Typically, these inputs each play essential roles; that is, improvements in one do not obviate the need for the other.

Consider the surprising complementarities between information technology (IT) and employment in banking, specifically the experience with automated teller machines (ATMs) documented by Bessen (2015).[3] ATMs were introduced in the 1970s, and their numbers in the U.S. quadrupled to approximately 400,000 between 1995 and 2010. Rather than eliminating bank tellers, their employment actually rose modestly from 500,000 to approximately 550,000 over the 30-year period from 1980 to 2010 (although bank tellers declined as a share of overall U.S. employment).

What are all of these tellers doing? Bessen observes that by reducing the cost of operating a bank branch, ATMs indirectly increased the demand for tellers: the number of tellers per branch fell by more than a third between 1988 and 2004, but the number of urban bank branches rose by more than 40 percent. Secondly, IT enabled a broader range of bank personnel to become involved in "relationship banking," using tellers as salespersons, forging relationships with customers and introducing them to additional bank services like credit cards, loans and investment products.

This example should not be taken as paradigmatic; technological change is not necessarily employment-increasing or Pareto-improving (that is, yielding only winners, with no losers). Three main factors can mitigate or augment IT impact. First, workers are more likely to benefit directly from automation if they supply tasks that are complemented by automation, but not if they primarily (or exclusively) supply tasks that are substituted. A teller who can tally currency but cannot provide relationship banking is unlikely to fare well at a modern bank.

Second, the elasticity of labor supply can mitigate wage gains. If the complementary tasks that workers supply are abundantly available, a flood of new workers could temper any wage gains. This is why significant improvements in the productivity of fast food workers—stemming from advancing technology—don't generally lead to large wage gains.

Third, the output elasticity of demand combined with income elasticity of demand can either dampen or amplify the gains from automation. As people and societies get wealthier, they tend to consume more—food, housing, transportation, entertainment—which generates additional demand. But when productivity is not rising rapidly, goods become more expensive over time (for example, education, healthcare, live performances and handmade crafts).

JOB QUANTITY VS. QUALITY

Although automation does not generally reduce the quantity of jobs, it may greatly affect the quality of available jobs. Following from the observation of scientist and philosopher Michael Polanyi that "we know more than we can tell" (1966), the tasks that have proved most vexing to automate are those demanding flexibility, judgment and common sense—skills that we understand only tacitly.[4] In fact, two broad sets of tasks have proven stubbornly challenging to computerize.

One category includes tasks that require problem-solving capabilities, intuition, creativity and persuasion. These "abstract" tasks are characteristic of professional, technical and managerial occupations. They employ workers with high levels of education and analytical capability, and they place a premium on inductive reasoning, communications and expert mastery. In combination, these forces mean that IT tends to raise earnings in occupations that make intensive use of abstract tasks and among workers who intensively supply them.

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JOB QUANTITY VS. QUALITY (CONT.)

The second broad category includes tasks requiring situational adaptability, visual and language recognition, and in-person interactions—which we call "manual" tasks. Manual tasks are characteristic of food preparation and serving jobs, cleaning and janitorial work, grounds cleaning and maintenance, in-person health assistance, and numerous jobs in security and protective services. These jobs tend to employ workers who are physically adept and, in some cases, able to communicate fluently in spoken language. While these activities are not highly skilled by the standards of the U.S. labor market, they present daunting challenges for automation. The potential supply of workers who can perform these jobs is very large, meaning that rapid employment growth in these jobs does not typically lead to rapid wage growth.

As the price of computing power has fallen, however, computers and their robot cousins have increasingly displaced workers in accomplishing explicit, codifiable tasks. The rapid employment growth in both high- and low-education jobs has substantially reduced the share of employment for "middle-skill" jobs. In 1979, the four middle-skill occupations—sales; office and administrative workers; production workers and operatives--accounted for 60 percent of employment. In 2007, this number was 49 percent, and in 2012, it was 46 percent. The employment share of service occupations was essentially flat between 1959 and 1979, and so their rapid growth since 1980 marks a sharp trend reversal (Autor and Dorn 2013).[5]

THE ROLE OF MACHINE LEARNING ON MIDDLE-SKILLED JOBS

This brief report has emphasized that jobs are made up of many tasks, and that while automation and computerization can substitute for some of them—particularly routine, codifiable tasks—understanding the interaction between technology and employment requires thinking about more than just substitution. With all of its rapid advancements, is computer science on the verge of tackling the remaining barriers to automating 'abstract' and 'manual' tasks as well?

The short answer is no. Engineering and computer science are traversing two paths to automate tasks for which we "do not know the rules:" Environmental control and machine learning. The first regularizes the environment so that comparatively inflexible machines can function semi-autonomously. For example, allowing sightless—and largely senseless—robots to perform effectively on automotive assembly lines.

In the second approach, rather than teach machines rules that we do not understand, engineers develop machines that attempt to infer tacit rules from context, abundant data and applied statistics. This is the field of machine learning, and it is growing rapidly.

Some researchers expect that as computing power rises and training databases grow, the brute-force machine learning approach will meet or exceed human capabilities. Others suspect that machine learning will only "get it right" on average, while missing many of the most important and informative exceptions.

My prediction is that many middle-skill jobs will continue to demand a mixture of tasks from across the skill spectrum. For example, medical support occupations—radiology technicians, phlebotomists, nurse technicians, and others—are a significant and fast-growing category of relatively well-remunerated, middle-skill employment. There are also cases where technology is enabling workers with less esoteric technical mastery to perform additional tasks: for example, nurse practitioners increasingly perform diagnosing and prescribing tasks in lieu of physicians.

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A significant stratum of middle-skill jobs, combining specific vocational skills with foundational middle-skills levels of literacy, numeracy, adaptability, problem solving and common sense, should persist in coming decades. Many of the middle-skill jobs in the future will combine routine technical tasks with the set of non-routine tasks in which workers hold comparative advantage: Interpersonal

This prediction has one obvious catch: the ability of the U.S. education and job-training system (both public and private) to produce workers who will thrive in these middle-skill jobs of the future. In this and other ways, the issue is not that middle-class workers are doomed by automation and technology, but instead that human capital investment must be at the heart of any long-term strategy for producing skills that are complemented by, rather than substituted by, technological change.

What if machines were, in fact, to make human labor superfluous? In that case, we would have vast aggregate wealth but a serious challenge in determining who owns it and how to share it. One might presume that with so much wealth at hand, distribution would be relatively straightforward to resolve. Unfortunately, there is always perceived scarcity and ongoing conflict over distribution, and I do not expect this problem will become any less severe as automation advances.

It's tempting to assume we will soon throw off the yoke of scarcity so that our primary economic challenge becomes one of distribution, but the observations of economist, computer scientist, and Nobel laureate Herbert Simon (1966), who wrote at the time of the automation anxiety of the 1960s, seem astute: "Insofar as they are economic problems at all, the world's problems in this generation and the next are problems of scarcity, not of intolerable abundance. The bogeyman of automation consumes worrying capacity that should be saved for real problems . . ."[6]

A half century on, the evidence favors Simon's view.

REFERENCES

[1]TIME. 1961. "The Automation Jobless." February 24.
[2]Erik Brynjolfsson and Andrew McAfee. 2014. The Second Machine Age: Work, Progress, and Prosperity in a Time of Brilliant Technologies. New York and London: W.W. Norton & Company.
[3]Bessen, James. 2015. "Toil and Technology." Finance and Development 52(1).
[4]Polanyi, Michael. 1966. The Tacit Dimension. New York: Doubleday.
[5]Autor, David H., and David Dorn. 2013. "The Growth of Low-Skill Service Jobs and the Polarization of the US Labor Market." American Economic Review 103(5): 1553–97.
[6]Simon, Herbert. A. 1966. "Automation" (a letter in response to "Where Do We Go From Here?" March 17, 1966 issue) New York Review of Books, May 26.

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