Will Computers Put Us Out of Work?

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Labor markets have adapted to past disruptions caused by technological change. Will they continue to do so?

I n 1996, a world chess champion was defeated by IBM's Deep Blue. Early in 2016 a human master of Go, a game considerably more complex than chess, lost to AlphaGo from Google's DeepMind. As artificial intelligence (AI) improves, some predict that computers will be able to do any human task. The fictitious "steel-driving man" John Henry died competing against his machine replacement. Will computers put us out of work? Opinions differ.

WORK AND TECHNOLOGY

Work has long held a place in the realm of ideas. The Book of Genesis said that humans must work to eat, and the Bhagavad Gita tied work to attainment of potential. More recently, Sigmund Freud considered the drive to work a major facet of human psychology.

Technology has long been tied to work. For millions of years our ancestors hunted, gathered, and fended off the predators that stalked their wanderings. About 10,000 years ago, hunter-gatherer skills declined as agricultural skills grew. With agriculture came a profusion of new occupations in crafts, arts, engineering, and social control. Industrialization began around 300 years ago, once again transforming the world of work. Computing technology in the late 20th century enabled work based on digital information, and might have the same transformative impact.

Capabilities enabled by new technology can threaten older forms of work. Hunter-gatherers gave way to farmers. Firearms in Japan made the samurai obsolete. English textile workers were replaced by machines despite Luddite resistance.

The interconnection of technology and work has been a literary theme for over a century. E.M. Forster's 1909 "The Machine Stops" describes a society whose every need is provided by a computer-like machine. Yevgeny Zamyatin's 1921 *We* depicts a world organized by "scientific management" principles. Kurt Vonnegut's 1952 *Player Piano* describes an automated society that depends more on a giant computer named EPICAC than on humans.

Speculation continues. In 1999, the US National Academy of Sciences predicted that IT would significantly transform work.[1] The World Economic Forum said the same thing in 2016.[2] Jobs define who we are. Most of us are more likely to identify ourselves as, say, "an accountant"

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or "a plumber" than as "a human being." Changes in work can have serious consequences for how we live and what it means to be human.

We address three questions related to computing and jobs.

Will AI eventually do away with jobs? We think not, and explain why.

Will computing impact job quality? Job quality is usually tied to compensation, so this is hard to answer. Some aspects of work might become worse as others improve. Political decisions, such as minimum wage provisions, could affect perceived job quality. In the end, we think it unlikely that computerization will change the quality of jobs.

Will computerization affect labor markets? Here the story gets more complicated. Localized, short-term effects happen often; they're inevitable. Our focus is on less predictable and more severe dislocations that could arise from digital technology's sustained and often exponential price decreases. What might start as small effects could rapidly become significant. Even entrenched industries like film photography and recorded music have been taken by surprise. Nonlinear threshold effects could produce conditions never seen before. The historical pattern is technology change followed by new jobs, so the likelihood of major labor market disruptions might be remote. However, Donald Rumsfeld memorably spoke of "unknown unknowns"—consequences that can't be foreseen. We raise a caution about this, acknowledging that reasonable people (including ourselves) can disagree.

AI AND JOB LOSS
In 1965, Nobel Prize–winning social scientist Herbert Simon wrote in *The Shape of Automation for Men and Management*, "Machines will be capable, within twenty years, of doing any work that a man can do."[3] Five years later, Marvin Minsky, founder of MIT's AI Lab, made a bolder prediction in *Life* magazine: "In from three to eight years we will have a machine with the general intelligence of an average human being … able to read Shakespeare, grease a car, play office politics, tell a joke, and have a fight. At that point, the machine will begin to educate itself with fantastic speed. In a few months, it will be at genius level and a few months after that its powers will be incalculable."[4]

Many AI pioneers reasoned, and still argue, that "super-intelligent" machines will do away with human jobs. If humans are needed for jobs because of what humans can do, human-like machines will replace them. It seems logical—after all, iron horses replaced real horses. However, the argument relies on questionable assumptions.

Many AI predictions have been wildly inflated. In the 1950s, there was hope that perfect machine translation from one natural language (say, Russian) to another (say, English) would arrive within one or two decades. Sixty years on, this hasn't happened. Machine translation, while better than it used to be, proved that human communication through natural language is subtle and sophisticated. It depends on the listeners' intelligence to infer meaning despite frequent errors and ambiguity. Machine translation doesn't eliminate the inferential job. Machine translation might reduce the number of translation jobs—or it might increase the number of such jobs by improving the efficiency of human translators, lowering the cost, and driving up demand. Automated telephone switching systems eliminated hundreds of thousands of telephone operator jobs but led to the creation of jobs designing, installing, and maintaining phone robots that call or answer.

People excited about new technologies often predict rapid change, but they're frequently wrong. Some think that predictable driverless vehicles will soon share the road with unpredictable humans. This is naïve. Driving involves specialized skills, such as handling unforeseen changes in road conditions, interacting with weather, and anticipating what humans will do. The first time a driverless semi squashes a human-driven car there'll be a reset. It will take decades to get all legacy vehicles off the road, and the "right to drive" will become a big issue as soon as someone tries to forbid humans from driving. AI is unlikely to put commercial drivers out of work anytime soon. In fact, the emergence of Uber, Lyft, and similar companies might increase the number of commercial drivers.

Unanticipated breakthroughs do occur—few predicted the impact of social media or the transformation of business operations following Internet commercialization. However, these weren't driven by AI. The deployment of manufacturing robots and the replacement of secretaries by "office automation" have occurred alongside strong job growth. We don't foresee AI advances leading to massive job loss.

COMPUTERIZATION AND JOB QUALITY
The impact of computers on job quality is complicated. Job quality is often conflated with pay. Most people don't want low-paying jobs that require them to toil on a boring and dangerous assembly line or drive a truck for long, lonely hours. However, if highly paid, such jobs become "good." Conversely, some people who aren't paid well, such as clergy who have taken a vow of poverty, enjoy their work. Some unpleasant, dangerous, or special skilled jobs pay more to attract qualified candidates, but there are also low-paying jobs with such characteristics. Enjoyable but

low-paying jobs can be stigmatized in a community that views compensation as an indicator of personal value, or they might not support a family or a comfortable lifestyle.

In addition, regional differences can affect perceptions of jobs. Compensation for distributed work (for example, call center or Amazon Mechanical Turk tasks) is considered good in some underdeveloped regions with grim alternatives. Working as a tour guide might be prestigious in tourism-dependent economies, but less so elsewhere.

Computerization helps people prepare for and find jobs. Some use LinkedIn to identify work skills that are in demand and then acquire those skills. A vast array of YouTube tutorials enables people to develop expertise on a broad range of subjects. General websites such as Monster.com and specialized career sites like Dice.com and TalentZoo.com match individuals to jobs. Companies leverage cloud computing and the Web to deliver specialized goods and services or to expand market share.

If computerization eliminates some jobs, we must ask what kinds of jobs are eliminated. Some people are affected by the loss of relatively low-paying jobs in farming, telephone and bank operations, secretarial and data-entry work, nonunion manufacturing assembly, retail sales, and so on. Elimination of jobs in highly-paid occupations affects different people. As predicted by Harold Leavitt and Thomas Whisler in 1958,[5] centralized decision-making could eliminate white-collar jobs and suppress compensation—or it could improve job quality if the economic gains from higher productivity are distributed equitably.

On balance, we think it unlikely that computerization will have a net negative effect on job quality. It's more likely to make work that is now hard, hazardous, tedious, and exhausting better. It could create new jobs that are more fulfilling, safer, and less physically demanding.

Technology-based productivity could make it possible for many to work less and pursue more leisure or self-enrichment activities, which most people would prefer.

Another concern is that fewer people will find *meaningful* work, work that is central to human identity (a theme of Vonnegut's *Player Piano*). But if computerization is like previous technology changes, it could liberate people to seek the kinds of jobs that are psychologically more rewarding and that Freud lamented as missing in his era.

The historical record is cause for hope. Computerization didn't lead to widespread "deskilling," as some forecast. Predictions that software developers would be displaced by automated programming never materialized; software developers are in high demand. Computerization has been applied to inherently dangerous, unhealthy, or "backbreaking" jobs such as welding and painting manufactured goods, heavy lifting, and farm labor. It has been used in jobs that few humans can do as quickly or well, such as calculating, sorting, and plotting missile trajectories. It can be used for parallel parking, even if driverless cars are uncommon. It has been used to help people work faster and more efficiently (communicating, organizing, ordering, and coordinating). Job quality hasn't declined from computerization, and is unlikely to do so.

COMPUTERIZATION AND LABOR MARKETS

The picture changes somewhat when we broaden our focus to include all aspects of computerization such as automation, and consider labor markets broadly as mechanisms that allocate the resources required for shelter, food, fuel, clothing, and amenities such as entertainment. The labor markets use pricing mechanisms to match individual job skills with job demand. Labor markets traditionally provide most such matching in capitalist economies. The question is

how computerization will affect the function of these markets.

The question is important because stable employment is tied to social stability. Governments intervene in times of crisis to put citizens to work. During the Great Depression, the Works Progress Administration employed over 8 million Americans (more than 10 percent of the labor force).[6] Even undemocratic countries recognize the risks of widespread unemployment. Building pyramids or organizing large armies to invade neighbors have historically been ways to reduce unemployment.

Technology plays a role in labor markets. Agricultural tools such as the plow and axe enabled large-scale food production, economic specialization, and cultural pursuits. Industrial inventions like machine tools and the steam engine brought mass production that resulted in low-cost consumer goods, longer life expectancy, sustained population growth, and improved living standards. These are desirable, but each has long-term consequences: the quest for low-cost consumer goods shifts manufacturing jobs from some countries to others, longer life expectancy affects pension systems and entitlement programs such as Social Security in the US, and improvement in living standards can lead people to expect continued improvement. Emerging information and communication technologies could usher in similar changes and expectations.

Technological changes haven't significantly disrupted labor markets in the past. The world's population has grown from several million to more than seven billion, yet labor markets have always accommodated such changes. Livelihoods have been altered by the shift from agricultural to industrial to postindustrial, yet jobs have remained plentiful.

Nearly 75 percent of Americans were farmers in 1800; that number shrank to less than 3 percent by 2000 as people moved into manufacturing and then into service and other postindustrial jobs.[7] The US population

rose from less than 6 million to more than 280 million, yet, despite periodic downturns, unemployment held steady at about 5 percent.[8] US labor markets thus adapted to both technological change and rapid population growth. Other countries experienced similar trends as they moved up the economic development ladder.

New jobs have replaced those made obsolete by technology. Over the past 20 years, new occupations have emerged: Web designers, digital artists, professional shoppers, Airbnb hoteliers, and many others.

Even as machines grow more capable, the US economy adds jobs. For the past five years the economy has expanded by millions of jobs every year. Computerization hasn't diminished jobs, and even if it did temporarily, money could be found to rebuild infrastructure or engage in other large-scale civic endeavors. However, computerization is uniquely able to affect many economic sectors simultaneously—agriculture, mining, oil and gas extraction, construction, manufacturing, communications, publishing, utilities, education, health, finance, and so on. It's powerful enough to affect both blue- and white-collar work.

Could the number of displaced workers so exceed the number of new jobs that the labor markets reach a tipping point beyond which they can't recover quickly enough to avoid broader social, political, and economic problems? For this to happen, computerization needn't be as intelligent as in the most enthusiastic depictions of AI. Simple automation might suffice. Computerization's effect on jobs might be exacerbated by climate change, resource depletion, wars and civil disturbances, disease outbreaks, refugee movements, recessions, and other events. The issue isn't that this *will* happen, but that it *could* happen. The question is how likely this is.

It seems unlikely given a history in which technology has brought productivity increases and improved quality of life. Negative social effects of industrialization such as urban overcrowding, pollution, squalid living conditions, and child labor exploitation were eventually offset by expansion of the middle class, reduced poverty, increased literacy, easier and cheaper travel, and reductions in malnutrition and chronic disease. Technology that improves the efficiency of labor markets might also help as the unemployed or underemployed use technology to supplement their incomes. Still, the past effectiveness of labor markets doesn't guarantee success in the future. The possibility of a disruptive tipping point is an unknown unknown.

We don't think that AI will eliminate more jobs than it creates, or that computerization will damage the quality of work. However, we wonder how labor markets will respond to automation in combination with economic, social, and environmental factors.

There's good reason to relax. Labor markets are well developed and have dealt with past disruptions effectively. They can benefit from digital technology. We have a collective interest in avoiding massive unemployment, which can lead to crime and insurrection, two forms of work that benefit few.

Nevertheless, disruptions can occur that are different from those in the past, presenting downsides that are hard to plan for. "What if ... ?" encompasses both likelihood and effects. How do we avoid the waste of resources in preparing for a catastrophe that doesn't occur while avoiding the costs if it does? Change seems certain, yet people don't like to imagine major disruptions. Nothing major will happen unless something major happens. Some aspects of how computers will affect jobs will remain unclear until we know more. ▣

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