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Introduction

In the year since SIIA released its issue brief on AI and the Future of Jobs in December 2016, economists, political scientists, educators and policymakers have provided new insights into how AI-systems might change the nature of work.

- Economists Daren Acemoglu and Pascual Restrepo released an empirical study showing that over the last 17 years exposure to robots has decreased employment and wages in local communities and nationwide.2
- The Economic Policy Institute provided a critique of the Acemoglu and Restrepo study and reiterated the evidence that technology as a whole and information technology in particular has had a net positive effect on employment and wages.3
- In a new study, law professor and economist James Bessen demonstrated that in the past new productivity-enhancing technology increased employment in US textiles, steel and automotive industries until these markets became saturated and that today’s computer technology increases employment everywhere except manufacturing.4
- A new OECD report identified three skills (literacy, numeracy and problem solving with computers) that are widely used at work and are an important focus of education, but the researchers found that only 13% of workers now use these skills on a daily basis with a proficiency that is clearly higher than computers.5
- The latest report from McKinsey’s ongoing research finds that about 50% of current work activities are technically automatable, and that 60% of current occupations have more than 30% of activities that are technically automatable by 2030. How much automation actually takes place depends on the economics. The report concludes that “Automation and AI will lift productivity and economic growth, but millions of people worldwide may need to switch occupations or upgrade skills.”6

New policy proposals related to the growth of AI-systems in the workplace have been advanced and old ones refurbished.

- Tech leaders such as Elon Musk have advocated a federal agency to manage the existential risks posed by the possibility of developing superintelligent autonomous AI-systems.
- Tech leaders such as Bill Gates have called for a “robot tax” to slow the introduction of AI into the workplace and allow a longer period for workers and businesses to adapt.
- Several groups, including the Economic Policy Institute and McKinsey Global Institute have renewed calls for investment policies to stimulate growth.
- Others revised and expanded their arguments for more inclusive economic growth, including political scientist Philippe Van Parijs who published a comprehensive review of the case for a universal basic income, which economist Benjamin Friedman succinctly criticized.7
- Thoughtful proposals for education reform have appeared including from Northeastern University President Joseph Aoun who proposed new ways to educate college students to fill needs in a workplace with increasingly sophisticated AI-systems.8
- Industry and policymakers have moved forward with new initiatives to increase skills training for workers in transition, including technical apprenticeship programs.
Congress has been active this year as well. In May 2017, Representatives John Delaney and Pete Olson founded the Congressional AI Caucus and began a series of briefings for Members of Congress and their staff on the implications of this technology for policy. SIIA hosted one session in November on AI and ethics and provided some introductory remarks focusing on AI and work as well as ethical principles for AI. In November, the House Energy and Commerce Committee held a hearing on how algorithms and data use affect consumers.

This SIIA update reviews these developments to provide a current snapshot of the economic, technical and policy discussion related to AI and the future of work. First, we review the background to the issue.

Background

Artificial intelligence refers to any computer system that mimics or surpasses human cognitive activity. Machine learning is a variety of AI that produces results based on examples rather than explicit rules. This general-purpose technology allows computers to learn to perform tasks and keep improving their performance without human programmers needing to provide explicit instructions. In addition to the well-known examples of voice recognition, facial recognition and self-driving cars, these technologies are in use today to improve the cooling efficiency at data centers, detect malware and prevent money laundering, automate insurance claims processing, improve customer support, decide which trades to execute on Wall Street, help make credit decisions, optimize inventory and improve product recommendations to customers, predict whether a user would click on a particular ad, and improve customers’ search and discovery process at online retailer.

This ability to have machines master tasks that require contextual understanding and tacit knowledge means that they can do far more than routine tasks and their impact on the labor market will be more profound than previous computer software. Several years ago, economists Frey and Osborne estimated that 47% of jobs could be automated using these technologies. If these possibilities were realized it would be a substantial shock to the economy. Even the lower OECD estimate of 9%, based on the recognition that within an occupation many workers specialize in tasks that cannot be automated easily, would be enormously disruptive.

Technical possibility does not mean that it will happen. It has to be economically sensible to install intelligent machines to perform the work that was previously performed by people. To take an extreme example, an intelligent machine that can make a salad for $30,000 will never make an appearance in the workplace. These studies are estimates of potential impact, not predictions of what will actually happen.

These potential impacts do not depend on the development of general artificial intelligence, but on the ability of specialized AI-systems to be quickly and inexpensively designed to do specific tasks. As Brynjolfsson and McAfee say about machine learning systems in use or under development, “typically their knowledge does not generalize...We are far from machines that exhibit general intelligence across diverse domains.”

For example, AlphaGo Zero is a new program from DeepMind released in 2017 that illustrates the potential of major impact without providing general intelligence. It surpasses all existing Go playing systems relying solely on a knowledge of the rules of Go and learning derived from playing repeated games against itself. It promises major advances in structured research areas like healthcare and
particle physics. But it is not likely that a system based on such tablula rasa learning will do well outside of contexts that are rigidly structured by precise rules. It will not transfer well to a task such as driving a car. So, this breakthrough is not artificial general intelligence.¹⁷

Policymakers and commenters are concerned that AI-systems and their implementations such as industrial robots will reduce the need for human labor, causing widespread technological unemployment.

History does not validate these fears of technological unemployment. In the past several centuries, technological change has increased overall employment and wages, even though it has reduced employment in specific industries.

There are good economic reasons why increased productivity usually leads to full employment. Technology reduces the amount of labor needed to produce a product or service, which decreases the demand for labor in an industry. This cost saving reduces the price and stimulates demand for that product, resulting in an increase in employment, even a net increase in employment, in the industry producing the product.

By lowering the price of a product, technology puts more money in the hands of consumers. If they don’t buy more of that product, they will look to buy other products or services. This increases demand and employment in these other sectors. More importantly, enterprises take advantage of other technical possibilities to devise new products and services that often need workers with different skills, performing tasks and jobs that previously might have not existed at all. Technological growth in one industry spurs job creation in other industries, and especially in brand new industries.

Historically, the net balance between the old jobs lost in the automating industry and the new jobs created in other industries has always been positive. There is nothing guaranteed about this process and it usually takes place after an adjustment transition, but it has invariably taken place in the past. Wants and needs expand as incomes increase and businesses respond by expanding production to meet these new needs, thereby creating more jobs in the other industries than are destroyed in the old ones.

As technology disrupts one sector, the major social task is to ensure that workers have the skills that match the new jobs demand. The transition from agriculture to manufacturing and service industries that took place in the 20th century illustrates this process. As agricultural work declined, a new generation of workers were trained in the basic skills needed for the new service and manufacturing industries through a system of free public education that produced a workforce able to read, write and calculate. The fit between the output of the educational system and the demands of the new industries meant that employment and wages both increased.¹⁸

But many are worried that this time it might be different. No new technology has been so pervasive and so capable of replacing human labor as AI and machine learning. New jobs will indeed be flung off as the economy adapts to cost reductions from the use of AI. But the vast capabilities of the new machine learning systems create a significant risk that machines will be able to do many of these new tasks more efficiently and for a lower cost than people. There will be new tasks and jobs to be done, but people might not be needed to perform them.

Of course, for the foreseeable future, machine learning systems will not be able to perform all the new tasks. Analysts have identified a range of skills that are for the time being the sole province of humans:
empathy, leadership, social interaction, to name just a few. So, the economy will still need human labor, but perhaps significantly less of it. The disruption to the existing labor market is likely to be substantial.

Policymakers continue to wrestle with the question of how best to manage a transition to an AI-economy where there might be less need for human labor. New studies released in 2017 provide some guidance on this urgent question.

New Research on AI and the Future of Work

Acemoglu and Restrepo on Robots and Jobs

One way to assess how AI might affect employment in the future is to assess how industrial robots have already affected employment and wages. Industrial robots were not in use in the 1980s to any significant degree, but from 1993 to 2007 the stock of robots in the United States and Western Europe increased fourfold. This increase in robot use provides an opportunity to assess the effect of the increase in robot usage on wages and employment.

Acemoglu and Restrepo’s study on robots and jobs suggests that increases in the use of industrial robots have already reduced jobs and wages. They compare employment and wage changes in local labor markets in which a large share of employment is in industries with high robot use with employment and wage changes in other markets with low shares of employment in high-robot-use industries. They find that the increase in robot intensity reduced employment as a percentage of the population by 0.37 percentage points, and decreased average wages by 0.73 percent. These estimates suggest that adding an extra robot per thousand workers to a local labor market will displace 6.2 workers in that area.

The researchers are sensitive to the possibility that the loss of jobs to automation in one area might not mean net job loss for the nation as a whole: “other sectors and occupations might expand to soak up the labor freed from the tasks that are now performed by machines, and productivity improvements due to new machines may even expand employment in affected industries.”

To assess this possibility, they try to measure the economy-wide effects of the introduction of robots into the workplace by seeing whether the reduction in prices caused by the introduction of robots might have stimulated enough demand to produce a more-than-compensating increase in employment and wages in other areas. They find that the countervailing effects of new employment and wage increases from increased demand are real. They reduce the overall negative effects of the introduction of robots. But the overall effect remains negative. The introduction of robots in the US since 1993 has reduced the overall U.S. employment to population ratio by 0.18-0.34 percentage points and average wages by 0.25-0.5 percent. On a national basis, they estimate that one additional robot per thousand workers would decrease employment by 3 to 5.6 workers.

The national estimates suggest that the number of jobs lost due to robots has been small, ranging between 360,000 to 670,000 over a 17-year period.
In short, there is some historical data suggesting that as the number of industrial robots per thousand workers goes up, wages and employment go down for the economy as a whole. Projected into the future, this trend is troubling. All estimates are that the use of industrial robots will continue to grow, from approximately 1.75 million today to 4 to 6 million by 2025.24 In the absence of policy interventions or other countervailing trends in the economy, this increase in the use of industrial robots could mean a decline in aggregate employment and average wages.

**Economic Policy Institute on the Zombie Robot Argument**

Economists at the Economic Policy Institute have long been skeptical of the idea that automation by itself reduces employment and wages. They are much more sympathetic to the idea that declines in labor force participation, increases in wage inequality and declines in average real wages are related to a variety of policy mistakes, including the erosion of the real value of the minimum wage, decline in bargaining power of labor unions, macroeconomic policy more focused on controlling inflation than stimulating growth, regressive tax policy and the harmful aggregate effects of trade and off-shoring of jobs fostered by one-sided trade agreements.25

They reviewed the study by Acemoglu and Restrepo and largely accepted their estimates of the local effects of increased use of industrial robots. But they offered several cogent criticisms. First, they suggest that the aggregation of the effects of robots on local employment into national effects “relies on stylized and largely unrealistic assumptions.”26

They rehearse the standard arguments for the compatibility of automation with full employment:

“...The machinery used to replace human labor must be built and installed, creating jobs. Complementary jobs are created in activities that necessarily accompany the investment, such as programming and maintenance. The main dynamic, however, is that employers deploy automation because it will lower costs, and lowering costs will ultimately lower the prices of the goods and services produced (in addition to raising profits). These lower prices mean that consumers who purchase the less costly goods and services will have income left to purchase other goods and services—unless, of course, consumers run out of things they want to buy, which we doubt. This increase in the demand for other goods and services will create jobs to generate those additional goods and services. Where these jobs will appear is unknowable, but history affirms that they do show up.”27

In particular, local employment and wage losses due to increased robot use cannot be translated directly into national estimates, because much of the increase in jobs and wages just described will take place in areas where robot use is not increasing. A lot depends on how the local estimates are aggregated into national estimates.

The EPI study challenges the aggregation techniques used by Acemoglu and Restrepo, roughly on the grounds that it is unrealistic to assume economic equilibrium and full employment during this period and to omit the institutional effects on employment and wages such as union bargaining power and minimum wages. These criticisms relate to larger issues concerning the best way to model the economy.
A further criticism is that the estimated national effects are small, roughly 40,000 jobs lost each year.\textsuperscript{28} Other factors appear to have a much larger effect on employment. For instance, according to the Acemoglu and Restrepo study itself, a local area with average exposure to imports from China has an employment to population ratio roughly 1 percentage point lower than a local area that is not exposed to China imports, an effect that is about three times as large as the estimated local market effect of 0.37 from use of industrial robots.\textsuperscript{29} Moreover, the robot effect accounts for only a very small part of the total change in the share of the working-age population with a job. The Acemoglu and Restrepo study estimates that at most robots have led to a 0.34 percentage point decline in the employment to population ratio from 1990 to 2007. But the EPI study notes that “from its peak in 2000 to 2016, the prime-age EPOP fell 4.1 percentage points, nearly 12 times the robot effect over the entire 1990–2007 period.”\textsuperscript{30}

Acemoglu accepts this criticism, agreeing that his study should not be interpreted as predicting large declines in overall employment due to increased use of robots. “But the numbers are not that large,” he says, “Even if we have a huge acceleration in the adoption of robots, we are still talking about a few percentage points lower employment in the next several decades.”\textsuperscript{31}

Finally, the EPI study emphasizes that robot investments are just one type of technology investment. Even if they have a negative effect on employment and wages other technology investments might have a positive and larger effect. They point out that Acemoglu and Restrepo themselves find that investments in non-robot technology, including IT and software, are positively correlated with or neutral with respect to employment. As they say, this finding “suggests that other types of capital equipment and even computers tend to increase the demand for labor.”\textsuperscript{32} This finding might mean that while investments in robots can decrease local employment, overall investment in AI-systems might increase employment enough to counterbalance this effect.

**Bessen on Technology and Employment**

**Bank Teller Jobs**

In 2015, Bessen released a study of employment of bank tellers after the introduction of ATMs in the 1970s. It showed that bank teller employment grew in from the 1980s through the early 2010, even as more and more ATMS were installed in branch banks.\textsuperscript{33} The reason was simple. ATMs allowed banks to open branches at a lower cost. Because each bank branch needed fewer tellers, it was cheaper to open a branch bank. So, banks opened more of them. As the number of branch banks increased overall employment of bank tellers increased, even though each branch employed fewer tellers. This chart from Bessen’s work\textsuperscript{34} tells the story:
Recent statistics, however, suggest that this trend of increasing bank teller employment has come to an end. There were 514,520 bank tellers in May 2014. By May 2016, that number had shrunk to 502,700, and the Bureau of Labor Statistics predicts that bank teller jobs will drop to 460,900 by 2026, a decline of 41,700 or 8 percent from 2016 to 2026.

The increase in branch banks drove job growth for tellers, but the number of bank branches has been in decline due to technological change. Online and mobile banking allows customers to handle many transactions traditionally performed by tellers, and even by in-bank ATMs. The industry needs fewer physical branches to serve banking customer needs. As a result, it needs fewer tellers.

Some have suggested that the bank teller story shows that automation does not benefit workers because over time the number of bank tellers eventually decreased. But a recent Bessen study shows that it is a typical pattern for technology introduction since the 1800s to produce an initial burst of new employment in an industry, followed by a decline.
Textiles, Steel and Automotive Manufacturing

Bessen’s new study on automation and jobs shows that technology often increases overall employment in an industry when it is first introduced. The following charts, drawn from his work, show that the number of wage earners in textiles, steel, and automotive manufacturing increased rapidly in the 19th and early 20th centuries following the introduction of more productive machinery into the workplace. This dramatic and rapid increase in both employment and productivity continues until demand for the product no longer ran ahead of improvements in methods of production. Even if technology at first maintains or increases employment, in the long-run it reduces the amount of employment in an industry. As the later stages of the following chart shows, this is what happened to textiles, steel and automotive manufacturing.
These historical studies and the recent example of bank teller employment suggest that technology can be expected sooner or later to improve productivity so much that the affected industry will need less labor. But this is compatible with an overall increase in aggregate employment through the creation of new jobs in other industries. These new jobs however will call for a different mix of skills, putting increased pressure on a nation’s educational system to meet the new skill demands.

McKinsey Report on Jobs Lost and Jobs Gained

The latest study in McKinsey’s series of reports on automation and jobs continues its focuses on the extent to which it is technically feasible to replace a job activity with machine labor.\(^39\) Their previous studies estimated that 50% of current work activities are technically automatable by 2030, but only 5% of occupations could be fully automated.\(^40\) The new study estimates that 60% of current occupations have more than 30% of activities that are technically automatable by 2030. If every hour of work that is automated results in one hour less of work for a full-time equivalent employee, and all technically possible automation is implemented, then the economy will need about 800 million fewer full-time workers world-wide by 2030.\(^41\) In the U.S. demand reduction from this extreme scenario would be the equivalent of 44% of the workforce, or 75 million of the estimated U.S. workforce of 166 million in 2030.\(^42\)

They are aware that technical feasibility is not the whole story and that the actual proportion of work displaced by 2030 will be lower:

While technical feasibility of automation is important, it is not the only factor that will influence the pace and extent of automation adoption. Other factors include the cost of developing and deploying automation solutions for specific uses in the workplace, the labor market dynamics (including quality and quantity of labor and associated wages), the benefits of automation beyond labor substitution, and regulatory and social acceptance.\(^43\)

They do not know how much of this technically feasible automation will be implemented or how fast. So, they construct two edge scenarios and a mid-point. In their mid-point scenario, automation will reduce the need for 400 million workers worldwide. In this scenario for the U.S., reduction of labor demand from automation will be 23% of the workforce, or about 39 million workers.\(^44\)

They find that certain job categories are particularly susceptible to automation:

Activities most susceptible to automation include physical ones in predictable environments, such as operating machinery and preparing fast food. Collecting and processing data are two other categories of activity that can increasingly be done better and faster with machines. This could displace large amounts of labor, for instance in mortgage origination, paralegal work, accounting, and back-office transaction processing.\(^45\)

Other occupations are less susceptible to automation:

Automation will have a lesser effect on jobs that involve managing people, applying expertise, and those involving social interactions, where machines are unable to match human performance for now. Jobs in unpredictable environments—occupations such as gardeners, plumbers, or providers of child- and elder-care—will also generally see less automation by 2030,
because they are difficult to automate technically and often command relatively lower wages, which makes automation a less attractive business proposition.46

This is all on the jobs lost side of the ledger, however. The economy will also generate new jobs. Existing trends allow McKinsey to estimate that expected increases in consumer demand, the need for workers to care for aging populations, and investments in technology, real estate, infrastructure and energy efficiency will increase the number of jobs worldwide by as much as 590 million workers. In the U.S., the trendline scenario means that labor demand will increase by 30 million workers by 2030. If additional investments are made in technology, real estate, infrastructure and energy efficiency and there is an increase in women’s labor force participation, worldwide demand for labor will increase by as much as 890 million.47 In the U.S. this step-up scenario would add an extra 10 million jobs, for a total of around 40 million.

The two scenarios relating to aggregate labor demand (trendline and step-up) intersect with the mid-point and edge case scenarios on the effect of automation on labor demand. If we adopt the extreme assumption that all technically feasible automation is implemented, then worldwide labor demand would drop by 800 million. The trendline scenario of worldwide job creation is 590, which would not compensate for this decline of 800 million and would result net unemployment. However, under the step-up scenario the global economy would create 890 million new jobs, which is enough to cover even the extreme case in which all technically feasible automation takes place. If we adopt the more sensible mid-point assumption of the effect of automation on labor demand, then only 400 million jobs would be lost. The trendline scenario the global economy would create 890 million new jobs; under the step-up scenario, that number would be 890 million. So, under the mid-point assumption of jobs lost, both the trendline and the step-up scenario of job creation produce enough jobs globally to allow workers to shift to new work.

The estimated effects for the U.S., however, are troubling. Under the trendline assumption the U.S. economy will not provide jobs for all workers displaced by automation. In the trendline scenario, 30 million new jobs are created in the U.S. But this will not cover the work displaced by automation under either the mid-point or the extreme scenario. Under the extreme scenario, demand for labor declines by 75 million due to automation; in the mid-point scenario, it declines by 39 million. In addition, an increase in the U.S. population over the next 14 years means that there will be an extra 15 million workers who need jobs. Under the trendline scenario, it does not appear that there will enough jobs for full employment.

Things are better for the U.S. in the step-up scenario. The assumption that we will increase investment beyond the trendline in technology, real estate, infrastructure and energy efficiency and add substantially more women to the labor force implies an increase in labor demand of an additional 10 million workers. This is enough to cover the decline of 39 million in labor demand under the mid-point automation assumption. But it is not enough to cover the 15 million new workers entering the labor market.

If we are to get to full employment in 2030 under the mid-point assumption, we will need to create new types of jobs that currently do not exist. Creation of totally new jobs is a standard element in a dynamic economy with substantial technological change. Jobs such as search engine optimization, for instance, did not exist as recently as a decade ago. McKinsey examines the new jobs that have been created in the past and concludes that typically 8-9 percent of the labor supply will be in new jobs that do not exist at
the time the technology is introduced. If the U.S. economy follows this historical trend, it will create about 15 million new jobs categories by 2030. The 15 million jobs in these new categories will provide the additional jobs the economy needs to find work for the increase in new workers entering the workforce. However, even under this optimistic scenario, the U.S. economy will generate only a total of 55 million new jobs, not enough to provide work for all the 75 million workers displaced by automation under the edge scenario that all technically possible automation will take place.48

McKinsey estimate the net effect at the occupational level of job increases and job losses due to automation under the mid-point automation scenario. Some occupational categories will show net growth:

Across all countries, the categories with the highest percentage job growth net of automation include health-care providers; professionals such as engineers, scientists, accountants, and analysts; IT professionals and other technology specialists; managers and executives, whose work cannot easily be replaced by machines; educators, especially in emerging economies with young populations; and "creatives," a small but growing category of artists, performers, and entertainers who will be in demand as rising incomes create more demand for leisure and recreation. Builders and related professions will also grow, particularly in the step-up scenario that involves higher investment in infrastructure and buildings. Manual and service jobs in unpredictable environments will also grow, such as home health aides and gardeners.49

Other occupational categories will show net declines:

Advanced economies may also see employment declines in occupations that are most susceptible to automation. These include office support occupations, such as record clerks, office assistants, and finance and accounting; some customer interaction jobs, such as hotel and travel workers, cashiers, and food service workers; and a wide range of jobs carried out in predictable settings, such as assembly line workers, dishwashers, food preparation workers, drivers, and agricultural and other equipment operators.50

These net declines and net increases are a good guide for policymakers seeking to adapt our educational and training systems to the needs of a 21st century AI-intensive economy. The excess workers in declining occupations might still find work somewhere in the economy, but they would need to have or develop the skills needed to perform the tasks in the other occupations where there is likely to be growth.

The size of these displacements is potentially large. In the U.S. McKinsey estimates that up to one-third of the 2030 workforce (54 million workers) will need to find work outside their current occupation if all automation proceeds as fast as is technically possible. This would be an enormous challenge even under the assumption of full employment, as displaced workers have to find the available jobs and retrain if necessary. However, as we have seen the U.S. economy will not generate full employment under the edge-scenario that all technically possible automation takes place. In that scenario, no amount of retraining can enable workers to find jobs that are not there.

Things are more manageable under the mid-point scenario of automation adoption. Under that assumption 16 million workers (almost 10% of the 2016 workforce) will need to retrain by 2030. As we have seen, there are enough available jobs to absorb the displaced workers and the increase in new
entrants into the job market. But it will still be an enormous challenge to move 16 million workers from one occupational category to another.\textsuperscript{51} The best way to accomplish it is to focus our educational and training efforts on worker adaptation, which, according to McKinsey, will require “higher educational attainment, or spending more time on activities that require social and emotional skills, creativity, high-level cognitive capabilities and other skills relatively hard to automate.”\textsuperscript{52}

**OECD Study on Computers and Cognitive Skills**

The OECD released a study that has implications for which skills might be valuable in the workplace of the future.\textsuperscript{53} They relied on a survey that assessed the skills of respondents in literacy, numeracy and ability to solve problems involving computers. The survey also asked questions about the use of literacy skills in the workplace. The researchers found that 75% of workers in OECD counties use one or more of these skills in the workplace on a daily basis. The other 25% do not. They consulted with computer experts to assess the current capabilities of computers to answer the questions that are the basis for assessing these skills. Each expert was asked whether a computer could answer the test questions using current computer techniques after a one-year development period costing no more than 1 million dollars. The computer experts projected a pattern of performance for computers in the middle of the adult human proficiency range. Some experts were more optimistic about computer potentials and others were more conservative.

Using a conservative measure of computer capabilities, the OECD found that 44% of workers use one or more of these cognitive skills every day and have a proficiency level above the projected level of computers. 31% have skills that the computers can match and use these skills at work every day. These 31% are at risk of having those parts of their job tasks automated. Using an assessment that is more optimistic about computer capabilities, only 13% of workers exceeded computer skills, while 62% were at the same level as computers and who are therefore at risk.\textsuperscript{54}

This OECD study belongs in the same group of technical feasibility studies as the original Frey and Osborne study that pioneered this approach\textsuperscript{55} and the earlier OECD report on tasks likely to be automated.\textsuperscript{56} The study does not assess whether computers will be developed to match or exceed human performance in these skills in the workplace. But it suggests that there might be strong economic pressure to develop these computer capabilities for workplace application in a process that could take several decades.\textsuperscript{57}

This possibility indicates that teaching these cognitive skills in school as preparation for workplace competence might be misdirected. If computers can replicate low and mid-level cognitive skills in the workplace, then the ability of humans to use these skills in the workplace will become less valuable. Education and training to increase these cognitive skills might simply prepare workers for jobs that are no longer there or jobs where there soon will be an oversupply of workers. The study concludes that “employment prospects for most adults one or two decades from now will increasingly depend on other types of skills.”\textsuperscript{58} Education and training programs should look in other areas of skill development to prepare workers for the coming world of work.
Polices Proposals to Manage the Transition

We might be at the cusp of a new AI-driven industrial revolution, but as economist Tyler Cowen says, that is not exactly comforting. He quotes economic historian Gregory Clark who estimated that English real wages may have fallen about 10 percent from 1770 to 1810, a 40-year period, covering the beginning of the first industrial revolution based on steam and mechanization of textile production. It took 60 to 70 years of transition for English workers to see sustained real wage gains at all. The first industrial revolution was the scene of Blake’s “Dark Satanic Mills,” Dickens depictions of industrial and urban squalor and the popularity of the revolutionary philosophy of Karl Marx and Friedrich Engels. It was a time of sustained economic dislocation and political unrest. Surely, we can do better this time.

In 2017, two tech leaders proposed wrong turns for AI public policy. Bill Gates called for a “robot tax” to slow the introduction of AI into the workplace and allow a longer period for workers and businesses to adapt. Elon Musk called for a federal agency to manage the existential risks posed by the possibility of developing superintelligent autonomous AI-systems. It would be a mistake to adopt either of these policies.

More promising policy proposals have come to the fore in 2017. These public policy initiatives can help to manage the introduction of AI into the workforce in a way that ensures social stability and preserves our values. They fall into four categories:

- Increasing economic growth
- Distributing AI productivity gains more equitably
- Reforming higher education
- Increased skills training

Federal Artificial Intelligence Agency

In July 2017, Elon Musk renewed his call for the federal government to actively regulate AI research. His concern is less with AI’s effect on the future of work and more with its potential to create a “fundamental risk to the existence of human civilization,” justifying “proactive regulation” to make sure that we don’t do something very foolish.

Fears of losing control to machines are not entirely unreasonable, particularly as smart technologies become everyday parts of our lives and specially designed computing systems become more capable, and are used in more fields. They recognize speech and spam, detect fraudulent transactions, select military targets, make educational recommendations, diagnose diseases, drive our cars, and beat humans at chess and Go. Increasingly, they perform jobs that were previously reserved for humans.

But in reality, today’s predictions of imminent human-level intelligence remain as speculative as they were at the dawn of the computer age.

Andrew Moore, Dean of Carnegie Mellon’s School of Computer Science, throws cold water on the potential for self-directed machines, saying, “… no one has any idea how to do that. It’s real science
fiction. It’s like asking researchers to start designing a time machine.”⁶¹ He estimates that “98 percent of AI researchers are currently focused on engineering systems that can help people make better decisions, rather than simulate human consciousness.”⁶²

Cutting-edge companies like IBM are not developing self-directed autonomous systems, saying clearly, “Cognitive systems will not realistically attain consciousness or independent agency. Rather, they will increasingly be embedded in the processes, systems, products, and services by which business and society function – all of which will and should remain within human control.”⁶³

A panel composed of industry and academic experts on AI issued its annual report in September 2016 and warned against regulation of AI as such: “...attempts to regulate “AI” in general would be misguided, since there is no clear definition of AI (it isn’t any one thing), and the risks and considerations are very different in different domains.”⁶⁴

A fear-driven policy approach could significantly slow the development of AI systems that will make our homes and roads safer, cure deadly and costly illnesses, drive economic progress, and lead to many other societal advancements. Government should be looking for ways to promote AI rather than creating regulatory roadblocks.

**Robot Tax**

In February 2017, Bill Gates made headlines by advocating a tax on robots.

“Right now, the human worker who does, say, $50,000 worth of work in a factory, that income is taxed and you get income tax, social security tax, all those things. If a robot comes in to do the same thing, you’d think that we’d tax the robot at a similar level.”⁶⁵

Gates wasn’t clear how this would work. Would the company using the robot pay the tax? The company producing robots? Would the tax be like an income tax based on an imputed income to the robot? And how would “robot” be defined? Is a distributed cognitive computing system like IBM’s Watson a robot because it helps doctors make a diagnosis? Are ATM machines robots because they replace the transactional tasks of bank tellers? Even asking these questions reveals that the idea has a long way to go before it is ready for prime-time consideration by policy makers.

Former U.S. Treasury Secretary attacked the idea of a robot tax.⁶⁶ Why pick on robots? Lots of technologies save labor - from kiosks at airports to automatic teller machines to industrial robots. Why not tax all of them? Some technologies enhance labor, increasing the effectiveness of humans at their jobs, rather than replacing them. AI systems do both. Do we tax both? If just the labor-destroying technologies, how can we tell from the outside which is which? AI also makes products better not just cheaper. Cars were a better product than horses, and autonomous cars will be safer than cars driven by humans. Why do we want to tax improved products? Besides, why do we want to tax, and thereby impede, developments that are making us collectively wealthier? Robot labor increases output – which we should then intelligently and fairly distribute to make everyone better off. Making us collectively poorer does no one any good.

The Financial Times weighed in as well, arguing that there’s no more basis for a robot tax “than there is for taxing the use of Excel spreadsheets, or electric Toasters, or any other labour-saving device. It makes
no sense to penalise technological innovation that raises productivity and creates wealth.”

In the absence of dramatic AI-driven productivity gains, we are likely to stay at the sluggish rate that has prevailed in the last decade. That is why former Chairman of the Council of Economic Advisors Jason Furman said in 2016 that his greatest worry about AI is that “we do not have enough of it” to pull us out of our productivity doldrums. A robot tax moves us away from the productivity gains we need to increase economic growth.

**Investment for Economic Growth**

The 2017 McKinsey report makes it clear that an increase above trendline investment in technology, infrastructure, real estate, and energy efficiency will be needed to ensure that there are enough jobs to provide for workers potentially displaced by AI-driven automation. Their key policy recommendation is for policies to spur robust economic growth:

> Sustaining robust aggregate demand growth is critical to support new job creation, as is support for new business formation and innovation. Fiscal and monetary policies that ensure sufficient aggregate demand, as well as support for business investment and innovation, will be essential. Targeted initiatives in certain sectors could also help, including, for example, increasing investments in infrastructure and energy transitions.

Former economic advisor and Treasury Secretary Larry Summers agrees. He calls for vigorous government policies to foster increased aggregate economic growth, including “major investments in infrastructure.”

The Economic Policy Institute, a labor-oriented think-tank, argues that over the past decades labor market “problems have their roots in intentional policy decisions regarding globalization, collective bargaining, labor standards, and unemployment levels, not technology.” They think the standard remedies for the challenge of automation will not be enough: “the education and training touted as solutions in the mainstream robot narrative will be inadequate, just as they were not adequate to help displaced manufacturing workers over the last few decades.” Instead they advocate for broader macroeconomic and labor market policies, including measures to “maintain genuine full employment” in order to “help ensure that there are good-quality jobs available for workers displaced by technology.”

There is a consensus that a priority for policymakers worried about the effect of AI on jobs is to find the right policy tools to increase the investment that will generate the growth that will generate the needed jobs.

**Policies for More Equitable Growth**

Technology has been reducing the amount of labor needed in the economy for well over a century. Compared to people living a hundred years ago, we work fewer hours per day, fewer days per week and fewer weeks per year. We start work later, take longer vacations and retire earlier. By any measure we have more leisure.

Economic historian Joel Mokyr documents this trend to less labor. The work week in US manufacturing declined from 59.6 hours in 1900 to 50.6 in 1930. During this time, the male labor force participation
rate fell from 87.3 to 78.8 percent among those aged 65–69. Between 1870 and 1998, the number of hours worked per year in developed countries fell by half, and this trend continued since 2000, as hours worked in the OECD countries dropped by an additional 75 hours per year. These reductions in hours worked were accompanied by substantial increases in our standard of living.

This trend should be a cause for rejoicing. If allowed to proceed, the increases in the productive capacity of technology could realize for all something approaching the aristocratic ideal of a meaningful life free of economic necessity.

The problem is not increased leisure. It is the distribution of leisure. As Mokyr says, “If this predicted decline in labor hours worked was spread evenly across the working population, that decline would be a minor concern—particularly with the rise of “quality” leisure.” The problem, says labor lawyer Cynthia Estlund, is that “Declining demand for human labor would likely leave many people not with fewer hours of work (and decent pay) but with no regular paid work at all.”

The decline in labor force participation among working age men has not produced an outbreak of relaxing, enriching leisure but an opioid epidemic fueled by anger, powerlessness, and a loss of self-worth. Leisure with income and social respect is an increase in human welfare. Involuntary unemployment and no income is a recipe for social disaster. The leisure and wealth created by new productive AI-systems must be broadly shared, not concentrated among the few.

What social policies do we need to manage a transition to a potentially less labor-intensive economy in a way that allows for equitable growth? The 2017 McKinsey Report supported various policies to promote more equitable growth:

- We know from history that wages for many occupations can be depressed for some time during workforce transitions. More permanent policies to supplement work incomes might be needed to support aggregate demand and ensure societal fairness. More comprehensive minimum-wage policies, universal basic income, or wage gains tied to productivity growth are all possible solutions being explored.

Policymakers need to be alert to the possibility that support mechanisms of a transitional and perhaps permanent nature might be needed to manage the coming workplace transformation fairly.

In 2017, political scientist Philippe Van Parijs published a comprehensive review of the case for a universal basic income. For him, the basis for a UBI is not as a solution to the workforce transition issues created by AI, but a moral belief that people need freedom from economic necessity to develop their own talents and skills and fulfill their human potential. He also favors cultural change that would allow people to find a sense of purpose and meaning and social worth outside their jobs. He estimates that a full UBI that would accomplish these ethical purposes would cost about $15,000 per year.

Economist Benjamin Friedman succinctly criticized this level of funding as politically and economically infeasible. He also suggested that a UBI at less than the funding it would take to support a person is not worth doing, since a lower UBI would not furnish people with real economic freedom and security. He proposes instead more traditional efforts at partial income support including an earned income tax credit and wage subsidies.
Rethinking of the basic mechanism for distributing work, leisure and income is needed. As economist David Autor has noted one of the major challenges created by the advances in AI and the automation it promises is to break the connection between work and the distribution of the output of work.\textsuperscript{81} If our major method of income distribution is no longer labor scarcity, inevitably we need imaginative new ways of thinking about how to accomplish this essential social function.

**Educational Reform**

An exclusive focus on increasing equitable economic growth is not enough. In the short and mid-term, AI technology has the potential to disrupt labor markets and send people in search of the occupations where tasks cannot yet be accomplished by increasingly intelligent AI-systems. Even if policymakers pursue the right macroeconomic and income support policies, workers will still not be able to find new jobs without the new skills. Today’s students who will be coming onto the job market in the coming decades will need skills very different from today’s workers.

We need major reforms in our educational system to accomplish these goals. That is how we shifted from an agricultural economy to a manufacturing and a service one. In the 20\textsuperscript{th} century, we pioneered the notion of universal education to deal with that enormous transition, and created the world’s most literate and numerate workforce. It was a progressive, far-sighted approach that still pays dividends today.\textsuperscript{82}

But with machines moving up the value chain from muscles and brawn to cognitive and emotional tasks, from routine tasks that can be replaced using old-style “if-then” computer programming to non-routine tasks that can be cheaply and easily performed by machine learning system, we need to do more than teach students the cognitive skills that are increasingly being provided by AI-systems.

In 2017, Northeastern University Chancellor Joseph E. Aoun published his recommendations on how to make higher education “robot-proof.”\textsuperscript{83} His basic theme is that higher education needs to reorient itself from an institution focused on delivering students with a fixed body of knowledge and skills and instead focus fostering what he calls technological literacy. This includes coding, of course. But it also calls for the kind of data literacy that will enable students to understand complex data analysis and its limitations. Most importantly, it requires human literacy including the power to communicate and engage with others and the traditional humanities.

Becoming conversant with the ethical issues raised by AI is an important element in this next educational paradigm. The goal is produce students who excel at some of the things that computers cannot yet do, in particular the divergent thinking that is at the heart of human creativity. Related skills that higher education should impart include critical thinking, to enable students to synthesize information and imagine new applications, systems thinking to combine different realms of thought in a new way, and entrepreneurship - the act of creating value in original ways.

Students will also need cultural agility—a capacity that will enable them to operate deftly in a global milieu and to appreciate the varying understandings and values that people from different cultures bring to an issue or situation.

Current teaching methods overemphasize content delivery. New methods need to turn toward teaching the new literacies and newer broader cognitive capacities. This will involve thematic study across disciplines, project-based learning, and real-world connections. Experiential learning is crucial too,
including internships, co-ops, (where students alternate their classroom learning with sustained, full-time immersion in the professional workplace and then integrate the two), work-study jobs, global experiences, and original research opportunities. The combination of theoretical knowledge that crosses contexts with lived experience is the key. The goal is to master skill that computers have not mastered yet and which they are not likely to be able to do so anytime soon.

**Skills Training**

One way to AI-created wealth more equitably is to make sure that people have the right skills to help create the wealth, so that their wages will be commensurate with the contribution they make to improved output. To do this, we need training and retraining programs designed for a 21St century economy, and substantial industry and government support for these programs.

Economist Acemoglu points out the huge challenge involved in skills training:

“...the biggest adjustment we need to make is in preparing our workforce to work productively with robots. For this, workers need to have skills that are complementary to robots, artificial intelligence and other new technologies, rather than skills that are going to be substitutable and thus easily replaced by machines. But we do not at the moment know exactly what bundles of skills are complements rather than substitutes to technology. How can we expect people in their teens to know this and make investments accordingly?”

Industry is doing its part. In October 2017, Google announced its new initiative called “Grow with Google” where it will spend $1 billion in grants to nonprofits who will train American workers and also help to grow American businesses. This announcement came in Pittsburgh, historic for its center as a manufacturing hub, showing its evolution into a major tech hub in the rust belt, and now a major center for training autonomous vehicles.

The billion dollars in grants will mainly support high-tech jobs in an effort to train workers to meet the skill requirements necessary to fill open jobs. The largest of these grants will be going to Goodwill to help launch Goodwill’s Digital Career Accelerator which will aim to equip more than one million people with digital and technical skills to meet the demands of today’s digital marketplace.

The demand for high-tech skilled workers has spurred other private companies to invest in career and technical education. IBM offers classes and training programs in data analytics, IT security, cloud-computing, coding, and many more skills. Adobe Education also offers similar training courses, workshops, and teaching materials in the creative tech space.

Substantial government support of these initiatives would increase their effectiveness, including a pending measure to reauthorize the Carl D. Perkins Career and Technical Education Act and provide full Federal funding for the educational programs that provide today’s students with the skills they need to succeed in an AI-intensive labor market.

Technical apprenticeships are making a comeback as a way to meet the burgeoning demand for technically literate workers in an age of artificial intelligence. IBM and other tech companies are taking the lead in transforming apprenticeships from a training arrangement for skilled craftsmen to the most efficient way to find the workers to fill the growing number of tech jobs.
Government is doing its part to promote technical apprenticeships. The White House issued an Executive Order expanding apprenticeships in America. In addition, legislation has been introduced providing for new technology apprenticeships that better align workforce upskilling with local and regional demands.

**Conclusion**

AI promises to make Americans more productive at work, lowering prices and improving the quality of the products and services they provide to customers around the world. The new research reviewed in this issue brief suggests that AI’s effect on work will be even more profound than it appeared when we examined this issue last year. Our findings include:

- Robots have already reduced jobs and wages where they have been introduced, an effect that has been reduced but not eliminated by the tendency of productive new technology to stimulate job growth elsewhere in the economy.
- New historical studies confirm that automation will typically increase employment in an industry at first, but then reduce it over time. New statistics show this has happened to bank tellers since the 1970s.
- We now know that it is technically possible to automate more tasks than we previously thought; and computer scientists suggest that computers can perform workplace cognitive tasks of up to 62% of the workforce.
- Jobs might well be available for all even if there is substantial automation in the next 15 years, but a large part of the workforce, perhaps up to one-third, will need to find new occupations.

We have made these transitions before. In 1850, almost 3 of every 5 workers in the United States were involved in agriculture. Today, agricultural employment is 2.5%, with the biggest decline coming during a 40-year period between 1880 and 1920, when the share of agricultural employment dropped 25 percentage points. Since 1960, manufacturing has fallen from 27 percent of total US employment to 9 percent today, due to the combined effects of automation, trade and increased demand for services.

AI promises to bring about equally large transformations of our workforce. Policymakers should be considering now how to manage this transformation of our workforce to provide jobs and good wages for all. With the right policies, we can manage the current AI-transition as well. This issue brief calls for policies to increase equitable growth, reform education and provide adequate skills training.
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