Taxes for Robots:
Automation and the Future of the Labor Market

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Abstract:

In the past there have been many panics caused by technology that ended positively for the economy and society, but is the current wave of technological unemployment caused by robotics and A.I. different? The purpose of this literary review is to evaluate the current wave of technological unemployment in relation to past cases and determine whether the present situation is another transition between dominant sectors of the economy or the beginning of a permanent form of technological unemployment. The results were that there are many aspects of this instance that differentiate it from past cases of technological unemployment. There are two main factors that set the A.I. revolution apart: the different capabilities of the technology and the unfamiliar economic trends that have been created by the technology. The A.I. revolution may lead to a transition of labor into another sector, but numerous factors indicate that there could be some permanent technological unemployment. Changes in government policy will have to be made to help the global economy transition through the A.I. revolution.

1. **Introduction**

Through the advancement of technology, humanity has benefited from healthier, happier, and longer lives. By reducing percent of labor that must be expended on menial tasks, technology allowed labor to specialize in other fields and raised the standard of living in all societies. In the last century, technology has developed at a speed that has never been witnessed before and it is growing exponentially faster each year. Technological advances have also spurred large waves of unemployment and instability in the labor market. Many artisan fabric weavers were put out of business by new textile machines after the Industrial Revolution. Many farm workers were laid off when machines became more efficient at harvesting crops. Automobile factory workers were completely replaced by simple automated robots. Throughout history the same story repeats over and over. New technology arrives, unemployment increases, the economy adapts to changes, and more jobs develop in other sectors. In every case, scholars raised the alarm claiming that this case is different from the last and that action must be taken.

There is another case of economic anxiety caused by technological unemployment gaining popularity today. However, this time the technological unemployment is very different because the technology creating it is very different. In all past cases, technology automated physical tasks. Today, Artificial Intelligence is automating cognitive tasks and in some cases becoming much more efficient than human labor. In the past, new jobs always came along to replace jobs made obsolete by technology, but will this case be the same when technology can replace both physical and cognitive labor? How different is this case of technological unemployment from past cases?

The purpose of this literary review is to evaluate the current wave of technological unemployment in relation to past cases and determine whether the present situation is another transition between dominant sectors of the economy or the beginning of a permanent form of technological unemployment. First, this paper will define the difference between technological unemployment and technophobia. Second, this paper will discuss the old and current labor market theories used to explain technological unemployment, then examine three specific past cases of technological unemployment. Third, this paper will review the latest technologies that are shaping the labor markets currently. Fourth, there is an analysis of three theories of which tasks are most suitable for automation. Fifth, there is a comparison between the trends and characteristics between the three past cases and the current case of technological unemployment. Last, there is a discussion of viable solutions for A.I. automation through government policy.

2. Technophobia

These advances in technology have not always been easily been accepted by the public. Technophobia is the fear or dislike of advanced technology and especially computer (Merriam-Webster, n.d.). These fears are frequently irrational, but some may be a cause for concern. This section will break down various aspects of modern technophobia, including job loss, technological mental dependence, safety, and privacy concerns. Technophobia is not the main focus of this paper, but many technophobic people are concerned about the jobs that technology will automate.

A. Job Loss

Luddites today are more likely to be called technophobes. Like Luddites before them, they fear that technology today will cause another permanent disruption in the labor market. Instead of fighting automated textile machines, they are fighting against advanced technology such as self-driving cars and general purpose A.I. robots. Some fear that technology is getting to the point where it can increasingly replace human capital and it is unclear where the market will expand to supply more jobs. Many low and moderate skilled jobs are in no danger of automation soon. Due to various technology jobs that previously required a college level of education are at risk of being automated. (see Section 6)

B. Dependence

Technophobes also fear that technology will create dependence on technology and a lack of basic skills and knowledge. This is not a new phenomenon. Socrates famously despised writing because he believed that it weakened the minds of his students. He believed that the only method to gain real wisdom was to memorize every scrap of information (Konnikova, 2012). In a way, he was correct. Due to the invention of writing, most people's memories have gotten transferred to written forms. Since the invention of the cell phone, people can barely remember telephone numbers. As the internet becomes more prevalent, memorization becomes progressively less important because all human knowledge is readily available on the internet.

Technophobes are also worried about our dependence on computers and the internet; they are worried about how interwoven technology has become in vital systems like hospitals and transportation. Technophobes fear that society would not be able to function properly if that technology stopped functioning. An electromagnetic pulse bomb could cause a disaster scenario where all electronic systems break down. Society may not be able to adapt because people have forgotten how to do basic things without technology. It is doubtful that many technophobes would recommend everyone start training to hunt and gather again, but there is some reason for concern that technology could break down.

C. Safety

Technophobes are also highly skeptical of new Artificial Intelligence regarding safety. Many people are skeptical of self-driving cars and their safety records. In the mid-2000s many well-known economists thought that self-driving car technology was not going to be fully operational for a long time, but by 2012 Google started testing driving their autonomous vehicles (Brynjolfsson & Mcafee, 2014). Tesla has brought one of the first partially autonomous cars to the consumer market. On their website, Tesla claims that autopilot hardware has been standard in their cars since September 2014. When a Tesla fatally crashed in June of 2016 in Florida, sceptics jumped on it as proof that these machines are not safe yet and that they should not be allowed on the road (Vlasic & Boudette, 2016). One theory for the cause of the accident is that the autopilot sensors did not recognize a white tractor trailer as an object to avoid.

Proponents of self-driving cars would argue that in comparison with human drivers, the self-driving car software is already much safer. A family in Germany was saved from a serious accident by their Tesla's automatic braking system (McCausland & Walters, 2016). Tesla's founder Elon Musk claims that his cars on autopilot are twice as safe as human drivers (Lum and Niedermeyer, 2016). Others claim that autonomous vehicles cause accidents because they follow the rules of the road too closely, but there is not any data to back those claims.

D. Privacy

Some technophobes reject technology because they are worried about data collection and the infringement of their personal privacy. It is very hard to remain anonymous on the internet when Facebook's algorithm can identify any person's face with an account in any pictures posted on their site. That is not including government sponsored surveillance such as the widespread surveillance uncovered by Edward Snowden or the 2016 Investigatory Powers Law passed in Britain that has the most invasive powers of any law passed in Europe or North America (MacAskill, 2016)

An example of how technology can infringe on privacy is new drone surveillance technology. It was originally developed to track terrorists planting car bombs in Iraq, but now it is beginning to spread from war zones to the domestic front. The technology owned by Persistent

Surveillance Systems has been test run in both Juarez, Mexico and Dayton, Ohio. The system works by a drone circling high above the city taking a picture every second. If a crime takes place the police can use the pictures to track where the perpetrator went (Timberg, 2014). Obviously, this raises some major privacy law concerns. The pictures are not very detailed, but if a crime is reported they can track down the suspects. This technology could easily be abused by an oppressive government and that is a very legitimate cause for their concern.

This literary review is focused on the first topic of this section, job loss due to technology. There are many reasons that people are concerned over advances in technology and automation is a legitimate threat to our economic system. Economists researching the effect of A.I. on the labor market have not come to a consensus on the magnitude of the changes that will happen to the economy, but there is consensus that policy will need to put in place to help workers transition to new occupations in the short run.

3. Labor Market Theories

This section will examine the different labor market theories that economists previously used to explain technological unemployment beginning with the Industrial Revolution in Great Britain and ending with the current theory. Past economic theory demonstrates the accuracy and fallibility of economists' predictions for the labor market. Predicting how a labor market will adapt and change is challenging.

In his essay, "Recent Economic Changes", economist David A. Wells (1899) concluded that no matter what the short-term harms of technological advancement are "the ultimate result is an almost immeasurable degree of increased good to mankind" (p. 366). The classical economic theory argues that with advances in technology the cost of production decreases and therefore the prices should decrease leading to higher demand, then the demand of labor increases to match the higher level of production. Technology makes an industry more efficient, therefore businesses can produce more with the same amount of resources and employ more people in the long-run. The effect of technology for the consumers is cheaper products and greater variety. Labor is temporarily inconvenienced, but in the long-run demand for labor returns to its natural level and the increase in marginal productivity of labor means that their wages will increase.

There were many economists that fully embraced technological advancements like David A. Wells or Sir James Steuart (1770). These economists saw technological innovation as a key to a more prosperous future. Other economists were less optimistic; they were concerned that there would not be an increase in labor demand. The father of Keynesian Economics, John Maynard Keynes (1991), predicted that his grandchildren would be working a 15-hour work week because of the advancements in technology. He feared that increases in productivity would make labor progressively less valuable. According to a 2014 Gallup poll 42 percent of American full-time employees work 40 hours a week and 50 percent work more than 40 hours a week (Saad, 2014).

Later in the early 20th century economists like C. E. Dankert (1940) from Dartmouth College argued that technological unemployment was not a major issue in the Industrial Revolution because their markets were responsive to cost changes. The market in the early 20th century was full of competition, but by the 1920s, competition had lessened in American markets. Powerful monopolies were keeping prices stationery and unresponsive to the fall in the cost of production created by advancement in technology, therefore not creating new demand for goods or labor. Manufacturers made record breaking profits due to increased efficiency, but the consumers saw almost no decrease in prices (p. 156-157).

Dankert also argued that government and union involvement in determining wages led to their inflexibility in the early 20th century. In his opinion that kind of interference amplifies the effects of technological unemployment and makes the transition period last longer. In Milton Friedman's calculation of the natural rate of unemployment, there is always some level of technological unemployment (Friedman, 1968). The growth of new jobs is always lagging the advancements in efficiency. As the rate of technological advancement increases in speed it may also lead to larger waves of technological unemployment that the economy must absorb.

One of the main current economic theory of wage determination is as follows: in a perfectly competitive firm, marginal revenue product is the highest amount that a firm can pay in wages. When hiring a new worker, firms must consider how much they are willing to spend on that worker relative to the value of the extra production that workers adds. For example, if a worker can produce 10 more units an hour (marginal physical product) and the units sell for $2 each (price), the firm can pay up to $20 an hour (marginal revenue product) for that hire. The marginal revenue product then determines a firm's demand for labor. According to the market theory of wage determination, wages are then determined by how much available labor (supply) there is and how much the firms demand labor. This theory assumes that the level of technology is constant.

Advances in technology increase the marginal physical product and decrease the cost per unit of output. Depending on the market's competitiveness and demand elasticity, the firm will adjust the level of output. If the market is competitive, prices should decrease and increase demand for goods and services; therefore, the prices of most electronic goods, like computers, decrease over time.

Regarding unemployment, the effects of new technology are evident from previous labor market fluctuations. As workers become more efficient, less labor is required to make the same amount of output. The term "technological unemployment" was coined by John Maynard Keynes in the early 20th century. There were cases of it long before the term was invented. One of the most famous cases being the panic that spawned the Luddite Revolt. The next section will examine three of these past cases of technological unemployment.

In all past cases of technological unemployment, the long run shows that more jobs were created than were lost by advances in technology. This new wave has new factors that have never been seen before and are having new effects on the economy. Some of the short run trends are the same as past cases, but other trends like job market polarization, slow job creation after recent recessions, and the erosion of the link between the increase in productivity and the median wage have never been observed before. These new trends will be addressed later in section 7.

4. **Past Cases of Technological Unemployment**

This section will review three major past cases of technological unemployment and the historical factors leading up to our current situation. The three past cases are the Industrial Revolution of the 1800s, the Technological Farming Revolution of the 1920s, and the Factory Automation Revolution of the 1960s. There are many more cases of technological unemployment throughout history, but these three cases are a few of the most significant in the past 200 years. Older instances of technological unemployment are more difficult to compare with the current economic situation because the fundamental factors of the economies are too incongruous. In section 7, these periods will be compared to find any repeating trends or new occurrences that may suggest whether this latest situation will have long lasting effects on our economy.

A. The Industrial Revolution (1800s)

Towards the end of the Industrial Revolution, new technology created an economic panic. The technology was the textile machine, commonly called a power loom or stocking frame, which began to encroach on jobs. During the Industrial Revolution in England, beginning around the 1760s, many people moved to cities and became dependent on their factory jobs. The automated textile machine put many of these laborers out of work. This new technology had dramatically lessened the number of workers the factories needed to produce the same level of output. Many workers displaced by this change in the labor market were unable to find work in other occupations. A group of textile workers in Nottingham led by General Ned Ludd in 1811 banded together to fight for their jobs and for compensation from the government. They became known as the Luddites. They were soon joined by thousands more workers in cities across the county and started destroying factories that had automated textile machines. Eventually, the government made destroying a textile machine a capital offense and punishable by death with the Frame Breaking Act of 1812. By 1817, the revolts died out after many leaders were exiled to Australia or executed (Sale, 1999).

The Luddite fallacy is a term in economics that comes from a phenomenon of societies panicking over technological unemployment and with the belief that it will lead to long-term structural unemployment. More specifically, the fallacy is the claim that new technology destroys jobs instead of creating new jobs in the long run. People fear that technology will devalue their human capital and eventually replace it. Today, it is apparent that was not the case in past instances, but panics like this persist to this day. When the Luddites revolted, they could not imagine that in 100 years Britain's economy would be mainly service based. The same can be said of modern panics. Economists today cannot tell where the economy will be in 100 years either.

B. Technological Farming Revolution (1920)

The technological unemployment wave of the 1920s was created by the advances made in farming equipment technology such as tractors, planters, harvesters, and cultivators. This modern technology allowed farmers to produce the same amount of output with less farmhands. At the same time as the shrink in the agricultural labor began to increase, there was a recession in the market due to the end of the first world war. Returning troops created a significant increase in supply of labor and there was a delay in labor market reabsorption. Additionally, there was a struggle for control between businesses and their unionized labor. Unions had become very powerful in industries like steel production during the first world war and fearing loss of control over wages they started resisting through strikes. These strikes began to radicalize lead to almost full on class warfare, which was very concerning due to the recently successful Communist Revolution in Russia (Brody, 1965).

All this economic and political turmoil was eventually resolved by a voluntary increase in wages negotiated by then Commerce Secretary Herbert Hoover and an increase in real wages for the average American due to the decrease in prices of commercial goods. Modern technology lead to greater productivity in factories leading to cheaper prices and greater demand, therefore reabsorbing excess labor back into the market with new factory jobs. The high school movement that began in 1910 also helped young unemployed farm hands attain jobs that required more skilled labor and slowly decreased the level income inequality in the United States in the 20th century (Goldin and Katz, 2008).

C. Factory Automation Revolution (1960)

In the Industrial Revolution and the Technological Farming Revolution, technology eliminated agricultural sector and created new occupations in the industrial sector. In the 1960s, the cycle began again, except the economy lost job in the manufacturing center and created jobs in service sector. One clear example of this job transfer from manufacturing to service labor is the automobile manufacturing industry. In 1954, the first industrial robot called the Unimate was invented by George Charles Devol. In 1961, the first Unimate prototype was installed in a GM factory. This innovative technology automated factory jobs that had been stable middle class occupation for decades.

Similarly, to the panic of the 1920s, this increase in technological unemployment coincided with a recession in the economy beginning in 1960 and ending 10 months later in 1961. During this period, media outlets like Times magazine started publicizing the slow growth of unskilled and semiskilled jobs in new service sector jobs (Times Magazine, 1961). In response to rising fear of systemic unemployment, President John F. Kennedy called for a federal job retraining program and signed the Manpower Development and Training Act in 1962 (Kremen, 1974). In the long run, people reskilled and new jobs emerged in the service sector to absorb the excess labor from the shrinking number of manufacturing jobs.

D. The A.I. Revolution (Present)

Today, the transfer of employment from manufacturing to service sector is almost complete. The majority of occupations in the United States are in the service sector (Central Intelligence Agency, 2016). The loss of manufacturing jobs created the “Rust Belt” where there is significantly higher unemployment than the rest of the country (O’Brien, 2016). Unemployed workers in these areas supported Donald Trump because his Presidential campaign focused on populist and nationalistic policies that promised a return of manufacturing jobs to the United States. Trump blames China for “stealing” American jobs, but most jobs America is losing in manufacturing are being automated not outsourced (Muro, 2016).

If the rapid advancement of A.I. technology continues at its current pace, many service sector jobs may be facing automation as well. Robotics and A.I. have the capability to replace jobs that traditionally required a college level of education; that will be discussed in more detail in section 6. Helping unemployed people increase their human capital through education subsidies may help in the short run, but in the long run economists have no idea where the economy is going just like the Luddites.

5. Current Advances in Technology

This section will analyze the numerous ways technology has advanced in recent years and how the differentiate technological revolutions from those in the past. First, there is discussion on the increase in computing power and the impact of the internet and data collection. Second, the digitalization of good and the economic effects of the process are analyzed. Third and finally, the revolution of A.I. and deep learning algorithms is examined. The next section will show how these modern technologies are changing specific job markets.

A. Computing Power

Since the Luddite revolution and even the automation of factories in the 1970s, technology has changed dramatically. Computing power has advanced significantly since their invention in the mid-20th century. One Apple iPhone 5 is 2.7 times more powerful than the Cray-2 supercomputer built in 1985. One of the co-founders of Intel, Gordon Moore, predicted in 1965 that computing power would double every year. This theory has become commonly known as Moore’s law. The trend for increasing computer power is due the shrinking size of computer chips packing computers with more processing power each year. These advances in computing power has allowed computers to perform many tasks that were thought to be too complicated for machines and required humans.

B. The Internet

Soon after the invention of the electronic computer in the 50s, the internet began to develop to connect computers across the Atlantic Ocean. In 2016, about 47 percent of the global population (3.4 billion people) used the internet (Sanou, 2016). The internet makes information easily available and creates a platform to discuss current ideas. The internet has caused some problems such as the proliferation of fake news and propaganda, but overall it has been a positive force by making access to knowledge and tools more universal. The spread of information and analytical tools has made it easier for innovation to come from people all over the world. Even in developing nations, the spread of cheap smartphone and internet access allows more people to contribute to the global discussion and become more educated than may be available to them in their country.

The internet era created an explosion of raw data that researchers and statisticians are scrambling to analyze. After events like the NSA surveillance scandal, data collection has been a source of controversy in media for at least the last decade. The internet and the digitization of many products has allowed companies to collect huge caches of data on our activities. According to their terms of service, Google collects data on web searches, ads clicked, location of users, websites visited, devices used, and IP addresses, as well as personal data about users like date of birth, name, phone number, and country (Google, 2017). All the data collected can be sold and used for a variety of reasons, such as targeted advertising and to track trends across user bases.

Many products on the market now are digital products. Some of the are completely new products, like phone apps or podcasts, and others are old products that have been digitized, like books and music. The internet has made distribution to these products almost zero cost to the producers. For example, video game development companies are very lucrative because after producing the game the only costs are packaging and shipping, and now that the product can be bought completely online the cost of distribution is approaching zero. This trend is completely new and is having some strange effects on the economy; zero cost of production lead to an industry where all goods are the same price and equally available so the most efficient product will gain almost all the market share. For example, no one settles for the second-best app on the App store when they are all the same price. Digitalization of products leads to zero cost of distribution that create winner-take-all distributions. In a winner-take-all distribution, a small number of firms dominate all sales in an industry (Ford, 2015).

C. Deep Learning and A.I.

As mentioned in Section 3, Artificial Intelligence (A.I.) is at the cutting edge of technology right now. In the field of computer science, A.I. is defined as intelligent agents that are devices that can take action to maximize their potential of completing a task by perceiving the environment (Russell & Norvig, 1995). In their book, *The Second Machine Age*, Erik Brynjolfsson and Andrew McAfee (2014) discuss the many ways that artificial intelligence has advanced so rapidly despite Moravec's paradox. Moravec's paradox describes the phenomenon where it is more difficult to program a robot to do a task that requires sensorimotor skills than to program a robot to do a logical task. A logical task is an action that can be defined with rules, such as chess. A sensorimotor task is action that takes movement like walking up a set of stairs. In 1996, IBM's Deep Blue was the first computer to beat the world's best human player at chess. That was more than 20 years ago. Computers have exceeded humans at logical tasks and simple, repetitive tasks for a long time. In recent years, advances in sensorimotor skills rapidly developed as well.

A.I. advanced so much in cognitive and sensorimotor tasks because of an algorithm development program called deep learning. Deep learning lets computers create artificial neural networks and teaches itself to a task. The computer learns by analyzing accurate results and then synthesizing them into a method to get to those results. Deep learning algorithms have been used to detect cancer in MRI scans (Copeland, 2016). Google's Brain Team has made their algorithm deep learning software TensorFlow open sourced. Anyone with an internet connection can download it for free. This is exposing the software to thousands of problems and making it better at solving them every day.

6. Effects on the Labor Market

As we can see, technology has advanced quite a bit and these modern technologies will likely have much larger effects on the labor market than past technological advances. This section will specifically break down the occupations and industries that will be affected by these recent technologies. The factors that determine whether a job will be fully automated, enhanced by technology, or not automated at all will be discussed and analyzed. First, the new factors influencing the labor market must be evaluated, beginning with general purpose robots and then discussing types of tasks that are more at risk of automation.

Just like the general-purpose computer before them, general purpose robots will revolutionize the labor market. A true general purpose robot would have the ability to learn and adapt to any task that it is physically capable of doing. The Baxter robot is one of the first general purpose robots in the market. Baxter can perform tasks on production lines such as packing and unpacking boxes and delicate assembly of a variety of materials. Baxter possesses nowhere near the level of versatility that a human has, but it can perform basic tasks effectively. The absolute minimum price of $25,000 is still relatively high from the perspective of the average business owner, but it is expected to fall as technology advances and there is more competition in the market (Rethink Robotics, 2014). Once the technology becomes cheaper and more efficient it will make more economic sense to substitute general purpose robots for minimum wage workers. Suppose the average American works 40 hours a week and the national minimum wage is $7.25 an hour. In a year that costs a company $13,920, not including the cost of benefits. When a general robot reaches, that price point many jobs will be automated, even if robots are less efficient on an hourly basis. Robots will not need sick days off. Robots will not even need time to sleep. Robots might be less efficient at production per hour, but they can work indefinitely if they are kept properly maintained.

In this paper, routine labor is defined as occupations that have rigid rules and defined systems; so far, these activities have been fairly simple to automate. An example of routine labor would be automobile manufacturing or computer assembly. These tasks are repetitious and do not require any decision making to complete. They are easy to automate because programming a robot to perform the task does not any change due to uncontrolled variables. The robot always performs the action the same way every time. The key difference between structured labor and highly skilled labor is that there is no decision making in the former. Highly skilled labor takes original thought and creative thinking.

David Autor and Daron Acemoglu (2011) of MIT categorized occupations into four overlapping categories. Tasks can be routine or non-routine and cognitive or manual. Autor and Acemoglu predicted that jobs that are routine are most at risk of automation, regardless of if they are manual or cognitive. Therefore, non-routine manual jobs like rule based, structured labor is simple for an algorithm to be programmed to do because computer systems are created with rule based programs. According to their theory, non-routine manual jobs like hair dressing and non-routine cognitive jobs like computer programming will not be automated, while routine jobs like cashiering will be automated. Autor and Acemoglu's data from 2011 shows that many jobs lost to automation were routine labor. Later on in this section, there is an analysis of whether this theory still holds true today. The introduction of deep learning A.I. may make even non-routine tasks vulnerable to automation and non-routine jobs may not be as secure as Autor and Acemoglu expected them to be. Some of their predictions (i.e. all non-routine tasks cannot be automated) have been proven incorrect by advances in technology.

In their paper, “The Future of Employment: How Susceptible are Jobs to Computerisation?”, Carl Frey and Michael Osborne (2015) identified nine factors that they theorized would make an occupation slower to be automated by robots based on current level of technology. The nine variables were finger dexterity, manual dexterity, cramped work space, originality, fine arts, social perceptiveness, negotiation, persuasion, and assisting and caring for others. They analyzed over 700 occupations using data from the US O*NET employment database and identified the skills required and the type of task being performed. Then based on that analysis, they weighted each job based on how much each of the nine factor would slow automation. They concluded that low skill workers will have to transition to jobs that require skills that cannot be automated, i.e. creative thinking and social intelligence.

Another report from the McKinsey Global Institute (2017) found that there are five indicators that predict how quickly an activity can be automated. The first is how technically feasible it is to automate the task; can a machine be invented that can perform that task? The second factor is how much it will cost to development and implement the technology; what are the costs of creating this technology and installing it? Third is the cost of human labor, would it be cheaper to hire a human? Fourth is the economic benefits; how much will this reduce costs and increase productivity and quality? And the final factor is how much time will consumers need to accept the new technology? Some tasks may be technically feasible and financially sensible to automate, but consumers demand human labor.

The McKinsey Global Institute found that tasks that involve predictable physical work, data processing, and data collection are the most technically feasible to automate with current technology. The team also determined that low wage jobs performing those tasks are most at risk. The study also concluded that tasks that require management skills, communication with stakeholders, expertise, were unpredictable, or took place in unpredictable environments were the least likely to be automated with our current level of technology; tasks that require some of these difficult to automate skills or took place in semi unpredictable environments can be partially automated.

The table below summarizes the findings of these reports and categorizes activities by their potential to be fully automated, partially automated, or slow to automate.

Table 1. Comparison of Theories of Task Automation

	Autor & Acemoglu (2011)	**Frey and Osborne (2016)**	**McKinsey Global Institute (2017)**
Complete Automation	● Routine tasks with any level of skill ● Primarily affecting routine manual work and middle skill routine cognitive work	● Routine or nonroutine tasks ● Primarily affecting low skill and low wage work	● Predictable physical work ● Data processing ● Data collection ● Low wage jobs most at risk
Partial Automation	● Jobs with a mixture of routine and nonroutine tasks ● Increases the value of compatible labor	● Tasks that require a low to moderate level of creative or social skills	● Require some skills that are slow to automate ● Semi unpredictable environment or tasks
Slow to Automate	● Non-routine tasks at any level of skill ● Including: truck driving, cleaners, & food preparation	● Tasks that require an elevated level of creative or social skills	● Management ● Communication with stakeholders ● Expertise ● Unpredictable environment or task

A. Fully Automated Jobs

Most labor economists studying automation agree (as shown in the table above) that the jobs most at risk consist of performing tasks that are routine. If the routine tasks are cognitive, they are easier to automate because programming raw data is simpler than programming movement. Automating cognitive, routine tasks would include primarily middle income jobs like tax preparers, paralegals, accountants, and legal assistants. Jobs that are routine but physical are also at risk of automation, but the how quickly it happens depends on environmental factors and how complex the task is. Routine, physical jobs in factories are easily automated because the environment is controlled and constant.

Some service jobs like baristas and cashiers are at risk of being completely automated in the near future because they are low skill and very routine. Self-service checkout machines are becoming more popular at a variety of stores. Developers are hoping that soon we will not even need to check out on machines at all. Customers will register with the store and walk out with an item and automatically pay from their set-up account (Fountain & Jiang, 2016). Baristas and restaurant counter servers are in a similar dilemma as cashiers. At some restaurants like Chili's, patrons can already pay for their meals directly from their tables. Once there is a cost-effective way of automating carrying food from the kitchen to the table, servers will be completely automated.

Another category of job that is at considerable risk of being automated in the new future is any job that consists mostly of driving; this includes jobs like taxi drivers, truck drivers, and bus drivers. The notion that driving jobs will be taken over by self-driving cars in a few decades is not inconceivable. Self-driving cars are much more cost effective than their human counterparts. These cars do not get in accidents as frequently as human drivers, they do not need to sleep or take breaks, and the initial cost is much less than an employee's annual wage. In fact, self-driving taxis by nuTonomy just began operations in Singapore summer of 2016 and days later Uber started a trial program in Pittsburgh (Watts, 2016). On one hand, the automation of driving could fit Acemoglu and Autor’s theory that routine tasks are more suitable for automation because driving is a very rule based task. However, driving could also be defined as a nonroutine task because of the nonroutine environment that the vehicle must navigate.

Once the public becomes more comfortable with self-driving cars, A.I. will automate most public transportation including driving cabs and buses. The starting price of the first self-driving cars will not be an obstacle for companies to automate because the technology is will be affordable. Honda has announced that they will release a car that drives autonomously on the highway for only $20,440 (Stoll, 2016). A self-driving truck is the perfect long haul trucker; it never needs to sleep or take days off. If an autonomous vehicle is fueled and does not need repair it can work indefinitely. A mining company called Rio Tinto in Australia is already utilizing giant self-driving trucks to transport their iron ore out of their mines (Clark, 2015).

Some jobs that require a high level of education are being threatened by automation now as well. Research and organization orientated occupations can easily be automated by clever algorithms because computers are much more efficient at sorting through large quantities of data than humans. The main role of these occupations is to help lawyers find evidence for their cases through a process called discover and organize their findings as well as drafting legal documents. As the world becomes increasingly more digital, more of the discovery process is becoming digital. Paralegals and legal assistants spend the bulk of their time searching through databases and emails looking for evidence. By creating an A.I. with a searching algorithm to filter through results, a computer could do the same amount of work as a paralegal in a fraction of the time. Archivists and bookkeepers are going to be completely automated for the same reasons. Their jobs can be easily automated when the work is digitized.

Due to digitalization, many jobs have been made obsolete because information is so readily available. Jobs in middle management are disappearing because technology has made monitoring employee activity and productivity much easier. The most profitable companies today tend to be technology companies like Apple that need much fewer employees than highly profitable companies in the past like General Motors. This makes middle management even more redundant and inefficient.

However, the automation problem is not only affecting routine jobs. A clear example of this is stock market trading. Trading stock is an activity that requires original thought and decision making, but A.I. stock trading algorithms are gaining popularity professional traders have mostly been replaced by highly programmed computers that trade stock in milliseconds to get the highest returns possible. Automated trading systems can outperform any human in a matter of split seconds (Mamudi & Massa, 2017).

A final example of a high skill, non-routine job now at risk of automation are financial analysts. Financial analyst positions have been automated by software like Kensho that can analyze new data and draw conclusions faster and more accurately than any human. Double-checking the results that the program produces is not even possible because it draws from so many sources of data. David Nadler, the creator of Kensho, predicts that in the next ten years most of the financial analyst positions at Goldman Sachs will be automated by his software

(Popper, 2016).

The McKinsey (2017) research suggests that many stock trading and financial jobs have been automated because the jobs are mostly data analysis and A.I. is more adept at it than humans. However, the A.I. is replacing traditional human expertise that is a skill they stated was difficult to automate. In the future, more jobs will be in risk of this kind of automation, especially if they do not require human interaction.

B. Semi-Automated Jobs

Jobs that will likely only be partially automated in the near future are occupations that require some skills that machines cannot recreate. Tasks that computers and A.I. cannot completely automate jobs require interpersonal skills and creative thinking according to Frey and Osborne (2017). According to the Mckinsey Institute predicted that tasks that require expertise, management, and communication were safe from automation. Tasks that are unpredictable will likely be partially automated.

There are many occupations that have some tasks that can be automated, but a person will still be needed to fully complete the job. In these cases, traditional economic theory, as discussed in the second section, would argue that automation would make employees more productive and lead to an increase in wages. Autor and Acemoglu (2011) agreed in their paper that the demand for workers that could perform complementary non-routine tasks would increase. Other economists, like Daniel and Richard Susskind of Harvard, conclude that technology will lead to professions like doctors and lawyers becoming less skilled, therefore driving down the cost of labor (Susskind, 2016).

Providing health care is not a routine task, but there have been significant strides in technological advances that will probably lead to partial automation. The healthcare sector is one sector where humans probably will not be completely replaced, but it is unclear if the remaining jobs will still be considered high skilled labor. A.I. and automation will probably greatly benefit the care that patients receive. Systems like Watson from IBM are already developing to provide healthcare to people based on data synthesized from millions of medical cases from the Mayo Clinic (IBM, 2015). The hope is that A.I. will be able to make diagnoses more accurate and make use of the most cutting edge medical discoveries at a much cheaper cost to consumers. The mass collection of medical data from patients could advance medical science and make each diagnosis more accurate.

Computer engineers have already made very significant advancements with A.I. in the healthcare. Researchers at Stanford developed a deep learning algorithm that is just as good as dermatologists at detecting skin cancer (Esteva et al, 2017). Google's A.I. software was used to detect warning signs of diabetic blindness in eye scans and the algorithm has proven to be more accurate than ophthalmologists (Gulshan, 2016). Technology can also lessen the manual labor for nurses and nurse's aides. In Japan, robotics companies are developing robots to help care for their increasingly elderly population. Japanese people have the longest life expectancies in the world and a growing need for medical assistants to take care of their aging population. Researchers at Riken-SRK, in collaboration with the Center for Human-Interactive Robot Research have created robots like the Robear. The Robear assists nurses lifting patients gently in and out of bed. (Riken, 2015) This new healthcare technology probably will not lead to the automation of all healthcare jobs because technology cannot replace human interaction, but it will make nurses and doctors more efficient and more accurate.

Writing and natural language skills were thought to be too complicated to program. Most journalists have been through years of university education honing their writing skills and has not been considered a routine task that could be easily automated. A.I. performing nonroutine tasks does not fit Autor and Acemoglu's theory, but does fit with Frey and Osborne's theory and McKinsey's research. To be able to produce writing that analyzes and clearly conveys the findings of gathered data traditionally required high levels of human capital. Nevertheless, some analysts and journalists are currently being replaced by report generating programs like Narrative Science's Quill. Quill is a natural language generating software that can analyze raw data and produce reports that clearly convey the information with a narrative and insightful analysis. It is already being used by news organizations and private industries to produce reports. One of the cofounders of Narrative Science predicts that by 2020, 90 percent of the news could be algorithmically generated by Quill or programs like it (Levy, 2012).

However, not all journalists will be replaced. Journalists will have opportunities to focus on investigative journalism and writing op-eds, that are tasks that require a higher level of creative thinking and interpersonal skills. A.I. will not be able to write about their own personal experiences or have individual style in their writing. Human creativity and interpersonal skills will always remain valuable.

C. Slow to Automate Jobs

Autor, Acemoglu, and McKinsey International theorized that tasks that are unpredictable or are in unpredictable environments are difficult to automate. On the other hand, Frey and

Osborne believe that those tasks can be automated. Driving is an unpredictable task with an unpredictable environment and the technology to automate that task has already been successfully developed. As discussed in section 2, A.I. have become safer drivers than people. In the long run, it appears that only jobs that require a high level of creativity or communication skills will not be automated, but how safe are those jobs? This section will discuss technology that may automate creative and social jobs.

Some occupations that require a high level of creativity are authors of fiction, artists, musicians, actors, scientists, researchers, and inventors. In the words of Elbert Hubbard, "One machine can do the work of fifty ordinary men. No machine can do the work of one extraordinary man." Artists and scientists are very different occupations, but their high levels of creative skills go beyond what computers and A.I. are capable of without full human consciousness. There have been experiments with A.I. that can create music like Emily Howell created at the University of California Santa Cruz (Cope, n.d.). A.I. may be able to recreate the aesthetics of art and the sound of music, but some of the value of art is the meaning behind it and that is completely lost when it is created by a program.

IBM's Watson, when it takes a break from doing taxes and practicing medicine, has also been training in the culinary arts. The supercomputer began learning how to cook in 2012 and in 2014 it developed its own unique BBQ sauce. On their official Tumblr, IBM stated that Watson developed the sauce by "modeled quintillions of recipes based on thousands of ingredient combinations to predict what new tastes people would find surprising and delicious" (IBMLR, 2014).

Some jobs that require a high level of social skills and intuition are therapists, psychiatrists, and managers. There is a branch of research called social robotics that is focused on creating A.I. systems that can communicate with humans and follow social rules. There are already products are the market that are using this technology. Researchers have found that autistic children responded better to therapy from social robots than human therapists (Robins, 2005). Robots4Autism (2017) has created a doll named Milo that helps children with autism learn communication and social skills.

In the long run, are there any jobs that will not be automated by A.I. eventually? There are some jobs like artists and inventors that would be very difficult to automate, but it does appear that majority of tasks that people currently perform in their jobs are susceptible to automation. There are some factors that may slow the adoption of technology in some fields, such as public acceptance or the cost of implementation. The economy may create more jobs that we have not thought of yet like David Autor supposes (2015). The McKinsey Global Institute (2017) found that 51 percent of job tasks at our current level of technology could be automated, but in the long run it will be much higher.

7. Differences and Similarities

This section will outline how some trends and characteristics of the current surge in technological unemployment are just like previous cases, while other effects are completely different from any case before. The four significant technological revolutions examined in this section are the Industrial Revolution, the Technological Farming Revolution, the Factory Automation Revolution, and the A.I. Revolution today. In the table below, the similarities and differences between these cases are summarized. Many of today's fears over technological unemployment are compounded by other types of job insecurity due to factors like immigration, globalization, and income inequality.

Table 2. Comparison of the Trends and Characteristics of Three Past Cases of Technological Unemployment and the Current Case				
	Industrial Revolution (1850-80s)	**Technological Farming Revolution (1920s)**	**Factory Automation Revolution (1960s)**	**Today**
Sector	Textile Manufacturing	Farming	Automobile Manufacturing	Service* and Manufacturing
Income Inequality	Rising	Rising	Falling	Rising
Link Between Productivity and Wages	Strong	Strong	Strong	Weak*
Job Creation After Recessions	n/a	(1920) Up	(1960) Up	(2007) Flat*
Job Market Polarization	No	No	No	Yes*
Strength of Unions	n/a	Strong	Strong	Weak
Distribution Costs	Expensive	Expensive	Cheaper	Cheap or free*
Globalization	Rising	Rising	Rising	Rising
Immigration	Low	High	Low	High

*= new trend that has never been observed previously

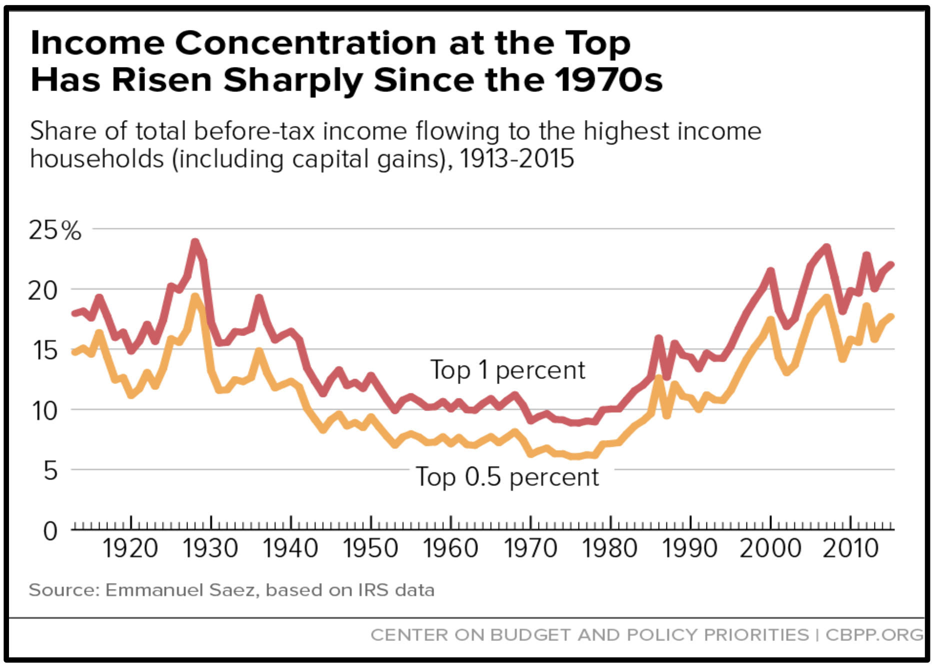
A. Sector

In the past, when an economy was losing jobs due to technological unemployment, it only affected the manufacturing or agricultural sectors. During the Industrial Revolution, the Luddites lost their jobs to weaver machines in the textile manufacturing sector. In the 1920s, American farmhands were replaced by tractors, combine harvesters, and other labor saving technology. Therefore, America lost jobs in the agriculture industry. In the 1960s, labor lost even more jobs in manufacturing because of automation through robotics like the Unimate. In 2017, almost all jobs in agriculture have been automated and jobs in manufacturing are rapidly shrinking. According the CIA Factbook, the agricultural sector contributes 1 percent to the GDP. The industry sector (which includes the manufacturing) contributes 19.4 percent and the Service sector contributes 79.5 percent to total employment (Central Intelligence Agency, 2016). Now a growing segment of service sector jobs are at risk of automation as shown in the previous section.

B. Income Inequality

One commonality between most past cases of technological unemployment and our current crisis, is that they usually occurred during times of massive income inequality. During the Industrial Revolution and the Technological Farming Revolution in the 1920s, there were high levels of concentrated capital ownership at the wealthiest levels of society. Today, we are seeing a resurgence is wealth inequality in developed economies. Economists like Emmanuel Saez (2013) of UC Berkeley agree that income inequality today has reached the same levels seen in the 1920s in the United States. This could be due to several factors including a lowering of restrictions on the financial markets, a cut back on wealth redistribution programs like welfare, and the increasing capital growth rate coupled with the concentration of capital. The exception to this rule is the 1960s. During the decade of the 1960s, there was not much effect felt by that wave of technological unemployment because there was rapid job growth, and income inequality was comparatively low to the rest of the century (illustrated in Figure 2) (Saez, 2013). However, by the end of the 1970s income inequality steadily increased and wages stagnated. The rise in income inequality was partially caused by several trends that are direct of new technology and automation disrupting the economy. These trends caused by modern technology include winner-take-all markets, lower distribution costs, job market polarization, and stagnant wages.

Fig. 1

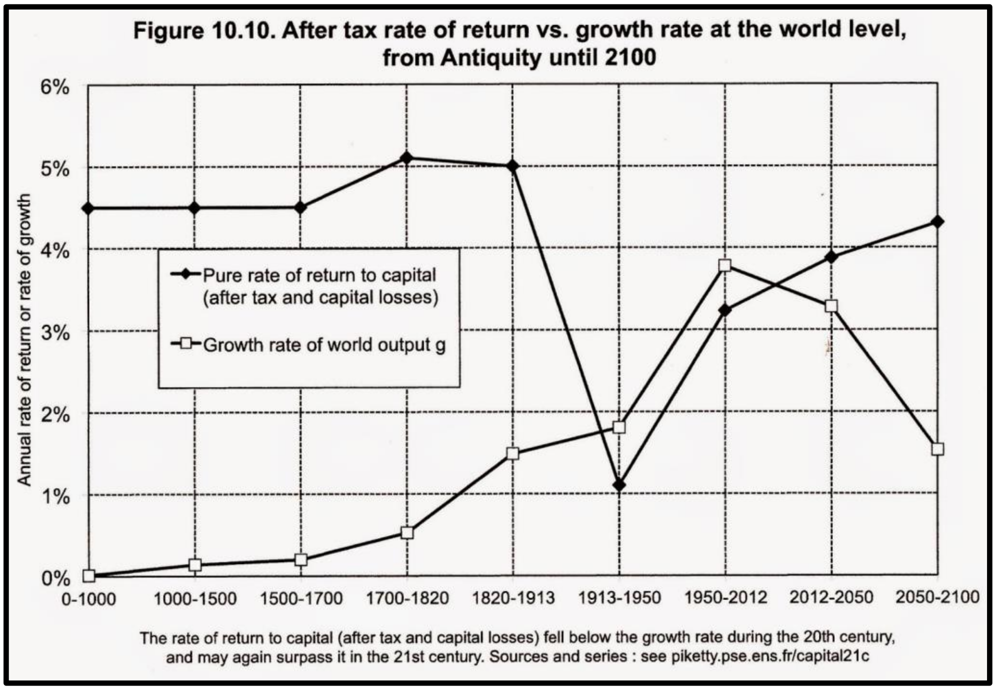


Source: A Guide to Statistics on Historical Trends in Income Inequality by The Center on Budget and Policy Priorities

Some economists like Martin Ford (2015) and James K. Galbraith theorize that financial systems redistribution of wealth back to the wealthiest. Studies have found a correlation between the rise of financial systems and increases in income inequality (Galbraith, 2012). Thomas Piketty (2014) discovered that before the 20th century there was always growing income disparity between the rich capital owner and poor laborers in the west because return on capital was greater than the GDP growth rate. Piketty believes that economic inequality is the natural state of a capitalist economy and that the emergence of the super-rich in the 21st century is a return to that natural state. Figure 3 shows how large the gap between return on capital and GDP growth was in the past and how it is predicted to widen in the future if policy remain the same. If Piketty is correct, the concentration of capital will become an even more significant problem if that capital (i.e. robots) can replace most human labor. A study from the Economic Policy Institute indicated that the stagnation in wages is another cause for the rise in income inequality (Bivens, 2015).

Another popular explanation for the increase in income inequality is the growing wage gap between people with various levels of education. From approximately 1980 to 2000, there was a massive increase in wage premiums for labor with a higher education. However, from 2000 to 2015, that rate of wage premium growth has fallen and eventually levelled off at a constant rate. The increase in wages for labor with higher education is widely attributed to skill biased technological change. A paper by Robert Valletta (2016) at Federal Reserve Bank of San Francisco concludes that if the slow growth in wage premium for higher education continues it could suggest that human capital is no longer the driving engine of developed economies.

Fig. 2



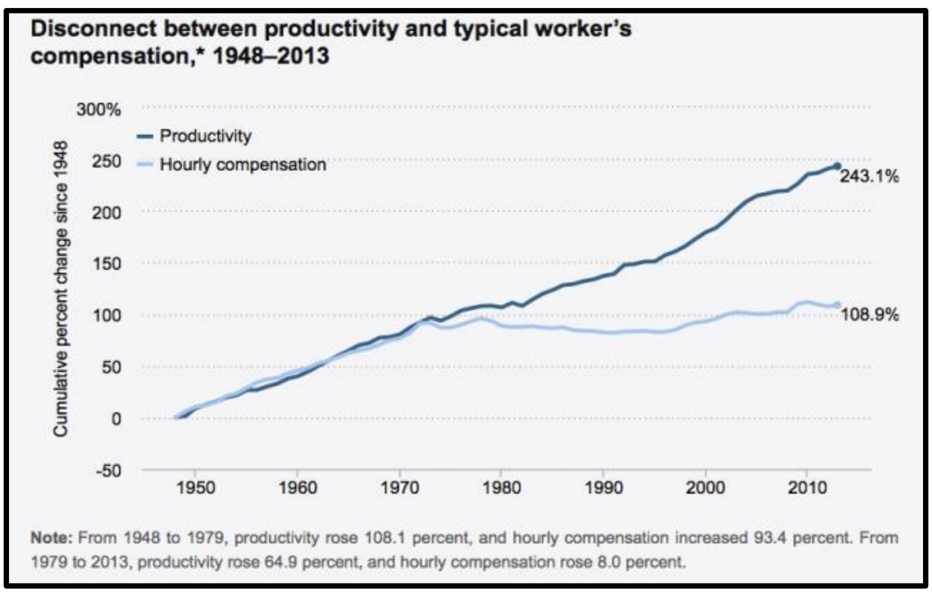
Source: Capital in the Twenty First Century by Thomas Piketty

C. Link Between Productivity and Wages

One of the most significant differences between the last cases of technological unemployment and our current situation is that the link between increasing productivity and increasing wages has been destroyed. A common assumption in many economic theories is that the percentage of a country's GDP that is given to labor in the form of wages is constant. It is the basis for many early economic theories like that of David A. Wells or Sir James Steuart, as discussed in section 3. When productivity increases, wages will increase in the long run. That assumption is called Bowley's Law and the data shows that it is not true anymore (Kramer, 2011).

In the all three of the prior cases of technological unemployment, there was a clear link between increases in productivity and increases in wages, but this time is different. Beginning in the 1970s, the increase in productivity and GDP created by technology, such as automation, has not lead to an increase in wages (illustrated in Figure 4). Some reasons that have been cited as causes of wage stagnation are global trade, the falling tax rate on the top earners, the deregulation of the financial market, the declining power of unions, and the lack of job creation after recessions due to fiscal austerity (Mishel, 2015). The lack of job creation, especially after the most recent recession in 2008, was caused by modern technology.

Fig. 3



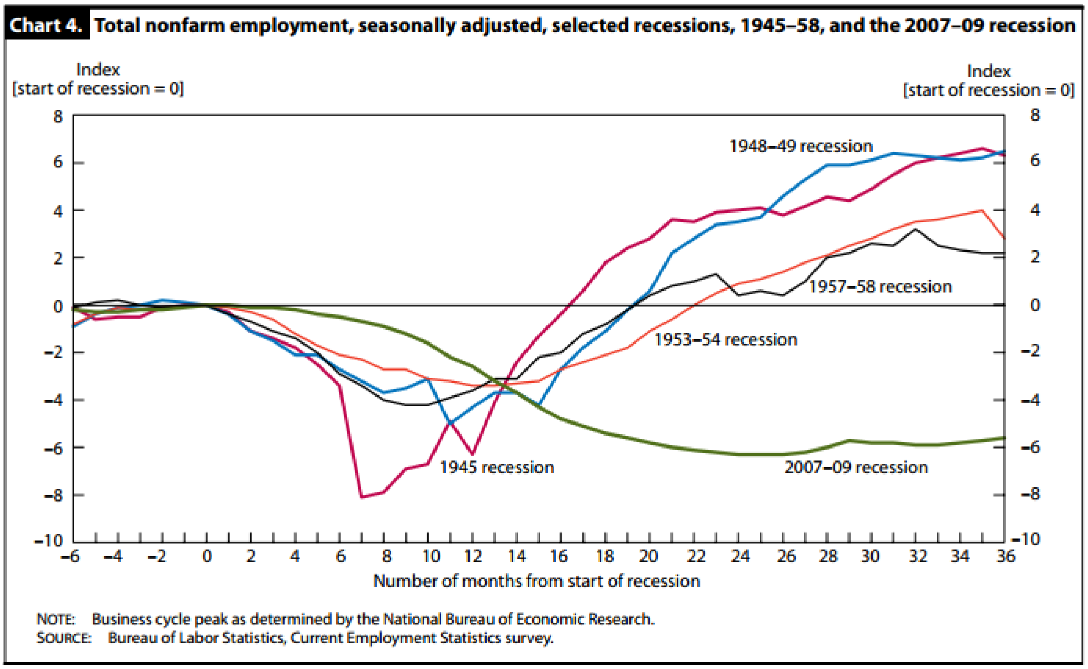
Source: Why America's Workers Need Faster Wage Growth- and What We Can Do About It by Elise Gould from the Economic Policy Institute

D. Job Creation After Recessions

Both the 1920s and 1960s began with economic recessions. As discussed in section 4, the 1920s began with a recession caused by the market's reaction to the end of World War I and the recovery lead to the Roaring Twenties and an age of great prosperity. The recession in the 1960s was a reaction to the shrinking American manufacturing sector and the recovery was the second longest expansion in American history (National Bureau of Economic Research, n.d.). Both these recessions were followed by periods of massive job creation. After the early 2000s recession and the Great Recession, there were jobless economic recoveries. The Great Recession began in December 2007 and it took the economy 7 years and 8 months to return to an unemployment rate of 5 percent. The data shows that the number of months required for the unemployment rate to return to the natural rate of unemployment has been increasing after every recession (Bureau of Labor Statistics, 2017). Figure 5 compares monthly job growth after the economic recessions from 1945 to 1958 to the monthly job growth from 2007 to 2009 after the Great Recession.

This lack of adequate job creation could be the result of many factors including automation and globalization. During the recessions, firms automated to save money and when the economy recovered, companies realized they did not need as many workers as before to have the same level of production. By investing in technology, firms are discovering that they can downsize their labor force significantly and make the few workers they need ultra-efficient. The jobs that were created were only in industries that required college degrees. A study from Georgetown University discovered that the majority of jobs created after the 2007 recession required at least Bachelor's degree and that the number of low skill jobs has been shrinking (Carnevale, Jayasundera, and Gulish, 2016).

Fig. 4



Source: Employment loss and the 2007–09 recession: an overview, by Christopher J. Goodman and Steven M. Mance

E. Unionization

Unionization began in America in the 1920s and gained popularity in the 1930s. By the 1960s, unions were fully entrenched in the US labor force. In 1964, about 29 percent of salary workers were members of unions (Hirsch, Macpherson, & Vroman, 2001). When factory automation was introduced, manufacturing firms threatened their unions with complete automation in an effort to pressure them for lower wages (Barbash, 1976). Eventually those factories did become completely automated by robots like the Unimate. Unions have steadily been losing membership since 1983.

In 2000, only about 14% of salary workers in the US were members of unions and most of the members worked in the public sector (Hirsch et al., 2001) According to the Bureau of Labor Statistics, nonunion members only earn 80 percent of what union members earn in the same industry (Dunn & Walker, 2016). Economists like C. E. Dankert (1940) would argue that the decline in unions is a positive development because they artificially increase wages and increase the amount of time required for the economy to expand again. Economists like Paul Krugman (2009) partially blame the above global average rise of income inequality in the US to the weakening of unions. Krugman's theory is since other countries that did not have political action unionization, like Canada and the countries of the EU, have not had as drastic increases in income inequality. Unions are effective at decreasing income inequality, but in the long run they are not effective for preventing automation.

F. Job Market Polarization

In the current situation, jobs that are most at risk of automation tend to be middle class jobs. As seen in Section 6, the jobs most at risk of automation at the current level of technology are routine, cognitive tasks that are usually middle class occupations like tax preparers and legal assistants. When these jobs are automated or outsourced it will create an unbalanced economy in which the only jobs available are high skill, high paying jobs at the top and low skill, low paying jobs at the bottom. The phenomenon is called job market polarization and it is already impacting the global economy. David Autor and Daron Acemoglu (2011) found that job loss in mid-range jobs has been rapidly increasing in the last decade. Autor and Acemoglu believed that the main causes of job market polarization were skill-biased technological change and outsourcing.

Job market polarization is a wholly new problem in our economy. After the three previous cases of technological unemployment, jobs that remained had higher wages because of increases in productivity and there was quick job growth. Now that the link between wage and GDP growth has been eroded and job growth is stagnant, America's economy is losing many middle-class jobs and the government has to develop wholly new strategies to deal with this problem.

G. Movement of Capital and Ideas

In all past cases of technological unemployment, the movement of capital and ideas was much more expensive and time consuming than it is today. The internet has changed the economy completely in this aspect because time and location have much less effect on economic decisions. Digitalization of goods and services is completely transforming some industries by bringing the cost of distribution down to almost nothing. For example, programs like Turbotax can be bought online and downloaded immediately. Before programs like Turbotax were invented, consumers' only option was to go to a trained tax preparer if they wanted help filing taxes.

When a good or service is available at zero distribution cost to the consumer, that has a strange effect on a market. According to economists Roy Jones and Haim Mendelson (2011), digital good producers have a huge cost advantage over rivals because of economies of scale; that allows them to have huge profits and still beat their competitors on price. Digitization is creating winner-take-all markets, that was originally used to describe trends like extremely large CEO paychecks but also describes the effects of digitalization (Frank & Cook,1995). The winner-take-all effect becomes more powerful when there are network effects, like on social media sites. By decreasing the number of firms successful in digital markets, this new phenomenon seems to be decreasing the already small number of jobs that can be created through digitalization and increases income inequality further (Brynjolfsson et al., 2014).

H. Globalization

Globalization issues have been a consistent theme in cases of technological unemployment dating all the way back to the Luddites. There has always been trade between nation states, but the Industrial Revolution was when global trade networks fully began to change the market. When job creation falls, the public tends to favor protectionist policies and disregard the benefits of global trade. During the Great Depression, the Smoot-Hawley Tariff was signed to protect American jobs from global trade.

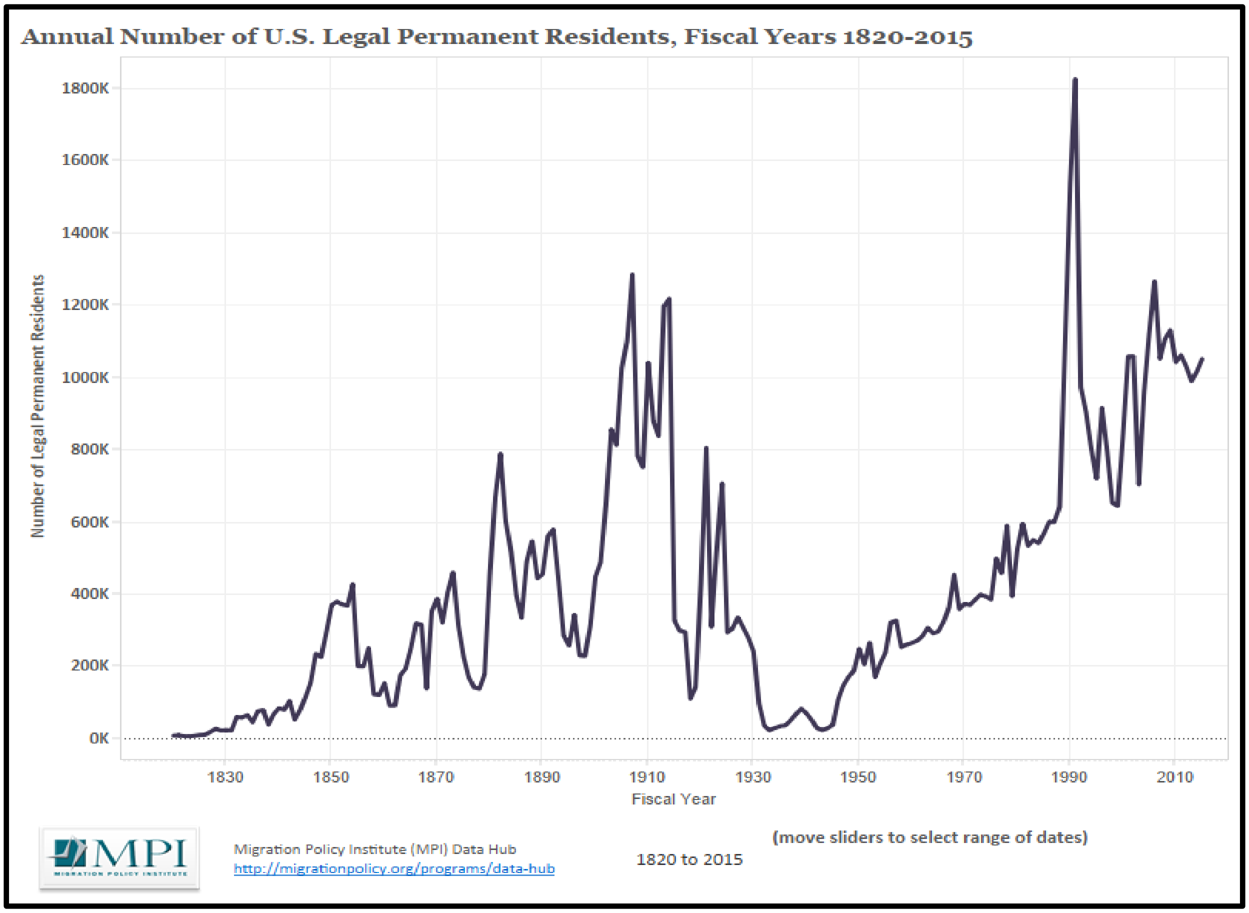
In 2017, President Trump blamed China for the decrease in American manufacturing jobs. It is true that America has lost 5 million manufacturing jobs since the early 2000s. However, manufacturing production has actually been increasing in the US in the last decade. American jobs lost due to importing goods from other countries only account for 13.4 percent of jobs lost in the last decade (Hicks, 2015). The same study also found that 88 percent of job losses in manufacturing was caused by increases in productivity. Globalization is a contributing concern for the growing unemployment and job market polarization issues, but it is not a main driving force this time.

I. Immigration

The immigration policy of the United States recently has become much more permissive. Before the 1990s, there had not been a significant spike in immigration since the beginning of the 20th century. There was a spike in immigration during World War I and in the 1920s the Government set up a quota system primarily determined by country of origin with a few exceptions. The Immigration and Naturalization Act of 1965 rewrote policy to disregard an immigrant's country of origin in favor of increasing the supply of high skilled immigrants to fill positions that the Labor Department verified could not find an American citizen to employ. (Pew Research Center, 2015). In 1990, the immigration policies were updated again to allow 675,000 new immigrants in very year after 1994 (Leiden & Neal, 1990). Figure 6 (below) tracks how these changes in policy affected the rate of immigrants entering the United States.

In recent years, many American are concerned that jobs that are created in America are being taken by immigrants. However, a study lead by some of the nation's leading economists and scholars from the National Academies of Sciences, Engineering, and Medicine concluded that immigrants have not made any negative impact of wages or employment rates of Native-born Americans (Blau & Mackie, 2016). The study also found that high skill immigrants have a positive effect on the economy because they create innovation and new jobs. Low income immigrants do increase the burden on some governmental systems (like the education system), but they do not have any negative effects on the job market.

Fig. 5



Source: Legal Immigration to the United States, 1820-Present by The Migration Policy Institute

8. **Policy Solutions**

By examining of the current technology available to automate jobs and the significant differences between this case of technological unemployment from those in the past, it is reasonable to conclude that technology will lead to a significant change in the way the labor market functions. The threat of automation to our current system is clear and under President Obama, the Federal government developed some policies to help the economy transition. A report from the Executive Branch published in October of 2016 focused on what can be done today to help prepare for the change in the future (Executive Office of the President, 2016). This section will examine the possible solutions that have been suggested to help smooth the transition into the A.I. economy in the short and long term.

A. Short Term Policy Solutions

The short-run solutions come from the report published by the Executive Branch of the President. The Executive Branch advisors assume that automation and modern technology will create more highly skilled jobs, at least in the short run. The solutions proposed by President Obama's policy advisors can be categorized into two categories: improve education and promote entrepreneurship.

a. Education

The main solution the White House proposed was reorienting public education curriculum to intensely focus on computer science and skills that students will need in the new economy (Executive Office of the President, 2016). Enhancing existing public education would help, but the significant increase in demand for highly trained workers may require more intense policies. Studies have found that the greatest job growth is for jobs that require at least a Bachelor's Degree. If the demand for highly skilled labor keeps growing and the demand for unskilled labor keeps shrinking because of job market polarization, having a Bachelor's degree will be essential for joining the labor market (Carnevale, Jayasundera, and Gulish, 2016). Presidential Candidates like Hillary Clinton and Bernie Sanders proposed reducing the cost of college education or making it free for all citizens.

Extending education to lessen technological unemployment does have historical precedent in the United States. The high school movement and adoption of mandatory high school attendance until the age of 16 made America's labor force one of the most skilled in the world and created employment opportunities for young unemployed former farm laborers (Goldin & Katz, 2008). During the Factory Automation Revolution, President Kennedy issued the Manpower Development and Training Act in 1962 to help retrain unemployed factory workers that lost their jobs because of automation (Kremen, 1974). The Federal Government still has retraining programs in place through the Employment and Training Administration, but the Federal and State Government need to make college more affordable because a college education will soon be a basic qualification for entering the labor market.

b. Promotion of Entrepreneurship

In the White House report, Obama's advisers advocated for making A.I. technology a publicly provided good (Executive Office of the President, 2016). By making access to A.I. technology universal, they hope to create a boom in employment through entrepreneurship. The report claims that the Executive Branch does not know where new employment will come from, but the future of employment will come from business that have not been founded yet. Other methods to promote entrepreneurship not mentioned in the report are to cut taxes on small businesses and strengthen the social safety net. Providing universal healthcare that is not dependent on full time employment would allow entrepreneurs to take more risks without fearing losing their healthcare.

B. Long Term Policy Solutions

These long-term policy solutions assume that in the long run, computers and A.I. will have the capability of automating the majority of human tasks. In that future, if our economic system does not change, only a small percentage of the population will earn an income from either owning capital or the few occupations that cannot be automated. The economy will need a form of wealth redistribution because there will not be enough people with income to support the economy. Martin Ford (2015) argues that as the economy automates more jobs, it will concentrate wealth into a small number of consumers and a large variety of firms cannot compete with only a small number of consumers. Thus, if most companies want to survive, the economy will have to adapt with a form of wealth redistribution.

a. Taxes Reform

i. Capital Gains taxes

Piketty theorizes that rising income inequality is the result of the global economy returning to a natural state where returns to capital is greater than GDP growth (Piketty, 2014). If the hypothesis that capital (i.e. robot and A.I.) will be able to replace most human workers is correct, owning capital will be much more profitable than it was 150 years ago. Elevated levels of automation coupled with growing capital gains could lead to more income inequality between the classes than Piketty predicted. If the gap between capital owners and the working class is growing like Piketty proposes the taxes on the wealthy are going to have to rise back to at least the level they were in the 1960s for the economy have some income equality. When the effects of automation and globalization are factored in, taxes may need to raise even further. Those taxes could be used to fund the expanded education system and support people that cannot find work because of automation through a system of wealth redistribution.

ii. Taxes for robots (Bill Gates)

In an interview with Quartz, Bill Gates proposed the simple solution of taxing the production of robots at the same rate we currently tax citizens. When a occupation is automated Gates thinks that the robot or A.I. should be taxed at the same rate that an employee's income would be taxed. Gates suggests that we use that tax revenue to improve education and train people for fields that still require highly skilled humans (Delaney, 2017). If most humans will not be able earn an income because of automation, that tax revenue could be used for wealth redistribution in the form of Equity Endowments or a Universal Basic Income.

b. Universal or Guaranteed Basic Income

The final solution that economists have provided is a universal or guaranteed basic income. If this case of technological unemployment does create permanent unemployment for a portion of the population, many people would agree that it is the responsibility of the rest of society to provide for them. The belief that society should support the unemployable is based on moral arguments like equity and efficiency arguments like positive spillover effects such as decreasing crime. A universal basic income is not a new idea. In 1796, American philosopher Thomas Paine (2010) argued in favor of a basic income. In 2016, Elon Musk suggested in an CNBC interview that a universal basic income may be necessary because of automation (Clifford, 2016).

However, the income level must be set at the right level to continue incentivizing innovation. The basic income level should be set at a point where it allows people to live at an acceptable standard of living, but they still want to earn more income through education and work. Most current plans for universal or guaranteed basic incomes in countries like Finland and Kenya only give a fraction of income needed to live comfortably in their countries, but as more people become unemployed due to automation the government can increase the basic income to support the unemployable. Like universal healthcare, if people do not have to worry about survival they may take more risks as entrepreneurs.

c. Equity Endowments

An alternative solution to a guaranteed of universal basic income, is universal capital endowments. A universal capital endowment system would give everyone a share of ownership of capital (i.e. the robots) at the age of 18. In this system, if a worker’s labor is automated they still gain income from the increase in their equity’s value (Smith, 2013). The main issue with the equity endowment system is if someone tries to take an entrepreneurial risk with their equity and loses it, they will not be able to recover from that loss. This system could stifle innovation and risk taking. Another system would have to be set in place to help people that risk their equity. Martin Ford (2015) also believes that to earn an equity endowment or basic income, the recipient has to meet a certain level of education. There has to be a policy that guarantees a basic level of universal education because an educated society is more productive and makes better choices in general.

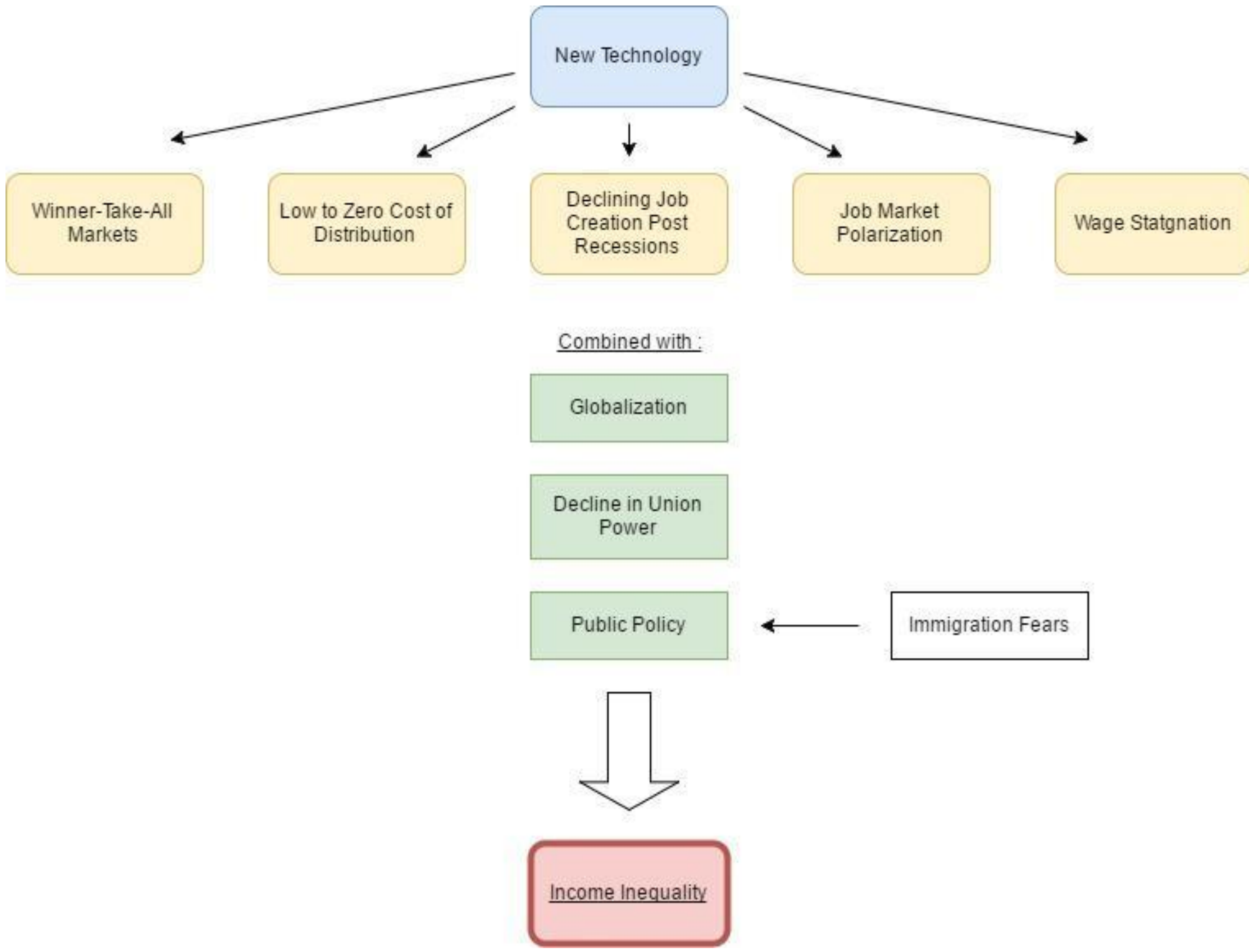
9. <u>Conclusion</u>

In conclusion, advances in technology have dramatically reshaped civilization. Since the invention of the wheel, technology has gradually replaced human labor. In the past, the workers it replaced were always able to transition to jobs with more complex tasks that had yet to be automated. However, the A.I. Technological Revolution could pose a greater threat to employment than previous technological advancements. There are two main differences between the current revolution and those previous: the automation capabilities of the new technology and the characteristics of technological unemployment.

The capabilities of today's new technology are unlike anything that precedes it. All past improvements to technology have allowed it to replace routine, physical labor. Never before has technology be able to replace cognitive, non-routine labor. There are some tasks that remain elusive to automation. However, the emergence of A.I. puts most jobs today at risk of partial or complete automation. According to Moore's law, the power of computers will double every year. Therefore, automation is going to rapidly become cheaper and more effective in a short period of time.

Second, the trends during this instance of technological change are not familiar in many ways and indicate a continued increase in income inequality, if no changes are made to public policy. These trends include wage stagnation, flat job creation post recessions, job market polarization, winner-take-all markets, and the decline in wage premiums for higher education. The trends emerging in the wake of technological advancement are compounded by exogenous factors like globalization, the decline in union power, and public policy to increase the growth of income inequality between the extremely wealthy and the average citizen. Figure 7 summarizes this concept.

Fig. 7



In his TED talk on September of 2016, David Autor (2016) said that automation is not a threat to the economy. Autor states there will always be new jobs created, they just have not been invented yet. He believes that technology will always increase the value of human capital. However, in the long view of human history, Autor is underestimating the power of technology and how fast it is advancing. One day, A.I. will reach the same level of intelligence and capability of the average human. When robots can completely automate human physical and cognitive labor, what can a human do that has value on the market? When horses were replaced by cars, the population of domesticated horses decreased because most of the tasks they were needed for were replaced with automobiles. When humans are replaced by A.I. and robots, this logic suggests that fewer jobs will be available for humans as well.

Perhaps, the economy will eventually expand in creative fields to absorb all the labor that was displaced by automation, but if the trends like lack of job creation after recession, the winner-take-all markets, and the low growth in wage premiums for higher education continue, that seems unlikely. Even if A.I. does not automate all jobs, drastic steps will have to be made to help the economy transition into a labor market that demands high levels of education to join the labor force and combat the very high rate of income inequality. Every case of technological unemployment is different, but this instance will be the most revolutionary and impactful case because it will require governments to utilize a variety of old and new policies to create a better society. The first step might be taxes for robots.

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