ALLEGHENY COLLEGE

POLITICAL SCIENCE 610

SENIOR PROJECT

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The Political Ramifications of Labor Automation with an Emphasis on Technological Unemployment and Income Inequality

Department *of* Political Science



November 28th, 2016

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Submitted to the Department of Political Science of Allegheny College in partial fulfillment of the requirements for the degree of Bachelor of Arts.

I hereby recognize and pledge to fulfill my responsibilities as defined in the Honor Code and to maintain the integrity of both myself and the College community as a whole.

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Chapter 1: Evidence for the Risk of Technological Unemployment

Caste stands up ireful against Caste; and the indignant, wronged spirit of the Middle Rank bears down in zeal and scorn on the famished and furious mass of the Operative class. It is difficult to be tolerant - difficult to be just - in such moments.

- *Shirley*, by Charlotte Bronte

It seems obvious today that technological innovation marches hand in hand with political and economic institutional changes. The nature of labor and consumption plainly define many of the key social institutions of any given country. In a time of unprecedented technological growth, the question of what societal changes we should expect is absolutely paramount. Historically, each subsequent wave of industrialization and technological innovation has brought both immense social benefits, as well as terrifying risks. The first European industrial revolution of the 19th century contributed to such diverse phenomena as mass migrations to cities, the rise of meritocratic forms of governance, the slow elimination of hereditary privilege, the secret ballot, modern taxation, the formation of public policing, modern sanitation systems, and hundreds of other ideological and institutional changes that we take for granted today (Allen, 2012). This is not to mention the social and political organizations that formed as a direct response to industrial changes, such as the appearance of worker unions (Hendrickson, 2015). The industrial revolution that shook the 19th century did not simply improve quality of life standards throughout Europe and America and shorten travel time dramatically, but more importantly changed the way institutions were structured and the way that people saw the world. It is no coincidence that the late 19th century solidified the field of political science as we understand it today, based first and foremost on questions of economics, industry, and labor. Where the ancients may have faced the problems of war, peace, and the quarries of social governance, none had to contend with rapid technological change or the logistics of global finance. A second industrial revolution with the improvement of computer and digital technology sapped manufacturing jobs from much of the first world during the 1960s through offshoring and automation in favor of a service economy. This too has produced political turmoil that is still being felt in

American and European political discourse to this day, from college campuses to factory floors. Today, as before, the specter of a third industrial revolution looms in the distance. This time, the unpredictable technological accelerant is improved artificial intelligence resulting in rapidly increasing labor automation. The main concern that scholars throughout the world have shown regarding this phenomena is its capacity to cause technological unemployment in a wide range of job sectors over a short period of time. One major study coming out of Oxford University has indicated that up to 47% of US jobs are at risk of being fully automated within the next two decades (Osborne, 2013). A separate study by the McKinsey Institute in measuring "work activities" concluded that 45-58% of daily work tasks are susceptible to automation (Miremadi, 2015). A meta analysis by the White House Council of Economic Advisors (CEA) has suggested that up to 63% of current jobs may be automated in the near future (Lyons, 2016). Even many of the most optimistic studies, such as Forester's 2016 report on white collar automation, have suggested a net 7% job loss in the US economy by 2025 (Vassallo, 2016). Nor are these results limited to the United States. A 2016 ASEAN study concluded that over 50% of jobs in Indonesia, Vietnam, Cambodia, Thailand and the Philippines are in danger of automation (Chang, 2016). These trends can be compared to and complemented by recent estimates that 22% to 29% of American jobs will likely be offshored within a decade (Levine, 2011). Furthermore, despite the fact that current scholarly opinion remains evenly split regarding whether increasingly sophisticated automation technology will displace jobs, according to Pew Research there is almost a unanimous agreement among experts that robotics and AI will be "integrated into nearly every aspect of most people's daily lives" by 2025 (Smith, 2014). Even if technological unemployment is minimal over the long term, it is clear that labor automation has the capability to change work hours, wages, and even the nature of labor itself over the next few decades. The question that must be asked then is whether the fears of job displacement are warranted, what dramatic social changes will they lead to if they are, and how can we best prepare for such contingencies. The organization of this work is based on a methodical approach to answering this question. This preface will focus primarily on the political, technological, and economic history of labor automation. From there, an economic projection will be made

regarding job risks over the next 20 years, from which political risks will be deduced. Finally, some political contingencies will be analyzed and potential solutions will be proposed. It is important to note that, much like any modern problem involving global finance, it is often difficult to perform isolated analyses that focus on individual countries or labor markets. This work cites a broad range of international literature, but for the purposes of necessity will attempt the cumbersome task of restricting much of its political analysis to the United States and Europe. Similarly, despite reaching far into the past, the temporal scope for the projections of this work is a decade ahead due to the combined difficulties of making political predictions derived from economic forecasts. Today we stand on a technological brink, and as we face an uncertain technological future, we must look back to see whether our 200 year industrial history has anything to teach us.

The worry about technological unemployment chiefly originated in the 19th century, when cheap industrial labor put tens of thousands of local artisans out of business and revolutions in industrial agriculture caused a sharp decrease in the number of employed farmers. Many traditional cottage industries, such as stocking weaving, shearing, and cotton spinning, as well as a large proportion of labor intensive farm work, such as reaping, became increasingly mechanized and displaced artisans and farmers alike (Stearns, 2007). This led to a series of social movements, like the Luddites, which predicted a catastrophic world of permanent job loss and despondency, and responded by violently destroying industrial machines. While the Luddite protests remain a very explicit symbol of misguided anti-technological sentiments during the 19th century, in reality they reflected broader cultural trends of working class opposition to the dehumanizing conditions created by the Industrial Revolution which ultimately resulted in more effective, organized, and long term resistance in the form of labor unions. A strain of technological Utopian optimism also emerged during this period, championed by such intellectual giants as David Ricardo and Karl Marx, who looked forward to an era where technological unemployment would eliminate the need for many types of jobs, freeing a large portion of the population to engage in other more creative labor. This too, had powerful consequences, fueling the ideologies of Utopian revolutionaries for years to come. However, despite the mass protests of the Luddites and the musings of the

technological optimists, the 19th century ultimately resulted in more jobs created than jobs displaced, with thousands of former artisans operating and repairing machinery within a few decades. Just as importantly, the major effect that the industrial revolution had on employment was that opportunities in manufacturing and industry crowded out agricultural labor. This, combined with more efficient agricultural technologies, resulted in a broad shift of European and American labor, from agriculture to manufacturing, without decreasing the productivity of the former. There are several conclusions that can be drawn from the fact that labor automation did not produce long term job displacement in the 19th century and yet had significant social consequences well into the present day. Firstly, even short term technological displacement can cause significant social turmoil without adequate safety nets and timely retraining. Even though there was no aggregate decrease of jobs in early 19th century Britain, the new jobs that initially emerged to replace numerous European cottage industries were more monotonous, had worse pay, and required less skill to perform. Life expectancy in cities such as Liverpool, England fell to an astonishing 29 years (Cash, 2012). Despite there being no net loss of jobs, the Industrial Revolution effectively hollowed out the 19th century middle class by forcing skilled artisan laborers into more dangerous work for which they were poorly compensated. Similarly, the job shift to factories, combined with the immense new productivity of 19th century machines, led to an unprecedented concentration of political and economic power in the hands of a small amount of wealthy industrialists. Finally, this increased economic inequality, along with the temporary displacement of workers transitioning to the factories (known as structural displacement), helped facilitate the dangerous political unrest and contributed to the massive upheavals throughout all of Europe in 1848 and more broadly fueled the dangerous and destructive revolutionary ideologies of Anarchism and Communism through the 20th century (Horowitz, 2005).

Similar panics about the role of automation permeated portions of the 20th century, though they were not taken seriously by most economists. Keynes, being the exception, mentioned the potential of technological unemployment to reduce the need for work and create a Utopian environment where all people would simply not have to work due to universal prosperity caused by “science and compound interest” by 2030 (Davis, 1994).

In the 1980s, a second major industrial shift took place in the United States which is still happening today. This shift, which involved offshoring and automation, sharply changed the composition of the American economy from having over a quarter of its jobs in manufacturing to a little over 11% ("Percent of Employment in Manufacturing in the United States", 2013). Millions of manufacturing jobs have been lost, with over 5 and a half million gone since 1997 (Long, 2016). Working in tangent with this phenomenon, since the 1970s the service sector has grown tremendously. Today, 80% of employed Americans work in service industries, and according to the Bureau of Labor Statistics, 98% of jobs projected to be created until 2022 will be in this sector (BLS, n.d). This surge has effectively transformed America into a service economy. The trend of increasing jobs in the service industry is expected to continue over the next decade, with the top twenty fastest growing jobs all in the service industry, thirteen of which will be in healthcare due to America's increasingly aging population. Much like the shift from agricultural labor to manufacturing a hundred and fifty years earlier, the new shift from manufacturing to service industries only temporarily increased unemployment and did not decrease manufacturing productivity despite massively cutting jobs. Despite having less manufacturing jobs than ever, manufacturing productivity has soared, with the United States currently ranked as the second largest manufacturing country in the world (Giffi, 2016). Despite this, the controversial shift from manufacturing to service jobs has not gone unnoticed. In 1964 the Triple Revolution Memorandum was sent to Lyndon B Johnson. The letter, prompted by both labor outsourcing and automation breakthroughs in the automobile industry, warned that an incoming cybernetic revolution would sharply decrease employment, forcing massive amounts of people to fall below the poverty line into a "permanent impoverished and jobless class" forced to rely primarily on governmental assistance (Pauling, 1963). More generally, the past forty years have seen hundreds of major protests, with 86% of Americans blaming offshoring as the main cause of the current problems in the US economy ("The Story So Far", 2013). This resentment toward job losses and shifts, despite booming economic productivity, has sparked resistance throughout first world countries, as can be evidenced by the rise of both radical left and right wing nativist movements in the United States as well as abroad.

We know today that the dire warnings and eager jubilations in the 1800s, 1930s, and 1960s of incoming technological unemployment did not come to fruition and that, to the contrary, quality of life has been slowly increasing as employment rates have been steadily and predictably fluctuating. This is largely why numerous key scholars today, such as MIT's David Autor, have argued that most of the worries regarding technological unemployment are simply historically unfounded and can be inductively reasoned away (Rotman, 2015). There are several key problems with this line of reasoning. Firstly, it can be demonstrated that the technological and economic shifts we see today are categorically different than those in the past. The primary difference is that previous advancements in automation have targeted single industries, almost all of them associated with various forms of narrow, easily defined and repetitive manual labor, such as cotton weaving, seed planting, or metallurgy. In contrast, modern advancements in artificial intelligence all have a broad range of applications, with the capability of quickly automating many white and blue collar industries such as paralegal research, soft tissue surgery, financial analysis, transportation, welding, medical diagnostics, as well as thousands of service industry jobs. This expansion of automation is largely thanks to massive improvements in artificial intelligence software over the past few years. The most important of these adaptations has been a series of strides in machine learning software, computing capability, and the increased use of large data sets. Machine learning is a computational process which uses algorithms to allow computers to perform work that they were not explicitly programmed to do. While machine learning programs have been around since the early 60s, a broad range of technical issues had made their applications largely unfeasible to the present day. Early machine learning software suffered primarily from a lack of computational power, lack of diversity in the algorithms used, and high fixed costs of computing. Today, computing power has grown exponentially thanks to more powerful and integrated microprocessors as well as improvements in cloud computing, resulting in a trillion fold increase of processing power over 60 years, with modern smartphones having vastly more computing power than massive supercomputers during the 1980s (Stone,2015). This does not even take into consideration more speculative technologies such as quantum computers, which have been shown to overwhelmingly improve upon certain

machine learning applications. Machine learning algorithms have also become more diverse, and easier to access and improve thanks to the advent of open software libraries, such as TensorFlow and Torch. This is compounded with the fact that this increased computational power and diversity has made purchasing computers and developing algorithms much cheaper. Finally, improved methods of analyzing large data sets have allowed computers to more efficiently recognize and solve non routine tasks such as instant translation that were previously considered unmanageable for AI ("Conquering Babel", 2013). In and of itself, the use of large data sets in computers in order to solve problems is not a new phenomenon. The first effective forms of AI software developed during the 1970s were described as "expert systems", utilizing large amounts of data to make decisions such as diagnosing diseases. Even in the 1990s, such systems were considered effective and performed at the same level of efficiency as junior doctors (Ford, 2015). Today, with a larger capacity for data storage and processing, such systems are more efficient and capable of performing a broader range of functions such as facial recognition. So far, the ability for computers to learn and adapt has largely been measured by their performance in various low variance games against human opponents. Previous sophisticated AI, such as Deep Blue, primarily employed computational methods to consistently beat world champions at chess. Since 2011, computers have managed to decisively win more complex games such as Jeopardy and Go, using learning algorithms. These improvements in artificial intelligence have allowed robots to operate in less predictable environments, perform less routine tasks, and integrate complex sensory information, such as sight, sound, and balance to more efficiently complete such work.

Besides serious technological improvements, there are a host of unusual and unprecedented economic trends that seem to indicate that labor automation will have serious ramifications this time around. The OECD has recently indicated that income inequality is at record heights, caused primarily by a dip in wages of the bottom 40% of the population (OECD, n.d). Furthermore, despite a steady economic recovery, the poverty rate has been steadily rising (Kaplan, 2015). Most unusually, the traditional connection between marginal increases in productivity correlating with increases in worker pay has disappeared (Brynjolfsson, 2014). Worker pay over

the past 50 years has stagnated in relation to booming productivity. There has also been an increase in the number of workers that are employed in temporary jobs, referred to since 1985 as contingent work. Despite there being a lack of clear statistics on the subject, according to the United States Government Office of Accountability 40% of workers are currently in such a category, up from 30% a decade ago (Pofeldt, 2015). This trend of workers taking shorter and more precarious contract jobs has also been linked to the fact that employers are able to automate larger portions of their labor. Similarly, the paradigm of corporations has changed with the rise of small but hyper productive Silicon Valley corporations. Where massive corporations worth hundreds of millions such as Ford would hire thousands or tens of thousands of employees, many of today's equally economically robust corporations such as Facebook and Whatsapp have only dozens of people employed (Wagstaff, 2014). In addition, workers with low levels of education have seen their real wages fall dramatically over the same time span (Ford, 2015). While the US job market has seen a recovery since the recession in 2008, it has been noticeably sluggish, with employment lagging behind improvements in GDP. This unusually slow recovery and its corresponding problems with employment have been partially attributed to increased automation, given that companies had an increased incentive during the recession to replace human labor in order to cut costs. Unlike in previous years when layoffs during recessions were balanced out by a speedy replenishment of the workforce during ensuing recoveries, today this trend is not as evident, partially because much of the labor force that was let off in the last recession has been outsourced or automated (Kaplan, 2015). Furthermore, the US's steadily improving unemployment rate has been notably undercut by a thirty five year low labor participation rate ("United States Labor Participation Rate 1950-2016.""United States Labor Participation Rate 1950-2016.", n.d). This is relevant because it shows that the unemployment rate hasn't kept pace with population growth, another telltale indicator of automation's encroachment into the US job market. In addition to these negative indicators, demand for automation has risen globally at an average rate of 12% per year, with numbers as high as 21% throughout Asia ("IFR Press Releasse", n.d). This trend has been especially pronounced in China, with companies such as FoxCon replacing thousands of workers in the manufacturing

industries with machines due to rising labor costs over the past five years (Wakefield, 2016). These numbers are compounded by the hard economic realities of rising global wages and the falling costs of industrial robots. A 2016 analysis by the Boston Consulting Group has not only indicated unprecedented increases in global demand for industrial robots, but also shows that on average, industrial employers will stand to save 16% in costs by replacing their human workers with machines by 2025 (Silkin, 2015). Another incentive to replace labor throughout much of the industrial world comes from an increasingly aging population. With birth rates in many first world industrial countries far below replacement levels, projected decreases in workforces provide an incentive to compensate for this effect with by automating industries.

Despite these indicators, the danger of technological unemployment is seen as "the boy who cried wolf" of the economic world, with a broad range of experts still reluctant to give it any credence. Experts are also hesitant because, despite there being plentiful data over the past few decades, there has been no statistical indication that labor automation decreases aggregate employment. The largest study done to date, which measured technological unemployment in relation to the use of industrial robotics over fifteen years in seventeen countries, concluded only that robots reduced middle and lower class employment while having no discernible effect on aggregate employment (Feldmann, 2013). However, even given this data, aggregate employment is a very narrow metric for determining whether automation will present political or social problems. As mentioned earlier, the first and second industrial revolutions did not result in decreases of aggregate employment, only the temporary displacement of middle class work, and yet even this minor displacement coupled with increased economic inequality and changes in living conditions led to severe socioeconomic repercussions. Moreover, unlike with the more contentious long term consequences, there is strong empirical economic evidence from numerous historical studies that demonstrates medium term unemployment increases in relation to labor saving technology. Whether automation takes away jobs as a whole in the long term is not a relevant question to the workers who lose their jobs, and if the jobs take several decades to come back and the replacement work pays substantially lower wages, the political consequences can

be extreme. To quote John Keynes, “In the long run, we are all dead” (Feldman, 2013). There is one final flaw in the inductive argument worth mentioning, which is that it requires a clear leap of faith regarding the free market's ability to generate new jobs. Of course, we know that today service jobs largely substituted manufacturing work, which substituted agriculture years earlier. But the question remains, what labor will replace service work? While researchers who sound the alarm bells with regard to labor automation can point to specific industries that are in the process of being displaced by machines, skeptics have made few efforts to predict what jobs will appear to replace them. There are even some economic trends which push against the notion of massive creative job growth. One of the most traditional indicators of innovative job growth has been business formation, due to the fact that entrepreneurs principally design new jobs for growing economies. Over the past 20 years the rate of business formation in the United States has fallen, notwithstanding the steadily improving GDP and productivity (Harrison, 2015). Despite all of the weaknesses of the skeptical inductive argument, there is a possibility that once again both Utopian and Dystopian views of labor automation will be unfounded yet again, and because of this the burden of proof is especially strong on those who believe that this time automation will be a more pressing problem. That is why it is especially necessary to elaborate on the types of jobs at risk today.

Chapter 2: What Jobs are at Risk?

In order to understand the jobs at risk of automation, it is first necessary to categorize them. There are numerous perspectives from which work can be categorized. Economists regularly classify work by its required skill level, its role in the chain of production, and its pay. For the purposes of grouping work according to its stage of production, economists use the three sector theory of work categorization, dividing work into primary sector, secondary sector, and tertiary sector labor. Each of these sectors represents a point on the process of the development of consumption goods, with the primary sector dealing primarily with raw materials, the secondary sector focusing on manufacturing, and the tertiary sector being the service industry. This labor can further be divided into categories such as skilled, unskilled, as well as grouped based on pay. Understanding which of these sectors may shrink or expand due to labor automation is integral to predicting any long term political forecasts. More importantly, these categorizations bypass more difficult and less predictive questions of aggregate employment loss, replacing them with more nuanced perspectives on technological unemployment. However, economic categorization is not the only relevant way to categorize labor. AI researchers have their own system of labor categorization based on the difficulty that tasks would pose to computers. This mainly comes down to whether the work in question is routine or non routine, requires high or low dexterity, and

whether it requires extensive personal interaction. Only an integrated system of categories based both on economic forecasts and machine capabilities can paint a useful picture of labor automation. Additionally, automation can have several different types of impact on these various forms of labor, by replacing, complementing, or transforming them. Replacing labor involves the direct replacement of workers with machines. Complementing labor involves improving the productivity of labor by introducing automated mechanisms while still retaining the fundamental skill level required to perform the job. Labor transformation involves changing the fundamental characteristics of the labor in question, thereby changing its worth as well as who is eligible to perform it. This most commonly involves deskilling, where previously skilled laborers such as warehouse material recording clerics or craftsmen have had their labor simplified and their wages reduced as a result. Upskilling is also possible, where workers are required to perform tasks more precisely and efficiently to keep up with the automation of their work. Of the factors listed, there are several that have been positively correlated to increased risk of computerization across multiple studies. Generally, the factors most associated with increased risk of computerization/automation are being in the service industry, having low skill, being routine, requiring minimal dexterity, and requiring low human interaction (Osborne, 2013). Questions of wages are complex, with the McKinsey Institute suggesting that there is in fact a very weak correlation between work pay and risk of automation, with all parts of the economic spectrum somewhat susceptible to automation (Chui, 2015). The most thorough attempt to categorize labor according to its automation risk was conducted by Oxford University, and took many of these factors into account in order to create a probability index to see specifically which jobs were at risk of being fully automated (Osborne, 2013). Some of the data from that study, particularly its probability indexes will be useful for my risk analysis.

Unsurprisingly, today the effects of automation are most easily and immediately visible in the secondary sector (goods producing) of the American economy. 230,000 robots are currently working in American factories and increases in annual robot sales are in the double digits (International Federation of Robotics, 2016). A large proportion of the robot workforce is concentrated in the automobile industry, which has been purchasing nearly

half of all industrial robots sold yearly (IFR, 2016). Today there are nearly 1.4 robots per 10 workers in the American automobile industry, with new robots being purchased at an increasing rate (IFR, 2016). Moreover, automobile production is booming, with industry experts describing it as an incredible recovery. Newly enhanced visual systems on industrial robots combined with improved managerial and analytic software have greatly increased the efficiency of production lines. Despite the generally positive economic indications, today prospects for America's 1.7 million automobile workers are far grimmer. Employment has been increasing over the past few years, but shows few signs of recovering to the level it was at only a decade ago. Wages have grown increasingly detached from productivity growth and average wages have declined substantially, with some auto parts makers earning as little as 10 dollars an hour (Cancino, 2012). Finally, unions have become severely weakened, at best forced into sharp compromises over wages and at worst dealing with plant closures and relocations down south and overseas (Gupta, 2016). The industry that used to represent the most comfortable, stable middle class blue collar work and the might of organized labor has effectively lost both comfort and collective strength. While globalization in the form of Mexican offshoring and stiff competition from Japan provide some explanation for these trends, increased automation is an equally serious culprit. Despite it having an abnormally high share of robots, trends in the automobile industry have historically been indicative of the health of American manufacturing as a whole. Across the board, American manufacturing companies have seen increases in robot sales and productivity, yearly decreases in employment, and steady erosions of worker wages. This is further complemented by the fact that the manufacturing industry has been a historic hub for research and development, much of which has been recently invested in automation technologies.

Another major portion of the secondary sector of the labor market is the construction industry. In terms of automation, the construction industry initially appears as a counterpoint to the trends in the automobile industry. Due to a combination of risk averse conservative management, low research and development spending, and the irregular non routine nature of construction work, automation technologies have made little

headway. This is evidenced by the low robot density in the industry as well as productivity indicators that have not seen significant increases over the past few decades (Steen, 2014). However, there is reason to believe that this will soon change. Substantial research is being conducted into several important technologies that may change the nature of construction work. Advances in 3D printing have recently allowed for the prefabrication of numerous sections of construction projects within controlled conditions (Wu, 2016). Autonomous driving technology has led to a limited amount of self driving vehicles and drones in today's construction workplace ("Entering The Age Of Self-Driving Construction Equipment", 2016). Broad improvements in software development have allowed for the autonomous management of numerous construction sites, with algorithms performing a range of data entry tasks and management tasks (Chen, n.d). Technologies have also advanced in the field of inspection, with ROMA climbing robots capable of inspecting difficult to reach construction sites for a fraction of the cost (Abderrahim, 1999). This is further supported by the recent Oxford analysis which puts the probability of construction automation by 2025 as high as 88% (Osborne, 2013). The American construction industry is already facing yearly job losses stemming from a lack of qualified workforce and offshoring. Even a modest implementation in automation technology that is already in development could lead to serious industry disruption.

The final major portion of America's secondary sector is the mining industry. The US mining industry currently employs over 600,000 workers (BLS, n.d). On a thirty year scale, the mining industry has seen the same trends as the automobile industry, with broad decreases in employment with large increases in productivity (Armstrong, 2016). For example, from 1978 to 2010 the US coal industry lost over 100,000 jobs while increasing productivity by almost 50% (Reis, 2013). Over the past few years the mining industry has faced three key problems, rising costs, safety issues, and a lack of skilled labor. Costs have been rising due to the increasingly isolated areas that are being mined combined with the fact that the mining industry has an abnormally high labor cost, spending 30% of its overhead on worker pay. In turn, increasingly deep mines in isolated areas have forced miners to work in worse conditions for longer hours and have undermined worker

safety. This has helped discouraged more skilled laborers from entering the industry. Incidences of black lung, a mining complication that was nearly eradicated in the 2000s, have increased by over 900%, resulting primarily from workers inhaling coal dust combined with silica dust found in rocks mined in especially deep shafts (Shipman, 2015). This skilled worker shortage is compounded by the fact that young people are moving away from vocational work and towards four year degrees at an increasing pace ("Key Questions", n.d). This is despite the fact that mining work continues to pay exceedingly well, with many workers earning upwards of $80,000 a year (Miller, 2011). This combination of problems has caused mining corporations to sharply increase investment in robotics and automation in the form of self driving vehicles, autonomous railcars, autonomous surveyors and monitors, and even direct robotic control of drilling. Almost all of these advancements are already used in major mining hubs such as Australia and Canada, and are being strongly considered by US mining companies (Lynas, 2011). While automation is likely to improve mining safety, there can be several serious unintended consequences. Mining unions have already been weakened, making the enforcement of mining safety regulations rarer and more difficult. If automation in the mining industry parallels that of the automobile industry, it may weaken unions further, hurting regulatory enforcement and putting workers at risk.

When looking at the secondary sector of the economy through the lens of its three largest industries, several conclusions can be made. The first is that the secondary sector has historically been the birthplace of union labor, and its decline poses significant threats to unionism as a whole. Secondly, unions in this sector are historically volatile, with massive and occasionally violent strikes being a hallmark through much of the 20th century. Under increasing pressure from automation, the clashes that were once provoked by technology in the 1910s and outsourcing in the 1980s may once again appear in response to automation today. Furthermore, unlike jobs in the service industry, secondary sector work has historically provided opportunities for people with limited or no education to earn a decent wage and become part of the middle class. Today, not only is employment falling across the secondary sector, but the work left behind is either low paying, with minimal

skill requirements, or pays fairly well but requires an extensive education. With the exception of the mining industry, it is especially rare today to see high paying entry level work with low educational requirements in the secondary sector. Even if jobs rebound, this element is likely to remain the same. This tightening of the secondary sector weakens the growth of the middle class and opportunities for prosperity. This has a high potential to lead to both increased income inequality and social tensions. Finally, even though automation has a strong potential to hurt jobs, there are some strong positive factors to consider. In most portions of the secondary sector, with some exceptions in the mining industry, workers that can be successfully retrained will work in safer conditions and will have their work complemented by state of the art robotics. This general logistical and safety improvement, while economically painful for those who lose their jobs, will help those still employed do more rewarding work.

Given the percentage of Americans employed in the tertiary sector (the service industry) and the various optimistic projections regarding its growth, it remains the most important place to look when trying to ascertain the risk that automation poses to American workers. The service industry has long been associated with varied forms of white collar work, to the point where the two terms have often been interchangeable in colloquial speech. The key distinction is that white collar workers specifically work in office and administrative roles, while service sector workers as a whole a far more diverse in their occupations. White collar workers account for nearly 40% of the US workforce and approximately 60% of the service industry ("Distribution of Nonelderly Adult Workers by Occupational Category.", n.d). Prior to the advent of modern information technology, white collar professionals have been largely immune to automation because many of their job skills, such as research, analysis, and cataloging, seemed out of reach for robots. Today the situation is markedly different, with robots capable of processing and analyzing large amounts of data much faster than any human is capable of doing. This capability is especially important in the world of finance, where timely analysis of large amounts of data is needed to maintain a competitive edge. Unsurprisingly, one of the first places that has seen a near complete displacement of white collar jobs has been stock trading. Today, robots

greatly outnumber human traders in most major firms (Hiltzik, 2014). But this trend isn't limited to stock traders. In the finance industry accountants and auditors are already being partially or fully displaced by software. These workers are particularly vulnerable because their work, which often primarily involves the cataloging of data, rarely requires any level of manual dexterity or human interaction. Start up corporations such as Smacc and WorkFusion have stepped in to provide software which is capable of analyzing vast amounts of financial paperwork and checking it for a variety of factors including consistency (BusinessWire, 2016). Tens of millions of Americans have already had their tax returns filed by software programs (Allan, 2016). Today there are almost one million jobs in the United States which involve tax preparation, accounting, or auditing and they are almost all are at risk (BLS, n.d). Nor are the higher, more cognitive positions in the finance industry immune to the threat of automation. Financial analysts and even managers who have been previously paid six figure salaries may be partially displaced in the future. While financial analytics is far less routine than auditing or accounting, it often requires hundreds of hours of historical research involving very large data sets. This is where software like Kensho and SigFig come into play, analyzing large reams of historic data to predict financial effects on key stocks and providing investment advice within minutes (Popper, 2016). While the use of such technology as a replacement to financial analysts is generally uncommon today, there are successful firms, such as Renaissance Technologies, that have claimed to be entirely algorithmically based for several years with little to no human input beyond writing the algorithms (Zuckerman, 2016).

Of course the automation of white collar work is not limited to the financial sector. Low level administrative and secretarial work is particularly at risk in the near future, once again due to its repetitive nature. Despite being one of the most common jobs in the United States throughout the 80s and 90s, automation in the form of virtual assistants has caused drastic yearly decreases in secretarial work ("The Software Secretaries.", 2015). While virtual assistants like Siri cannot necessarily do all administrative duties, they can cover many of the basics including planning meetings, typing dictated speech, looking up information, and screening emails ("The Software Secretaries.", 2015). This is especially pressing because unlike most

secondary sector automation, which has a tendency to primarily affect the employment opportunities of men, lay offs in secretarial work have disproportionately affected women. Between 2009 and 2011, women lost over 900,000 administrative jobs due to a combination of an economic downturn and increased automation of secretarial work (Kolhatkar, 2013). Similarly, the European Center for the Development of Vocational Training has projected a million more secretarial job losses by 2020 (Allan, 2016).

Legal services represent another white collar field that is experiencing the encroachment of automation. The most notable example can be seen in the field of paralegal research, which broadly encompasses the research and discovery process that ultimately provides the evidence that lawyers use to prepare for the trial. Because of the timely nature of trials, the occasionally incredible scope of the evidence that needs to be examined, and the price of legal counsel, automation of research and analysis has been strongly incentivized in the legal sphere. Responding to this, several software startups such as ROSS, Clixex, and Autonomy have already managed to provide paralegal research at a fraction of the cost (Turner, 2016). The automation of the discovery process, nicknamed e-discovery, has already displaced thousands of paralegals and freed up the time of many law associates. This is not to say that figures higher up in the legal food chain have nothing to worry about. While there is little indication that most trial lawyers are in danger of automation, low level legal cases have seen some interesting precedents. In particular, AI software touted as the first robotic lawyer and appropriately nicknamed Donotpay, has successfully challenged millions of dollars worth of parking tickets in several major US cities (Gibbs, 2016). By asking only a few questions the program manages to both consult with the client and write a legal appeal if it deems that the case is winnable. With nearly 800,000 paralegals, legal support workers, and judicial clerks working in the United States, automation of these professions may put a serious dent in the incomes of traditionally middle class workers (BLS, n.d).

Beyond finance and law, another white collar field which may be expected to see significant changes is advertising. While the creation of advertisements remains highly creative work, out of the reach of any algorithm, the buying and selling of advertisement space has become a largely automated process on the

internet (Krashinsky, 2015). Much of the current ad buying and selling occurs on digital marketplaces and the automated flash trading that has become ubiquitous in the stock market has largely taken hold there as well. However, the largest portion of the advertising industry that will most likely be affected by automation is telemarketing. In fact, telemarketing is the most likely profession to be automated by 2025 according to the Oxford Martin study, with a probability of 99% (Osborne, 2013). Up to this point, a large portion of America's telemarketing jobs have already been offshored, leaving a little over 200,000 telemarketers employed in the United States (BLS, n.d). Today, even offshoring occasionally proves to be too costly and many businesses have come to rely on automated telemarketing, which calls hundreds of homes a minute with prerecorded messages. Interestingly, despite the drastic projections by Oxford Martin, deep learning technology has not yet found a use in telemarketing, partially because robots do not yet have the conversational skills to convincingly imitate humans in a dynamic conversation. This has led to a sort of middle ground, where currently many offshored telemarketers do not speak but rather use a soundboard on which they press buttons that produce prerecorded accent-free phrases (Madrigal, 2013). Given this current phenomenon, it would not be a leap to suggest that deep learning algorithms could analyze this data and automate the soundboard process. This development is especially likely given the enormous progress that voice recognition technology has made in the past few years.

Of course not all work in the service industry can be corralled into the category of white collar jobs. In fact, most of the service jobs that may be subject to automation in the near future are not office jobs in any capacity. The most publicized example of impending automation comes precisely from this category and relates to the automation of transportation. Millions of people in the United States work full time transporting goods, with nearly a million people working in trucking alone (BLS, n.d). As of 2014, the Bureau of Labor Statistics has estimated that for hire transportation services generate $135 billion a year, accounting for 3% of America's total GDP (Bureau of Transportation Statistics, n.d). Moreover, almost all transportation jobs, from mail delivery to truck driving and Uber service have served as an important form of employment for people without

advanced degrees. Truck driving, despite its often modest pay and long hours, has helped hundreds of thousands of Americans reach a comfortable middle class life. Given the magnitude of the transportation industry's contribution to the economy and employment, the impact of self driving vehicles must be looked at especially carefully. In many ways, the remarkable progress of self driving vehicles is a poster child for the larger alarming trends in automation technology. As recently as a decade ago, specialists in numerous fields predicted that self driving cars would remain a product of science fiction or otherwise appear in the distant future (Ford, 2015). Google's wildly successful endeavor to make them a reality started only six years ago and today these vehicles have already accumulated millions of miles and are expected to achieve commercial viability by 2020 (Muoio, 2016). Only now, with the technology nearly viable and the cars on America's roads, are legislators, corporations, and unions trying to catch up with the implications of this technological blitz. Self driving vehicles have utilized the full range of recent technological advancements to achieve their aim. They use deep learning technology to combine sensory information gathered from several visual recognition sensors along with GPS, and use this information to make intelligent decisions in a dynamic environment (Armstrong, 2016). Furthermore, all experience is cumulatively added to cloud servers allowing every self driving car to have an incredibly large experience pool to learn from. Initially, much was touted about how self driving vehicles were largely a positive phenomenon and would make the notoriously accident prone industry of truck driving safer and more reliable, reducing driver stress and saving lives. However, the notion of self driving vehicles merely complementing the work of a driver instead of replacing them is simply nonsensical. Today the main hurdle that prevents driverless trucks from being on the road is political, not technological and it is clear which political direction companies like Google are lobbying for. While most states strictly require a driver to operate road vehicles, states like California have recently passed, under intense lobbying pressure, changes in their regulatory policies that allow for self driving vehicles to operate "without a licensed driver" (Guardian News and Media, 2016). Even relatively tame legislation that lifts the requirement for long haul truck drivers to have a present backup driver, could result in hundreds of thousands of lost jobs when self driving cars appear on the

commercial market. This is especially a possibility in the trucking industry, where Reagan era policies have led to mass deregulation and union membership falling from 52% in 1978 to just over 17% today (Mengison, 2009). Automation threats to the trucking industry also come with their own special breed of political ramifications. 80% of food is transported by freight trucking and almost every industry somehow relies on trucking as a means of transporting key materials or finished commodities (Farber, n.d). Even with severely diminished unions, large scale trucker strikes could have devastating economic and social consequences, endangering the lives of millions of people and potentially grinding large portions of America's economy to a halt. All these factors make trucking automation an especially sensitive flash point in the debate on technological unemployment. Of course any conversation about transportation automation would be incomplete without discussing the future of car service operators and taxi drivers. There are currently over a million people employed as either cab or bus drivers in the United States (BLS, n.d). All over the world, taxi services have already faced a strong disruption because of systems like Lyft and Uber, which allow any person with some free time and training to become a part time cab driver. However, this trend has not necessarily reduced cab driver employment, but rather relegated it to a part time status for many people, with relevant reductions to pay, health care coverage and union memberships. The more worrying trend is Uber's autonomous driver initiative, which plans to introduce autonomous vehicles to select cities around the United States (BLS, n.d). Uber CEO Travis Kalanick has explicitly stated that this is part of an initiative to replace current Uber drivers with fully autonomous vehicles (Newcomer, 2016). Obviously, the same legal barriers, mandating drivers at the wheel of every vehicle, that are currently holding up Google from fully automating the trucking industry are posing problems for companies like Uber. But once again it is clear that for taxi services, much like for commercial trucking, it is not technical mishaps that prevent mass unemployment , but rather a lack of political will. There have also been numerous more speculative advancements in transportation automation that are worth mentioning. In 2016, the US Department of Transportation announced that it would be forming an advisory committee on automation in transportation. Beyond simply focusing on freight trucking, the committee has been

designed to also look at the effect of disruptive technologies on "aviation automated navigation systems technologies" as well as developments in "unmanned aircraft systems" (Department of Transportation, 2016). This inquiry is not merely hypothetical but is in fact a response to several real disruptive effects of automation on aviation technologies. Today air traffic control centers with increased levels of automation are the norm in most modern airports from Singapore to Scotland, and by most accounts they are more efficient and reduce stress on all their employees, without any drops in employment (Xuan, 2016). However the main concern related to the automation of air traffic control systems is not in fact one employment. The main concern is that increased automation of air traffic control systems will have a noticeable deskilling effect. Now normally deskilling is a mild side effect of automation, leading to a worsened salary and a more boring job for the workers in question. However, in aviation deskilling can be a massive national security risk due to the very real possibility of air traffic controllers being simply untrained and understaffed to perform their duty in the event that the automated system stops functioning. This potential problem has been recorded in simulation exercises run by West Point, and has been repeatedly pointed out by former employees (Rovira, 2010). Overall, this should indicate that in certain limited high risk applications the complementary benefits of automation may breed complacency, resulting in serious security risks.

In addition to trucking there is a litany of other service sector jobs whose automation may have a significant impact on US employment. Perhaps the most significant but mundane occupation that may soon be automated is fast food work. Given America's economic transformation into a service economy, it is unsurprising that employment in food service has been growing at an accelerated pace over the past decade, with an above average government projected growth rate of 10% in the decade to come (BLS, n.d). All in all, restaurants today employ nearly five million workers as cooks and servers (BLS, n.d). However, despite the government projections, the fact is that most restaurant work is routine, requires minimal human interaction, and no creative thought making the industry ripe for automation. Today separate fast food institutions have slowly but surely partially automated their restaurants. McDonalds, Carl Junior's, and countless grocery stores

have all replaced many of their cashier positions with kiosks (Johnson, 2016). Furthermore, today there are numerous startup restaurants that have made far more radical shifts. Eatsa offers quinoa bowls impersonally with no waiters or service staff to greet customers (Peterson, 2016). Zume pizza, on the other hand has fully automated pizza making, with a limited number of staff exclusively assigned to deliver the food to customers (Entis, 2016). Furthermore, prototype technologies are already available which allow robots to do such dexterous tasks as grilling burgers to order. The only upside to this disruption is that the food industry has not been known to provide a stable incomes for the middle class, but rather it typically provided entry level positions with a high turnover rate for temporary workers. Part time and temporary low skill work can always be found in great abundance, from house cleaning to street sweeping and is projected to increase greatly in the coming years because the digital economy has in fact created thousands of temporary jobs and part time jobs that simply didn't exist in the past.

Up to this point, in the portion of the service industry that has most successfully resisted automation has been in healthcare, where until very recently much of the relevant diagnostic and administrative information was stored in handwritten documents, or otherwise in difficult to transcribe audio logs. In fact, despite all the high technology that the modern healthcare industry utilizes, it is difficult for most people to imagine an automated healthcare system precisely because at its root healthcare professionals must regularly deal in a sensitive way with people at their most human and vulnerable moments. Ascribing that form of duty from a doctor to a technician or even a machine seems both counterintuitive and even cruel. Moreover, despite the chronic inefficiencies and rampant medical errors that exist in the US healthcare system, American trust of healthcare professionals to most effectively address their health concerns is over 90% (Pew Research Center, 2013). It is also difficult to overstate the importance of the healthcare industry in the United States, not simply because of the immense public and private yearly expenditures on it or because of the 14 million people that it employs but because it is vitally import for the health and safety of the entire country. In terms of employment, healthcare does not simply comprise one of the largest portions of the service sector, but has the highest

projected growth rate of any US industry, at approximately 19% (BLS, n.d). This owes itself to a combination of expanded healthcare coverage and a rapidly aging US population. These new jobs are projected to be diverse, ranging from nurses to technicians and healthcare administrators. They are also, broadly speaking, expected to pay a decent wage. So if projections for job growth are largely positive, both in number and in income, it begs the question as to whether healthcare will thrive even if other industries are hurt by automation induced unemployment. Automation in healthcare can be applied to several different fields, with differing effects on wages and employment. Healthcare administrators, who by some estimates comprise up to 25.3% of healthcare costs, are automatable the same way most other secretarial, managerial, and administrative positions are (Adamopoulis, 2016). In particular, there is a strong moral and economic incentive to automate medicinal administrative tasks, given that it is precisely administrative errors that often cause serious harm to patients and consequent lawsuit related financial losses. One of the most frequently cited causes of medical error is miscommunication, most notably in a written form (Hughes, 2008). Simple errors in handwriting alone have likely resulted in thousands of deaths. Brightmd, Averinformatic, and Athenahealth are all part of a new wave of corporations which attempt to gather, streamline, and analyze electronic medical records using a combination of deep learning technology and cloud computing ("Automated Patient Intake", 2016). Often these groups do not simply record and analyze known medical information but go beyond this by providing constantly updating personalized data from individual patients. Where previously patients would go see the doctor periodically and report changes to their health into a poorly managed system, today wearable technology can regularly update doctors on a daily basis on the condition of the patient allowing for earlier diagnosis and superior preventative medicine. Systems like SweetSpot Diabetes Care and Blue Star help diabetics test and monitor their condition, while also providing valuable data to their physicians ("DexCom, Inc. Announces Acquisition, 2016). Other systems like Dr.Chrono allow doctors and patients to regularly share and keep track of medical information via an Ipad app ("Medical Application Directory", n.d). But by gathering vast amounts of data, these corporations form the foundation of more powerful and controversial forms of medical automation, in which artificial

intelligence provides diagnostic support to physicians. As mentioned previously, “expert systems” designed to diagnose diseases based on external symptoms have been in development for over thirty years. Today, IBM’s Watson supercomputer, the same one responsible for winning at Jeopardy, is being trained to diagnose cancer (Kohn, 2013). The greatest advantage that computers have over humans when making a diagnosis is their ability to peruse, cross reference, and utilize the immense amount of new critical medical literature that is available in medical journals on a yearly basis. This ability allows machines like Watson to avoid many of the biases that commonly plague doctors, which often stem from a non comprehensive or insufficiently recent knowledge of the relevant medical literature. While few trials have been conducted, the evidence that is available suggests that computers like Watson are able to consistently diagnose patients more accurately than most doctors (Steadman, 2013). This is doubly true in fields like radiology, where companies like Entilic have shown that they could use deep learning to scan images of human tissue and more accurately diagnose cancer than radiologists, with fewer false positives and false negatives (Eugenios, 2015). Given that much of the analysis of diagnostic scans has already been offshored, with foreign experts from India and the Philippines rendering a diagnosis, it would not be surprising if this process was fully automated to increase accuracy and reduce costs. Even diagnostic tasks in subjective fields like psychology may be automated. Today, one of the most successful examples of this is Ellie, a robot therapist that uses visual scanning and auditory cues to diagnose PTSD in soldiers with the same accuracy as military psychologists (Stone, 2015). Much like administrative errors, errors in diagnosis are often fatal and cost thousands of lives per year, making robots a generally attractive option for second opinions. While such technologies are unlikely to cause doctors to lose their jobs, they may have a host of unexpected side effects. Such technology may provide a more affordable medical alternative short of a doctor’s visit for millions of Americans. Today, Americans already use Web Md, a crude systems that involves imputing symptoms and receiving an often misleading diagnosis. One could imagine that a better alternative in the future would be a Skype consultation with a doctor, nurse, or even a medical technician who would input the relevant diagnostic data into an expert system like Watson to produce a diagnosis. This would be especially possible

with many of the remote wearable devices which track important vital signs that are available today. Even if the patient still has to visit the clinic, simply being able to get a temporary consultation with somebody with a lower medical education than a doctor may be remarkably helpful if this person has artificial intelligence providing a second opinion. All of this is especially relevant given that the US is expected to have a doctor shortage over the next few decades. Another possibility is that diagnostics may be relegated to low level work thanks to AI, forcing doctors to train primarily in more applied fields, like surgery and physical therapy. This would cause some doctors to become upskilled into professions like surgery while other doctors could conceivably be downskilled to medical associates or technicians. In any case, this does not pose any particular threat to employment. Nurses would also be difficult to automate, though for different reasons. Nurses do not necessarily perform highly creative tasks, but their work often involves a large amount of mobility and human interaction in unstructured and sometimes unpredictable environments. Today autonomous robots are capable of performing some of the logistical tasks that nurses do on a daily basis. For example, Atheon's Tug robot is currently able to autonomously roam hospitals and deliver basic necessities like towels, food, and even drugs ("TUG Robots in Healthcare.", 2016). Other robots such as RoBear are capable of doing tasks that nurses find physically demanding, such as lifting elderly patients out of their beds and putting them back in (Stuart, 2015). In practice such machines effectively free up time for nurses, but do little to replace them. Perhaps, the only element of the healthcare industry that may be fully automated in the near future, rather than streamlined or redefined, is pharmaceuticals. Pharmacy workers have long used machines to count, categorize, and even distribute medicine. Their work happens to be routine, often taking place in a confined and heavily regulated environment. While pharmacists need to have a very strong education for the job, this is mostly because they need to have a near encyclopedic knowledge of adverse drug interactions in order to prevent medical error and safely and responsibly distribute highly regulated substances. Various types of software have already been developed which are able to recognize adverse drug interactions and warn pharmacists about them. It is unsurprising then, that there are pharmacies today that have been fully automated. From Hanouver County to

the University of San Francisco, there are already a handful of fully automated pharmacies which deliver millions of drugs to patients every year ("UCSF Robotic Pharmacy, San Francisco.", n.d). There are no studies that suggest that these automated pharmacies have any higher rates of medical error than their human counterparts and in the long run they are also cheaper to operate. However, this does not signal any real decrease in employment in the pharmaceutical profession since pharmacists have for years been utilized as alternative physician's assistants. This means that pharmacists can easily apply their training to diagnostic and treatment tasks, which when complemented with powerful artificial intelligence could produce results that are cheaper and maybe even more accurate than doctors. Today, some pharmacists are already lobbying the government to be accepted as primary care physicians under certain circumstances (Jacobson, 2013). Overall, the medical profession will likely be one of the few to truly thrive off of automation, undergoing a powerful transformation involving the personalization and streamlining of patient diagnosis and care, while offering one of the last vestiges of new employment in America.

To conclude, it is important to take a larger comparative perspective of tertiary sector industries in relation to the secondary sector. Despite strongly relying on manpower, secondary sector businesses typically only spend between 20-30% of their overhead costs on laborers, while the rest goes to improved technology, infrastructure, etc. This is partially because much of the work that is done in the secondary sector is strictly physical, and partially because it has been the place with the most technological innovation over the course of almost two centuries. In contrast, employers in the service sector, which has only recently encountered automation technologies, often spend over 70% of their overhead costs on workers. These costs may be driven up in the future because of policies like universal healthcare and the minimum wage. Both of these policies strongly encourage downsizing, due to a higher strain on employers to pay wages and health care coverage. This provides an incredible economic incentive to automate labor in the service industry. More importantly, because most white collar jobs within the service industry do not require any meaningful amount of physical work, many automation technologies come in the form of software, which is both easier to produce and cheaper

to purchase than the bulky machines that often streamline work in factories. Much like in the secondary sector, entry level positions in the tertiary sector are being systematically displaced, causing fewer opportunities for people with little education. The positions that remain may have some nefarious downsides. A common complaint among factory workers has been the alienation that they experience from doing repetitive, often mind numbing work while being monitored minute by minute for efficiency. While it's true that automation has been successful at clearing up routine tasks, it has also introduced the same type of industrial monitoring into the service sector that was previously only encountered in the secondary sector, making work more stressful. Smart systems actively gauge each minute task such how long drivers have been on break, or how long waiters take to deliver food, comparing the data against other monitored workers. This type of analytics may increase efficiency but is also likely to increase both worker stress and alienation, making a lot of remaining work far more stressful. This can potentially even apply to creative labor, as greater tracking can force scientists and journalists into a more scheduled and rigorous mode of work. Of course this is unlikely to affect the doctors, lawyers, and journalists at the top of their profession but that is precisely the point. Formerly middle class work may become hyper competitive, stringently monitored, deskilled, and alienating. This, in conjunction with the polarized wages caused by automation, may breed political instability and discontent. There are also some positives to be mentioned in relation to mass automation of the service sector. Law, healthcare, and administrative services are all industries that have components in the private and public sectors. In the public sector, these services are often inefficient and underfunded because of a poor profit motive. This causes a situation where the least advantaged groups of people suffer from subpar social services, which is especially relevant when these services are meant to bring them justice or save their lives in an emergency. Automation in this sense will lower the costs of public services for the taxpayer and may make some modest private services more available. Even if a robot lawyer or a technician assisted AI doctor will not be as personable as real public servants, they will certainly provide much needed assistance for low income families. Overall, it is clear that in

the future every profession will have to contend or cooperate with artificial intelligence, perhaps fundamentally transforming it in the process.

Chapter 3: Contours of an Automated Future

Up to this point our analysis has examined what jobs are at risk of automation, and provided some narrow consequences that automation of particular types of work may have. In order to better envision the form in which structural unemployment may take in the future, it is important to provide alternative ways to

categorize the coming job losses. The first significant avenue of approach would be geographic, in order to pinpoint which areas will be most affected. The second avenue would be broadly statistical, providing a general view of the political, social and psychological effects of unemployment and labor polarization, regardless of what particular form they may take. Once the location and the symptoms of automation have been addressed, only then can more speculative projections of more precise future scenarios.

As noted earlier in the text, when the Industrial Revolution occurred in England, it signaled a mass migration from rural areas to cities, fundamentally changing the institutional characteristics of English society. The moving of factories off of US soil along with the automation of manufacturing labor in the 70s cut a concrete swath through Ohio, Michigan, Indiana, New York, and Pennsylvania, depopulating massive cities like Detroit, and creating a Rust Belt of destitution in its wake. These areas in turn became the face of the white working class, an increasingly radical and highly influential group of voters in the United States. If we are to imagine a future of technological unemployment, it is imperative to know where the next Rust Belt could appear. Taking data from the Oxford Martin study and cross referencing it with data from the Bureau of Labor Statistics provides a clearer geographic picture of the future. My methodology involved the construction of three metrics, each of which measured the risk of automation in a unique way. The first two metrics were constructed by recording all the jobs that the Oxford Martin study estimated had at least a 75% chance of being automated by 2025, along with all the jobs that had only a 25% chance of being automated. To simplify further descriptions and to prevent undue verbosity, jobs with at least a 75% chance of automation will be called vulnerable and jobs with a lower than 25% chance of automation will be called robust. Comprehensive employment statistics were then used to approximate the amount of robust and vulnerable jobs in each state. The two resulting numbers were then taken as a percentage of each state's current employed population. Hence, the first metric represents the percentage of vulnerable jobs in each state in relation to the state's population and the second metric functions the same way as the first metric but instead tracks robust jobs. The third metric takes the first and divides it by the second to create an instability index. Any resulting number higher than 1

indicates that there are more vulnerable jobs than robust jobs in a state. All three of these metrics were separately plotted on maps of the United States in order to find any useful geographic pattern that might emerge. Finally, these three metrics were cross referenced for correlation with each other and with five independent factors, comprising of a state by state poverty index, income inequality index, GDP per capita by state, political affiliation, and current unemployment. A Pearson product-moment correlation coefficient was then constructed using the formula $r = \frac{\sum_{i=1}^{n}(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_{i=1}^{n}(x_i - \bar{x})^2}\sqrt{\sum_{i=1}^{n}(y_i - \bar{y})^2}}$ and used to determine the relevance of each property. This was done to provide further context for the geographic analysis. All relevant tables and graphs appear in the Appendix.

The results were decidedly mixed. Initial results indicated that, in contrast to more localized phenomena like the Rust Belt, all states in absolute terms would be hard hit by automation, with percentages of vulnerable jobs varying from 22% to 37%. Equally disheartening is that the instability index was almost universally higher than 1, with the District of Columbia and Massachusetts being the only outliers. Even more worrying was that the percent of vulnerable jobs had a strong negative correlation with the percent of robust jobs, indicating that states that would be hit the hardest by automation would also have the fewest robust job roles for people to migrate to. No correlation was found between the state by state poverty rate and any of the three metrics. The same goes for the state by state Gini coefficient, which measures income inequality, and the state by state unemployment rate. For the voting statistics, Gallup's Democratic Advantage (DA) statistic was used, which simply subtracts the number of polled republicans from the number of polled democrats in a state. The number of vulnerable jobs and the instability index per state actually had a moderate negative correlation with the DA statistic. Similarly, the number of robust jobs per state had a moderate positive correlation. This indicates that states that are more likely to vote Republican are also more vulnerable to automation in the future. The relationship may be dialectic, with pro-business Republican policies paving the way for automation and automation encouraging more desperate voters to vote for a nativist Republican Party. The strongest correlation,

which was still quite moderate, was a negative correlation between each state's GDP per capita and the number of vulnerable jobs in the state. Similarly there was a strong positive correlation between each state's GDP per capita and the number of robust jobs in the state. This correlation is the least interesting since it simply fits the common sense narrative that states with more high income residents will be less affected by automation. The statistical outlier that stood out the most was Washington DC. Washington DC had by far the lowest instability index, deviating by as much as .5 from its nearest competitor, with 50% more robust jobs than vulnerable ones. In a time of populist movements, this level of security is a testament to how alienated Washington DC is from the rest of the United States. Also of interest was the fact that Washington DC had the highest level of inequality (as measured by the Gini Coefficient) of any location measured. While correlation between the Gini Coefficient and the Instability Index is relatively weak (-0.44), it is hard to ignore the fact that the area with an economy that is most prepared for automation happens to also have the worst inequality in America. This, in and of itself, is a worrying indicator. Geographically, the states that had the highest instability index were geographically concentrated in the central Northern states and portions of the South. If there will be a new contiguous Rust Belt that will function on the state level, as opposed to city or county level, it would be located in two groups of states. The first is Minnesota, Wyoming, North Dakota, South Dakota, and Nebraska. The second is Louisiana, Mississippi, Alabama, and Florida. Of course this miniature analysis has some notable limitations. Even the Rust Belt was far from uniform in its effects on states, damaging large parts of New York and Pennsylvania while leaving others almost entirely unaware of the infrastructural change. A county level analysis would be a fitting future avenue of research. However, to complement this analysis it is interesting to look at a similar one done in January, which instead focused on the risk of automation for major cities. This study was a followup to the original 2013 Oxford Martin study. The conclusions it came to were largely consistent with the geographic analysis presented in this paper. The effect on cities mimics a concentrated version of the effect on states, with cities uniformly losing over 30% of their labor force to automation, with a variance of sixteen percentage points, almost precisely the same as the result in my study (Osborne, 2016).

Moreover, almost all the lowest risk cities were located in states that were themselves low risk. The key difference is that the high risk cities that the study suggested had no correlation with the high risk states that were determined in my study. The final thing to note is that much like in the study presented here, the new Oxford study determined Washington DC to be an outlier, even among cities. From this additional information, it can be more firmly concluded that automation will have a strong effect on employment in all parts of the country, states that will be harmed less in total may still have highly vulnerable cities, and that in regards to automation, Washington DC will be alien to America.

If a broad conclusion can be made that there is a substantial risk of unemployment in the United States in the near future, it is important to see if there are political, social, and economic effects associated with unemployment. One of the most significant general factors about unemployment is that, much like many other negative economic conditions, it tends to lock people into vicious cycles on personal and social levels. On a personal level unemployment has several well documented effects. Financially, people who are unemployed experience a drop in lifetime earnings, assuming a weak system of social welfare, and generally find it more difficult to find work the longer they remain unemployed, regardless of job experience. Unemployed people, because of a lack of income, tend to make poor consumers, purchasing only what is necessary and doing little to stimulate the economy. Furthermore, the psychological effects of unemployment are severe, correlating with a host of negative conditions, ranging from anxiety and chronic stress to a higher risk of suicide along with a general sharp increase in mortality (Preti, 2003). Going hand in hand with the cascading problems related to finding work after long term unemployment, psychological symptoms of unemployment are known to increase in severity with duration. The psychological effects of unemployment also increased in severity when other significant economic problems are present, most notably high income inequality (Moser, 2009). Psychological symptoms, particularly stress, lead in turn to physiological problems, primarily in the form of chronic illnesses (Moser, 2009). In addition to causing personal psychological problems, unemployment has many interpersonal effects. In particular it has been linked to increased chances of divorce and marital strife (Clifford, 1997).

Unemployment has been shown to lead to increased family conflict, higher family stress, and lower educational attainment for children (Clifford, 1997). In general, unemployment has been shown to cause ripple effects, reducing the overall quality of life of whole families in numerous quantifiable ways. In turn, this leads broader social problems related to unemployment, such as poverty, crime, and social isolation (Gallie, 2003). The link between unemployment and aggregate criminal activity remains controversial, but sectors of criminal activity, such as property crimes, are strongly related to high unemployment (Winter-Ebmer, 2001). Criminal activity is especially a concern with unemployed young men. In addition, on a larger scale the general decrease in consumption associated with unemployment can lead to severe economic problems and can spiral into recessions or even depressions. On a political level, despite common misconceptions about unemployment consistently leading to fascism and totalitarianism, the reality is that unemployment is actually negatively correlated with extreme right wing voting (Bjørklund, 2007). However, historical precedent generally tends to suggest that unemployment is somehow linked with political instability, though there have been few quantifiable studies done on the subject. There is some evidence that many of the negative effects of unemployment, especially on a personal level, are made less severe by a functional welfare system (Bjørklund, 2007). In addition, the data has generally shown that blue collar workers suffer more stress while unemployed than white collar workers, which is a silver lining given that much of the unemployment in the future will be targeted at white collar jobs (Bjørklund, 2007). Unlike unemployment, which is a personal and social metric, income inequality is first and foremost a social condition, not independently experienced by any single citizen. Given that one of the most predicted effects of automation is the hollowing out of middle class work, it is important to review the existing literature on the societal effects of such a phenomenon. On the broadest level, meta analyses of income inequality have indicated that a wide variety of social problems, ranging from violent crime and imprisonment rates to pregnancy and increased infant mortality, are positively correlated with income inequality in rich countries (Pickett, 2009). Most notably, one of the strongest known correlations regarding income inequality is its negative relationship with social trust and social cohesion (Pickett, 2009). Moreover,

increased income inequality has been known to have differing effects on various demographics, being correlated with a notable weakening in the status of women and, in the case of the United States, an increase in racist convictions (Pickett, 2009). Much like with issues of unemployment, it is controversial whether income inequality has any real effect on political stability, with studies showing largely contradictory results. However, it is obvious that in countries where the rich hold considerable political clout through lobbying, an increased labor polarization would also concentrate political power in the hands of the wealthiest citizens. When looking at income inequality and unemployment in conjunction and the social ills that emerge with them, it is clear why there is good reason to either avoid these conditions altogether or to try to mitigate their harsher effects.

Chapter 4: Scenarios and Conclusions

Now that a broad geographic analysis has been done and the social symptoms of the economic problems of income inequality and unemployment have been addressed, a more general picture has emerged that can be used to build more specific scenarios. The general picture is that in the next 10-20 years, technological unemployment will cause significant disruption around the United States, with both cities and rural areas strongly affected and with some particular focus on two geographic regions mentioned previously. Moreover, this unemployment will likely be compounded by the general trend of income inequality that has been consistent in America over the past few decades. Both the unemployment and the income inequality will likely cause adverse and well documented personal and social effects. However, the exact form in which this financial shift will take place will strongly influence how much the more negative effects can be mitigated. With the general contours in place, it is now possible to speculate on and categorize the more general scenarios that may arise in the not so distant future. Since these scenarios are particularly diverse, the best way to categorize them may be by the actors most involved in crafting them. This is to say that in an automated economy, the general public, entrepreneurs, and the government can all take actions that will drastically influence the general livelihood of the nation and can mitigate or exacerbate existing economic trends. Hence, any scenario would have to take into account a range of responses by each of these groups.

The first useful group to look at would be businesses which may have the most agency regarding their reaction to technological unemployment, especially given the fact that it is ultimately the businessman's choice whether to lay off workers and buy labor-replacing software/machinery. The first reaction is that businesses may largely continue the race to the bottom, automating large amounts of work with little worry for the well being of displaced laborers. This approach would likely be devastating for the general public and may have some unexpectedly negative side effects for the businesses. The key side effect would be less purchasing power

for consumers because of the inevitable rise in unemployment, and therefore lower profits for the corporations selling the goods. The scale of this drop would be hard to predict and economists disagree on whether or not it would be large enough to encourage companies to keep more of their workers, but it's certainly an effect worth considering. Complementing this aggressive cost cutting response, the need for people to earn wages might be filled in by corporations which offer to help connect millions of people to do various forms of part time work that, when patched together, would functionally replace full time jobs. This would essentially be a nationwide expansion of what is today known as the "sharing economy", coined as such because it involves average people hiring each other through a corporate middleman to do diverse part time labor. I categorize this primarily as a corporate choice, because it is impossible for large amounts of people to live off this sort of labor without fast, easy access to a database of work. These sort of part time jobs are already highly diverse, ranging from renting out your home using Airbnb, to working as a temporary driver for Uber, to doing various odd jobs with TaskRabbit. Normalizing this sort of decentralized work will have its upsides and downsides. The key advantage of having a dozen different diverse jobs is that it may make for more robust employment, with any single loss of employment causing only minor harm to overall wages. Working hours would inevitably also be more flexible, with most people becoming self employed in some way. At first glance, this sort of mass self employment may even look like the famous scenario described by Marx where a man can be a "A farmer in the morning, a laborer in the afternoon, and a philosopher in the evening". On closer inspection however, this scenario quickly becomes more disturbing. The key problem with this scenario is that traditional full time jobs offer significant protections, ranging from health insurance to overtime pay and vacation days. A fully decentralized economy would also likely pay its workers less, with part time employment rarely leading to good wages. Finally, it is difficult if not impossible to unionize in a "sharing economy". It is hard to argue that, regardless of any benefits that self employment provides, working a plethora of part time jobs would be done out of anything other than desperation. Furthermore, if the geographic analysis is largely accurate, many of the areas worst hit, like North and South Dakota, would be primarily rural, making it difficult if not impossible to

do the odd jobs that might be found in more concentrated urban environments. If such behavior becomes normal with no governmental or business intervention, one can imagine a mass exodus from the countryside to cities, at a similar rate to what was seen during the first Industrial Revolution. Cities, according to the secondary geographic analysis in turn would have higher than average unemployment. Hence, this may result in overcrowded cities with high unemployment where everyone is constantly involved in small part time work to make ends meet. A compatible offshoot of this idea involves a reversion to artisanal labor, in which millions of people handcraft various goods at home and sell them through a centralized online vendor. This phenomenon already exists in the form of Etsy, an online marketplace for homemade wares that 1.4 million Americans currently use to sell their goods ("Discussions", n.d). Of course there would be several problems related to this. The first would be that, despite the success of companies like Etsy, the fact of the matter is that people making handmade goods from home would still be competing with much cheaper goods sold by large corporations such as Walmart, which at this point would be able to undercut prices even further because of their lower costs of labor. This would be complemented by the fact that consumers in such an economy would naturally have less money to spend on goods. So, in this dystopian scenario, a significant portion of the economy would involve desperate artisans who would compete to make handcrafted luxury goods for the upper class. Of course in any case the key benefactors to this sharing economy would not be the general public, but rather the few people that help found and work for the highly profitable corporations that create the marketplaces themselves. There are of course, alternative and more benign responses that businesses could have to more efficient automation technologies. The closest to the one mentioned previously, is for businesses to use the same type of organization and data analytics that allow them to create "sharing services" and use them to more efficiently connect full time employers with workers, making the economy more efficient. While this will not remove the unemployment caused by automation, it would make the process of employing people for the jobs that remain more efficient. Such services already exist to some capacity, with Linkedin functioning as a social network where workers and businesses can effectively meet. The implementation of more intelligent and personalized

technologies to the process would certain provide mild alleviation to the unemployment problem while stimulating the economy. One of the most challenging but powerful responses would be for businesses to creatively find ways to more efficiently allocate their human workforce, allowing technologies to augment, rather than replace human workers. This is the solution proposed by Thomas Davenport, a renowned adviser at Deloitte analytics (Kirby, 2016). He has suggested that most businesses in a post-automation world can greatly improve their productivity and expand by hiring people to do less structured work, such as charismatically selling their products, monitoring their machinery for errors, or creating work that requires broader decision making. While this solution sounds tempting, many of the new augmented jobs that Davenport has suggested are not entry level positions given the large amount of creativity required for them, and those that are entry level positions tend to require education that many people simply don't have.

While certainly the group to have its livelihood most affected by automation, the general public is likely to be in the least powerful position to mitigate its effects. If there is a period of high, sustained unemployment with minimal government intervention, one of the first reactions of the average person will be to find some alternative form of work. This work is typically provided by businesses, whose general range of decisions have been described earlier. Even self employment, as we have seen, only becomes a reasonable form of work for millions of people if businesses can solve many of the associated logistical problems. There is, however, a narrow range of behavior that entirely depends on consumer initiative and is largely independent of government or business involvement. One type of behavior involves low level criminal activity. People may increasingly turn to illegal market activity such as drug dealing and prostitution, which regardless of automation will likely continue to be human dominated, have a high demand, and have decent earnings for part time work. This may be especially likely if there is a large displacement of white collar professionals, many of which are already familiar with managing supply chains and doing administrative tasks. Depending on the regulations present, more consumers may turn to legal entrepreneurial activities. However, given the risks involved in business, such a choice would strongly depend on the incentives that the economy and the government provide. Another

choice that people could make in this scenario would simply be to more actively seek an education and to stay in school longer, in hopes of meeting the minimum requirements for a more qualified workforce. While it is tempting to say that this is a positive outcome, the reality may be more dubious. More education would mean more people in debt. Recent trends have already indicated that, while higher education makes sound economic sense as an investment today, the value of a bachelor's degree has been steadily decreasing (Ip, 2008). In the event that there is an even sharper increase in people attempting to get an education, severe degree inflation may result with associate's and bachelor's degrees becoming nearly worthless. Another more confrontational consumer response may involve new types of consumer activism. Today, portions of the population boycott certain goods or prefer others due to ethical concerns, such as avoiding purchasing products made by corporations that exploit workers. One could imagine a machine-free consumer movement that would use its leverage to force companies to employ workers. A continuation of this activist approach might be a sharp surge in unionized labor. This would have to happen prior to truly large scale technological unemployment, but would serve as a preventative bulwark to the impending automotive ambitions of businesses. There are also a host of community behaviors that, without reducing unemployment and income inequality, would mitigate some of its worse effects. The most important of such behaviors is for people to continue to encourage and organize around traditional charitable organizations, such as religious institutions, which may provide a much needed benefit in an increasingly decentralized economy. Of course the most radical consumer reaction would be Neo Luddite in nature, using violence and terror to attempt to create a distinct new cost for automation. While this would likely add costs to businesses, the reality is that such an approach would reduce businesses investments in already struggling areas and generally cause greater harm than good to affected communities.

Naturally, businesses, while powerful tend to be constrained in their decision making by larger economic forces. Consumers, on the other hand, tend to be constrained by a lack of organization and general weakness in bargaining power. The organization that independently has the most power to react to automation is the government. After all, economics isn't destiny, and government policies have often been used to protect

workers and consumers when the free market falters. Also, as an indirect participant to the market, the government is also the only actor that can be totally passive, choosing to not interfere at all with the unfolding economic situation. Government policies can be divided into five types, passive, redistributive, direct job creating, indirect job creating, and job protecting. On paper, the simplest category is redistribution, where the government uses one of several known methods to distribute tax payer dollars directly to those most affected by automation. This type of solution can take many forms, the most proportion of which by technology scholars is universal basic income. This policy, supported by such varied figures as Nobel Prize Winner Joseph Stiglitz, Silicon Valley Entrepreneur Martin Ford, and Former Secretary of Labor Robert Reich, advocates for using taxpayer dollars to give every American, from the richest to the poorest, an unconditional guaranteed minimal income ("Joseph Stiglitz Endorses Unconditional Basic Income.", 2015). Such a policy would be unprecedented in scope and unpredictable in its effects. Today, the only place where it has been attempted has been Alaska, which has given a yearly portion of oil proceeds to its citizens (*Alaska Permanent Fund Corporation, n.p*). Analysis of this policy from a very small historical sample has suggested that it mildly retards work in communities, with some controversial studies also indicating an increased rate of entrepreneurial activity. More importantly, it is entirely unclear whether such a policy would actually mitigate the negative psychological and social effects of chronic unemployment. The reality is that nobody really knows how such an expensive policy would play out in the United States and it is difficult to say whether it is politically viable under current conditions. Of course this money would have to come from somewhere, with the most commonly proposed option involving hiking up taxes on the wealthy. While this would certainly lower income inequality, such a policy would have to tread carefully to not cause the rich to leave the country. One could also imagine tax collection policies more precisely tailored toward the problem of automation which would allow for a less direct redistribution of wealth. For example, given that a large portion of AI software and robotics are patented in the United States but sold internationally, one could imagine additional taxes on international sales of these products which would go toward social policies. Of course such taxes risk driving businesses out of the US,

given that capital tends to be more easily transferable than labor. Taxes that economists more broadly recommend are consumption, and property taxes, both of which will be especially effective at targeting the wealthy without many of the negative economic incentives that come from their more direct counterparts. For people that do not like a universal basic income, it is possible to also imagine the tailored distribution of tax dollars, given only to people that can demonstrably prove that they were displaced by automation. This sort of government funded "automation insurance" would involve the government paying a stipend only to people directly unemployed by machines. This type of program would obviously have to have strictly defined criteria in order to avoid fraud.

The second category of policies worth examining involves the direct government creation of jobs. The key jobs that the government knows how to create almost all relate to construction. These jobs would involve building and maintaining American infrastructure, such as its roads, buildings and dams. Such work, as shown previously, is generally more resistant to automation than most blue collar labor, while also being remarkably beneficial for the country. There are of course downsides to such projects. The first is that almost all construction work is largely temporary, and while it's true that we may need people to fix some of our infrastructure year after year, this would comprise far from the majority of construction jobs. Another problem is that the construction industry, due to a combination of cultural factors and physical realities, has been dominated by men, with men occupying over 90% of construction jobs. If such a policy became the main avenue of alleviation for the unemployed, it would do little to help some of the most vulnerable members of society, like single mothers. Of course it may also integrate women into the construction industry in much the same way that women have been integrated into the military, but it seems to me that this is the less likely outcome. However, construction may not be the only type of work that the government may create to alleviate technological unemployment. MIT scholar Erik Brynjolfsson has recommended an alternative governmental job creation program where the government would subsidize "beneficial social works", such as street sweeping and cleaning the environment (Brynjolfsson, 2014). The notion of employing people to do virtuous behavior is an

interesting concept, though it would also exclude especially vulnerable portions of the population, in particular the elderly and the disabled.

The third category of government intervention would involve means of creating employment indirectly. Of these, the most well known and broadly accepted is the government funding of higher education as well as vocational educational programs. Historically, this type of program has been used as a long term investment in human capital, a means rewarding people who served America in its armed forces, and as a way to generally provide an opportunity for Americans to advance to the middle class. A side benefit of education has also always been a general reduction in antisocial and criminal behavior. Funding for education has historically also had broad bipartisan support in the United States, recent political trends notwithstanding. Of course, in a more tightly packed labor market with a smaller amount of jobs it would be imperative for the government to more selectively finance education than before, mainly financing majors that are currently in demand in the workforce. Beyond scholarships for vocational work and higher education, the government may even create scholarships to finance job retraining, keeping a steadily more automated workforce highly adaptable. There may also be some gains in improving K-12 education. This could be done by investing government money in newer educational technologies, such as free or low paying online courses as well as simply creating premium economic incentives for some public school educational positions. This position in particular has been strongly advocated by MIT scholar Andrew Mcafee (Brynjolfsson, 2014). Another method of creating work indirectly would be to provide increased incentives to entrepreneurs. This would mean creating entrepreneurial grants, with stipulations that the entrepreneurs would have to work for several years in states with vulnerable economies. It may also mean reducing some government regulations that limit business growth today. Obviously this approach would have to be carefully created, given that removal of too many regulations would likely make it easier for businesses to fire their automatable employees. One last relatively simple policy from this category would involve the government simply subsidizing human labor. This could be done in two ways. It could subsidize industries that are particularly resilient or it could subsidize vulnerable industries, paying

whatever extra share of profit businesses would otherwise have earned with machines as on the condition that they keep human workers. These sorts of subsidies would in effect promote many of the positive business policies mentioned earlier, in particular worker augmentation over automation. However it is unclear how much this would cost and whether in the long term it would make the United States far less economically competitive.

The two other categories of responses are worth mentioning but only briefly. Total passivity of the government in response to chronic unemployment would leave citizens entire up to the whims of businesses and large corporations, who are by law incentivized to maximize profits for their investors. It is relatively clear how asking businesses to simply regulate themselves in this scenario would be dangerous, especially given the fact that it is businesses that are expected to automate their jobs in the first place. Another general response that the government may take could be to actively protect jobs using forceful government policies. At its most extreme this would entail prohibiting the use of certain technologies or forcing businesses to keep a certain amount of workers. This type of heavy handed government intimidation of businesses would likely hurt the economy as a whole and is typically seen as one step short of government control of industry. Of all the potential responses, this one is the least likely in the United States but it is still worth mentioning primarily because internationally in countries with a more socialist lean these types of policies may become reality.

Of course, this list is not exhaustive, and there are no doubt alternative fiscal and political policies that the government may wish to pursue as a response to increased automation. However, there is one policy that is both narrowly realistic enough to be a real choice but worrying enough to cause a dystopia. This policy involves one of the oldest and most efficient economic drivers, employers, and industrial producers, known as the military industrial complex. It could be envisioned that, in absence of easy to find work, a larger portion of the population will join the military. A more militarized population often has more war-like attitudes and in turn military industries may provide ample incentives for the United States to engage in armed conflicts. This would stimulate the arms industry, likely creating jobs in the process. Ammunition, weapons, and bombs are disposable goods that stay in demand for as long as a war happens. War would also speed up research and

development of technologies and generally force the public to conform even in a time that is more socially dysfunctional and economically fragile. Importantly, such a constant state of war readiness would not need to be "hot". Even a cold war, as we have seen over the past half century sharply stimulates arms production, boosts military membership, and encourages research and development of more technologies. While such a policy might be seen as unlikely or cynical, it can't be ignored as a possibility in particularly desperate scenarios.

Given the options listed above, there are numerous general scenarios that can be constructed by mixing and matching potential responses. Of course all such combinations cannot be explored and the combinations that exist are not exhaustive but some choice scenarios can be constructed based on which based on factors such as severity and likelihood, and proceeded by a normative policy evaluation. First, it is useful to rank all the possible responses from positive to negative. For government responses, the most broadly positive involve investment in education, investment in entrepreneurial activity in poor areas, direct creation of jobs, and the creation of a universal basic income, and a combination of property and consumption taxes along with a mild increase of taxes on the richest Americans. The worst government responses would likely be, complete passivity, broad and burdensome regulations mandating businesses to keep employees, a dramatic expansion of the military industrial complex, and heavy direct taxation on corporations and the wealthy. The most positive business responses would be the streamlining of jobs searches and, ideally, incorporating a corporate philosophy focused on worker augmentation as opposed to replacement. The most negative business responses would be to continue to lay off workers at high rates and to rely on the sharing economy or government compensation to keep people employed. The most positive responses by the general public would involve increasing political participation, encouraging the continued development of charitable organizations, and attempting to get a higher education in some form. From this, several negative scenarios can be constructed.

One scenario that is very possible is the possibility of businesses blindly moving forward with automation technologies, even as the unemployment level starts to rise, and the government responding in an entirely passive way. In the event of aggressive job displacement and government passivity, it is likely that the

general public's response would be profoundly negative, with mobilized protests and increased political instability responding to worsening living conditions. This in turn would likely lead the public to vote out their passive representatives, assuming the government remains largely democratic. Such a scenario would potentially continue to grow the economy, but would happen at immense public expense and, while worryingly probable, is generally not recommended as the only possible beneficiary of it would be businesses in the short term. There are arguments that could be made suggesting that aggregate drops in demand would result from increasing unemployment, forcing businesses to rehire human workers who are actually able to purchase their goods. While this is a tempting reason to for the government to not interfere, the reality is that relationships between aggregate supply and aggregate demand areas still not fully understood and such a scenario would actually lead to further job cuts, ultimately spiraling into a depression. This scenario is especially worth noting simply because government gridlock or a heavily pro business administration could conceivably cause it to happen. The second profoundly negative scenario would involve the government increasing either taxes or business regulations to such a degree that businesses would begin to flee the country. In the event of particularly widespread technological unemployment, such a move may not actually cause many job losses, but would greatly hurt the ability of the economy to recover as well as the ability for consumers to buy cheap products. The problem with estimating or predicting this scenario is that economists generally do not agree as to what the threshold is regarding acceptable tax rates. This makes it easy to worry about over regulation of such industries, but difficult to actually make policy suggestions regarding such choices. The best advice that could be given in this case is that the government should actively listen to business leaders and vice versa, attempting to establish clear lines of communication instead of an antagonistic relationship.

A communicative relationship between government and business would provide a good starting point for the more positive scenarios that can be envisioned. Several previously mentioned government policies have particularly good synergy when combined, usually covering for each other's faults. For example, government ordered construction jobs would be highly beneficial but would need both a long term employment policy to

complement them in the form of a job retraining and education funding to make up for the lost opportunity costs that workers may have for choosing to go into construction as opposed to going to further schooling. The money for all of these programs could be gotten through sensible tax raises on the rich, on luxury products, and by incurring debt. While such a policy is doubt highly reliant on Keynesian economic assumptions, it would likely work fine in the absence of some massive disaster like runaway inflation or insolvency.

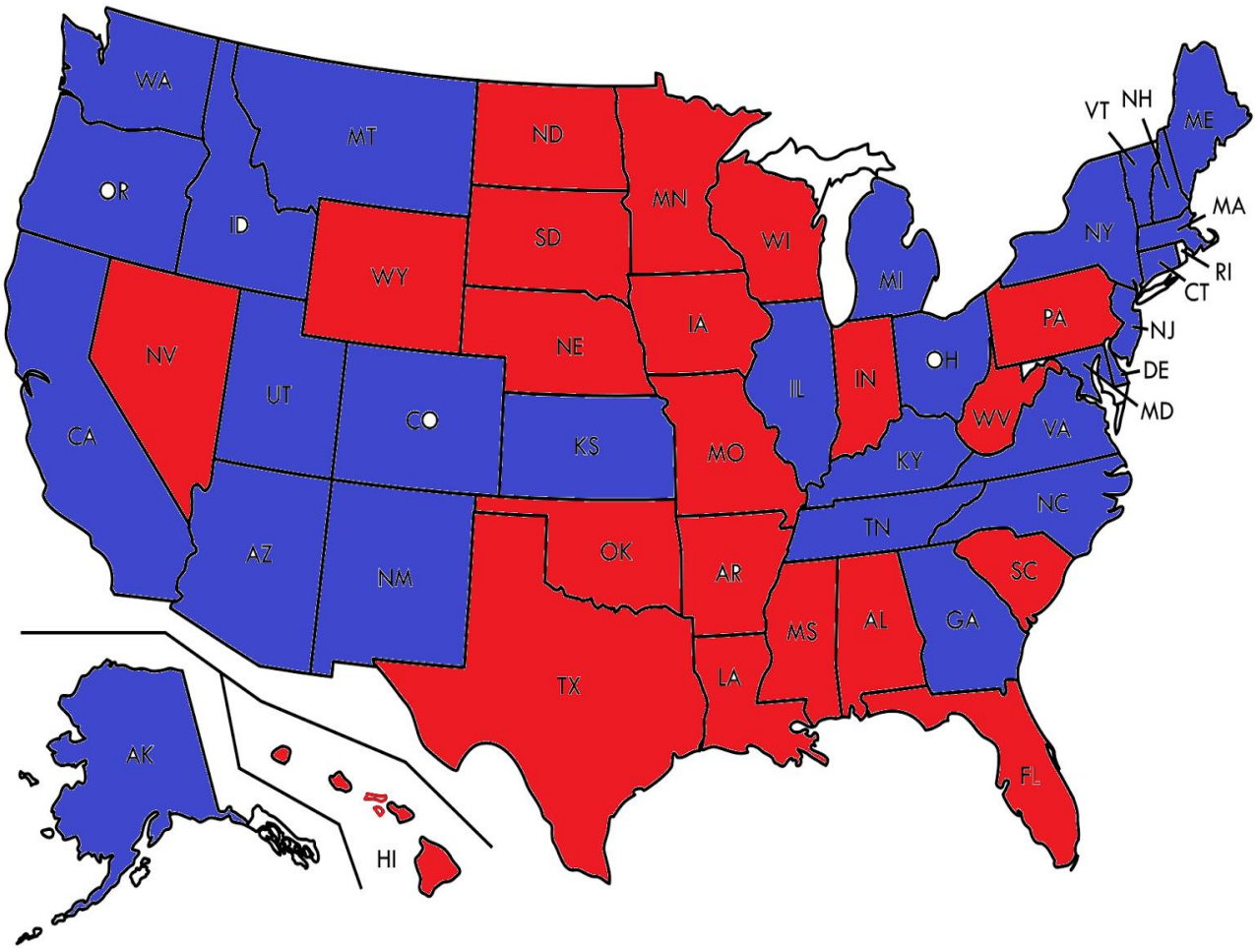
The other generally synergetic set of policies is entrepreneurship encouragement programs coupled with the institution of a universal basic income and some moderate tax increases on the wealthy. These policies are synergetic because universal basic income may already encourage the growth of small businesses, increasing the strength of a system of business enabling grants. This in turn would grow the economy and create jobs, all of which would make taxation revenue higher, paving the way for a universal basic income. Of course all of this would be under the assumption that universal basic income does not strongly decrease the amount of people in the workforce.

Today it is safe to say that to face of the challenges of automation we will need thoughtful leaders in the future, heading a government that people can trust. This will be especially important in the event of severe unemployment, however temporary. Today's political schisms provide a dangerous road map for catastrophic policy failure in the future. This is not to say that there has ever been a period of totally representative or gridlock-free government, but each real crisis in modern American history, from the Great Depression to the Cuban missile crisis, has required steady leadership and some level of bipartisan cooperation. In the face of unemployment simple solutions, whether they be market self regulation or oppressive taxes on the wealthy or nationalist consolidation of power are always easy to market but in reality do the least to alleviate underlying problems. This creates the unfortunate paradox that the most marketable solutions in a democracy, and hence the most likely solutions, tend to often overlap with the worst ones in the face of complex problems. Any politician can sell dreams of a pre-automation world, where factories still employ millions and a ticket to the middle class does not require anything past a high school degree. But these illusions are just that, and

responsible leadership ought to find a way to market real adaptable solutions to automation, without going to the old resorting to populist demagogues standbys of years past.

Appendix

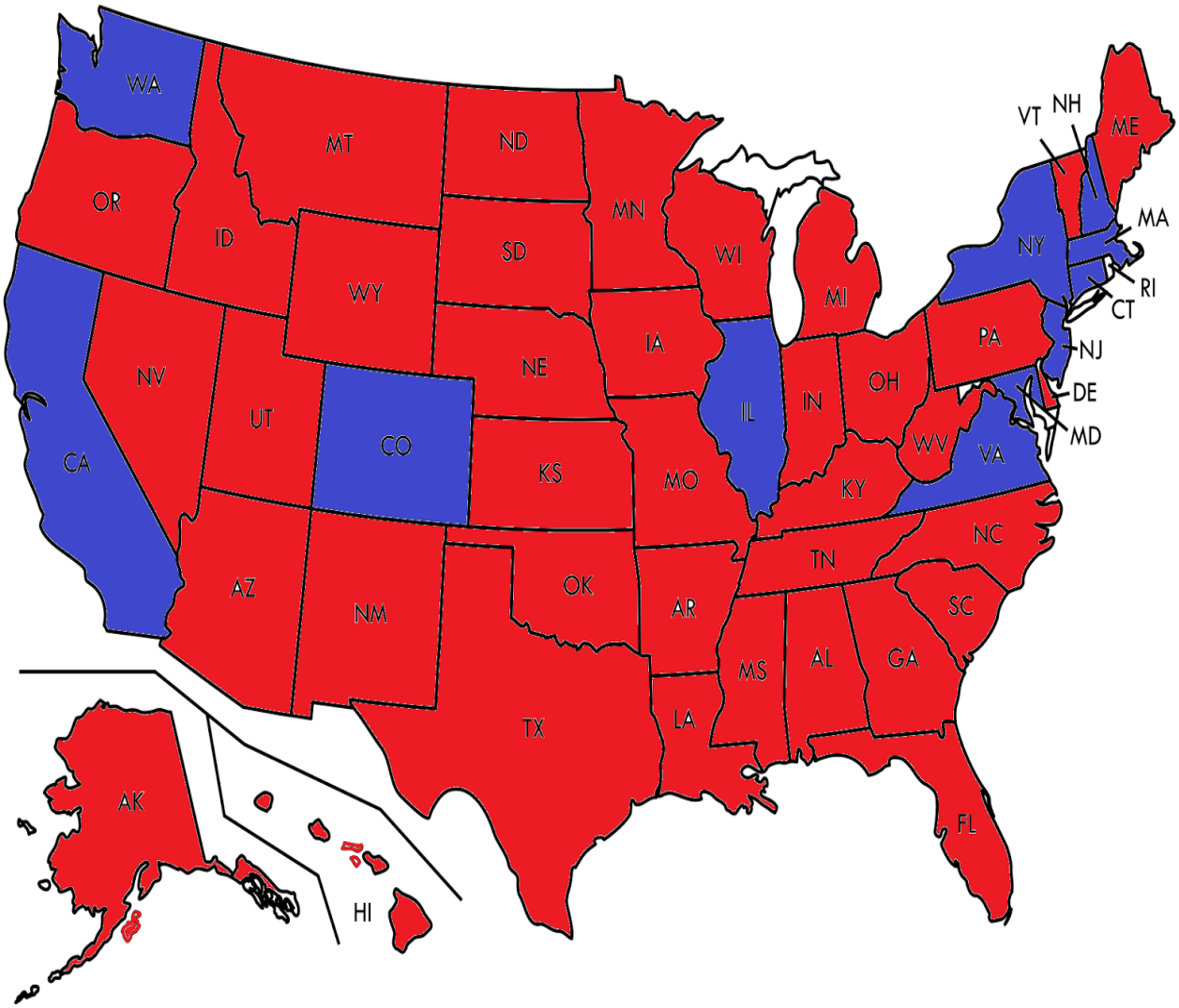
Graph 1-3 Vulnerability Percentage by State



Blue States: less than 32% vulnerable jobs

Red States: more than 32% vulnerable jobs

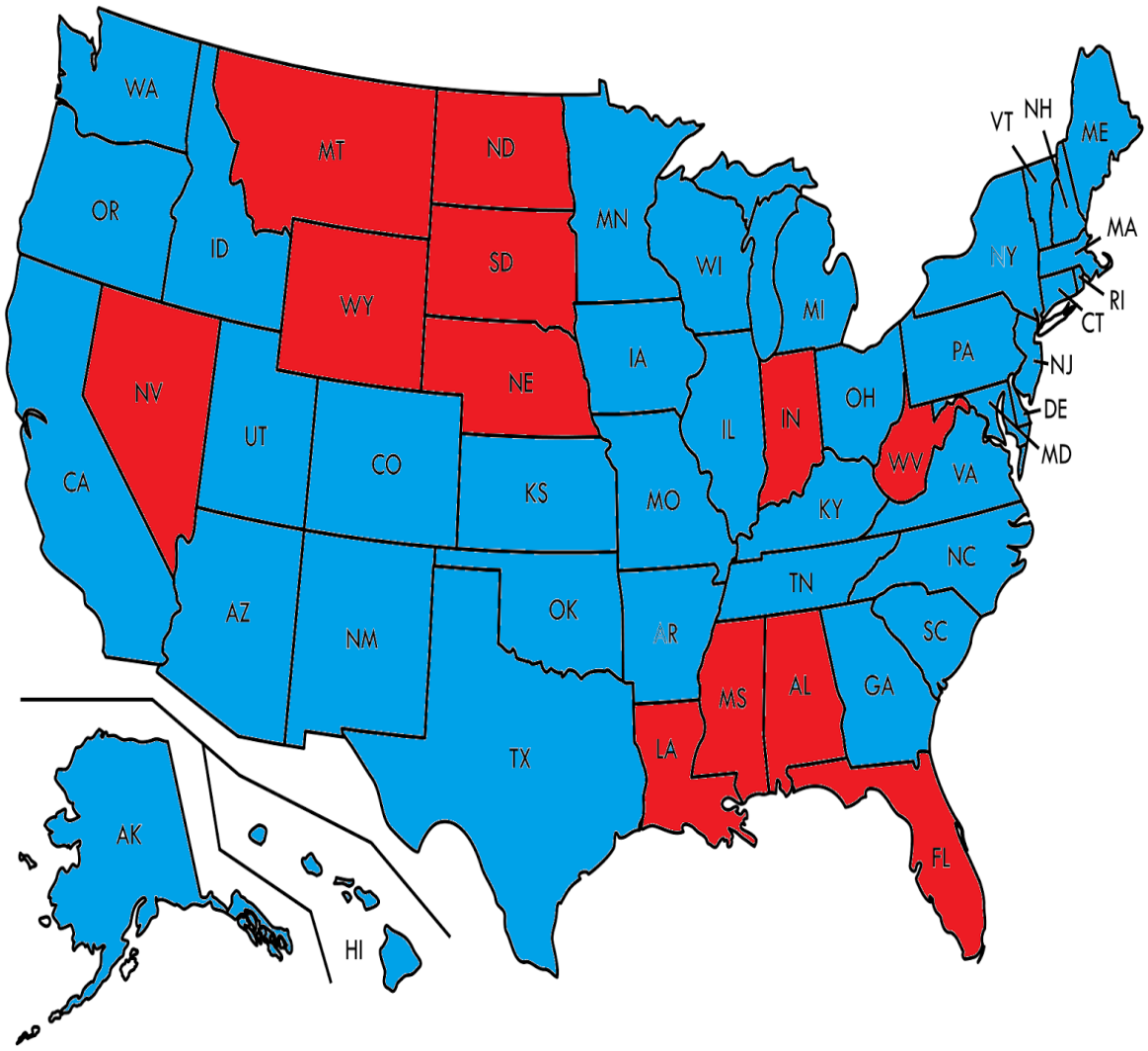
Graph 2-3 Robust Percentage by State



Blue States: more than 24% robust jobs

Red States: less than 24% robust jobs

Graph 3-3 Instability Coefficient by State



Blue States: Instability Coefficient below 1.55

Red States: Instability Coefficient above 1.55

Table 1-3

Name	Total	Vulnerable Jobs	Percentage of Vulnerable Jobs	Robust Jobs	Percentage of Robust Jobs	Instability cofficient	Partisan Split	Unemployment Rate	Poverty Rate	Gini Coefficient	GDP per capita
Alabama	1,883,310	618920	32.9	385210	20.45	1.61		6.1	0.184	0.532	181185
Alaska	327,250	102180	31.2	75560	23.09	1.35	18.6	3.3	0.117	0.475	69705
Arizona	2,587,070	783170	30.3	602320	23.28	1.30	15	4.2	0.104	0.443	60097
Arkansas	1,176,130	382960	32.6	254590	21.65	1.50	10.5	10.5	0.108	0.486	72331
California	15,496,600	4664910	30.1	3838070	24.77	1.22	-1.6	4.2	0.118	0.459	56891
Colorado	2,451,490	761640	31.1	624240	25.46	1.22	18.4	5.2	0.159	0.499	72965
Connecticut	1,659,430	477420	28.8	454220	27.37	1.05	10.2	5.2	0.111	0.464	64070
Delaware	433,840	133250	30.7	96790	22.31	1.38	15.5	5.5	0.164	0.471	61924
District of Columbia	676,060	151790	22.5	284010	42.01	0.53	9.1	5.4	0.132	0.441	62213
Florida	7,925,300	2658060	33.5	1633530	20.61	1.63	10.8	5.6	0.143	0.465	59472
Georgia	4,107,960	1291060	31.4	976230	23.76	1.32	-1.4	3.5	0.121	0.457	58009
Hawaii	619,960	203810	32.9	131350	21.19	1.55	0.5	4	0.114	0.44	60256
Idaho	642,700	205190	31.9	133040	20.70	1.54	21.7	3.3	0.122	0.444	47520
Illinois	5,852,710	1742450	29.8	1429720	24.43	1.22	19.4	5.5	0.148	0.467	53321
Indiana	2,947,380	966470	32.8	591810	20.08	1.63	-8.8	2.8	0.092	0.425	53834
Iowa	1,526,950	495120	32.4	330190	21.62	1.50	-1.4	5.2	0.182	0.455	43269
Kansas	1,371,630	434350	31.7	293030	21.36	1.48	-3.9	5.2	0.184	0.468	48574
Kentucky	1,838,220	575670	31.3	375940	20.45	1.53	11.6	6.7	0.206	0.464	41551
Louisiana	1,939,300	639350	33.0	401940	20.73	1.59	-17.2	6.8	0.114	0.422	81801
Maine	591,520	181080	30.6	132300	22.37	1.37	-3.7	4	0.14	0.437	41477
Maryland	2,596,630	736510	28.4	709560	27.33	1.04	-29.9	3.2	0.118	0.419	48965
Massachusetts	3,396,840	948510	27.9	988620	29.10	0.96	5.8	4.3	0.13	0.44	69930
Michigan	4,146,600	1289610	31.1	928260	22.39	1.39	5.8	5.3	0.164	0.449	56009
Minnesota	2,772,240	822550	29.7	663030	23.92	1.24	4	4.7	0.162	0.451	46585
Mississippi	1,106,550	368620	33.3	225020	20.34	1.64	0.2	4.9	0.158	0.452	51052
Missouri	2,712,240	877410	32.4	578070	21.31	1.52	0.2	4.9	0.172	0.464	50159
Montana	447,180	146200	32.7	92040	20.58	1.59	-10.3	4.8	0.182	0.468	46531
Nebraska	953,710	317480	33.3	203100	21.30	1.56	3	5.8	0.136	0.461	52925
Nevada	1,232,800	461680	37.4	207690	16.85	2.22	-13.1	4.4	0.135	0.445	50218
New Hampshire	635,360	195750	30.8	153680	24.19	1.27	-0.7	4.1	0.132	0.43	51456
New Jersey	3,906,800	1155720	29.6	963650	24.67	1.20	-3.3	4.1	0.123	0.427	52807
New Mexico	798,150	250920	31.4	185620	23.26	1.35	-6.9	4	0.187	0.458	41129
New York	8,984,890	2701860	30.1	2276240	25.33	1.19	-13.4	5.2	0.166	0.454	46298
North Carolina	4,125,070	1297270	31.4	904720	21.93	1.43	-7.9	5.1	0.155	0.455	47209
North Dakota	447,820	155230	34.7	91310	20.39	1.70	-12.5	4.7	0.179	0.461	40212
Ohio	5,280,850	1661000	31.5	1193700	22.60	1.39	-5.5	4.7	0.172	0.469	59994
Oklahoma	1,597,130	534970	33.5	354180	22.18	1.51	-2.8	5.1	0.19	0.466	41586
Oregon	1,735,220	533690	30.8	387440	22.33	1.38	-30	3.8	0.148	0.433	39398
Pennsylvania	5,709,480	1855910	32.5	1256240	22.00	1.48	20.8	3.2	0.115	0.433	55598
Rhode Island	471,290	137820	29.2	108930	23.11	1.27	-8.7	3.3	0.123	0.432	59175
South Carolina	1,928,140	618130	32.1	407130	21.12	1.52	-14.4	4.3	0.152	0.435	44308
South Dakota	413,260	149760	36.2	78260	18.94	1.91	-1.6	6.3	0.199	0.475	54159
Tennessee	2,814,230	878320	31.2	607540	21.59	1.45	-17.3	5.7	0.192	0.472	42663
Texas	11,572,540	3900940	33.7	2553230	22.06	1.53	0.7	4.8	0.166	0.474	42595
Utah	1,324,460	418920	31.6	305570	23.07	1.37	-6	4.4	0.152	0.44	49328
Vermont	303,550	88480	29.1	70030	23.07	1.26	-5.2	5.9	0.219	0.468	35717
Virginia	3,682,450	1081190	29.4	967700	26.28	1.12	-6.1	6	0.183	0.451	38567
Washington	2,983,930	907980	30.4	746610	25.02	1.22	-31.8	5.1	0.106	0.423	68536
West Virginia	707,000	237930	33.7	143500	20.30	1.66	-20.8	3	0.111	0.433	70926
Wisconsin	2,771,600	899230	32.4	601980	21.72	1.49	-18.4	2.8	0.141	0.442	51902
Wyoming	283,830	98930	34.9	59640	21.01	1.66	-4.1	5.5	0.154	0.448	48639

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