

The Impact of Automation on the Manufacturing Industry

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On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

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Introduction

After working as a cooperative mechanical engineer for Honda Motor in the summer of 2022, I was tasked with designing and upgrading the stations that would form the assembly lines where associates work alongside robots to create various car parts, I became especially interested in the impact of automation on the manufacturing industry. I realized that associates only place these components inside each of the units that ran across the line, but it is the robots themselves that adjust, tighten, and test the parts before they move to the next station on the line. If one were to look at the production associate role for any company on their opportunity's website, one could clearly see that the responsibilities of those associates are to mainly learn a simple procedure to assemble their portion of the final product. These procedures are usually very fast - less than a minute - but very repetitive. For this reason, associates are usually asked to rotate positions and learn three or more procedures at different assembly stations. While these manufacturing jobs are necessary for society to run, these jobs are easily replaceable by the inclusion of robots in those factories. At this point in time, most manufacturing companies are shifting to including robots to automate jobs. According to McKinsey, the manufacturing industry is projected to be one most impacted by automation, with greater than 64% of global manufacturing activities considered to be automatable (Lemay 2022).

On top of automation making manufacturing jobs obsolete, the skill level of those associates in the industry is drastically decreasing. A case study by General Electric points out that while they were hiring employees in Louisville in the early 2000s, they found out that those operator positions were “unskilled” and therefore needed additional training which cost the company time and money (Blankenship 2021). As there are fewer incentives to work in the manufacturing field, fewer workers are inclined to learn the necessary skills to be successful in

those positions. The issue then becomes a larger problem as those associates are necessary for the manufacturing industry to survive given that the cost of automation is still too high and some skills, such as testing the equipment, are still not trusted to be performed by robots. Charles Blankenship, the former CEO of GE, believes that in the near future, there will be more open manufacturing opportunities than workers available for them. This last statement is usually a disconnect between the arguments against automation: while some argue that automation will make millions of jobs obsolete, others believe that automation will not only create new jobs, but those manufacturing companies will keep their employees. While evaluating any ethical dilemma it is often important to ask ourselves who exactly is getting impacted. In this case, manufacturing employees, especially those working hand in hand with the robots in the factory, are the most affected by automation, but it is not so clear who will benefit from the new automation opportunities. In other words, for whom will be the new jobs? This unclarity is the reason why there is this disconnect. While automation itself is not to blame for future layoffs, I believe that the aggressive replacement of the American worker by modern-day automation calls for the implementation of ethical-responsible innovation in the manufacturing industry to reframe the professional responsibilities of future first-line workers. This paper will explore these ethical dilemmas by providing a background on current literature of economists and engineers, following my own analysis to conclude if the current pace of automation, as well as its impact on the manufacturing field, follows the requirements of the responsible innovation framework.

Literature Review

During the past twenty years, automation and AI have been more prominent in the United States society than ever before. Since the first automation department in 1947 run by Ford,

robots have been able to replace ordinary tools as they can easily improve their designed task and output quality for cheaper (Michael 2015). While this is a positive change for many industries, it is important to analyze this change before it is too late. Senior economist Neil Irwin describes that the next wave of economic dislocation won't come from overseas, but rather from the relentless pace of automation that makes a lot of good, middle-class jobs obsolete (Neil 2018).

While it is important to understand that automation will create new opportunities for the American workforce, the number of jobs available will continue to decrease as new robots take their place in the factory. In fact, it is estimated that automation could threaten, or at least alter, 73 million US jobs by 2030 (Manyika 2017). These numbers are very similar to other studies, such as reports from the McKinsey Global Institute, which state that up to 30 percent of the hours worked globally could be automated by 2030. This percentage is an even bigger number when we realize that this is a global study and not all countries have the technology to be automated yet. Looking at the United States, studies show that around 47 percent of total US jobs will be displaced by robots.

Amid the different opinions on automation and the fear of millions of Americans for the longevity of their jobs, one crucial fact that often goes unnoticed is that those American citizens that are being displaced from their jobs are also the ones that are subsidizing the transition to automation with their taxes. It is predicted that the US government will spend \$10.4 billion on robotic automation, \$13 billion on intelligent process automation, and \$10.8 billion on AI business operations (Thormundsson 2022). With the exception of intelligent process automation, these processes have almost doubled since 2022. A reason for this is that the US tax system favors excessive automation, as it encourages firms to automate more tasks by placing heavier taxation on human positions. Brookings Economic Studies shows that while labor jobs get an

average tax rate of around 25%, automated labor through equipment or software gets taxed an average of 5% (Eberly et al. 2020). On top of that, California is one of the states that are using public funding to finance a multinational technology company based in China, with no US employees, to conduct research and development for automated vehicles that will not even be manufactured in the States (Garcia et al. 2019). To support this argument, the Acemoglu's paper systematically documents the lopsided tax treatment of capital and labor to conclude that too much automation destroys jobs while only marginally improving efficiency (Acemoglu et al. 2020). Professor Acemoglu and his colleagues believe that eliminating the capital bias in the tax code would raise the number of employed people by 6.5 percent and increase labor income share by 1.1 percentage points.

While all the data above points to multiple arguments against automation, economist Mark Paul has a more positive approach to dealing with robots. In his article, he explains that unlike the industrial revolution in the 20th century, from agriculture to an industrial one, these frontline workers have worked with or alongside robots (Paul 2018). Steve Lohr, an awarded New York Times journalist, shares Paul's view and uses a task force assembled by MIT to examine how technology has changed, and will change, the workforce (Lohr 2020). In his article, he goes in-depth explaining that the American system is structured in a disproportional way as two-thirds of American workers do not have a four-year college degree. This does more harm than good, as the "US is getting a low return on its inequality." The lack of education will hurt the average worker as they might not have the skills to provide value to their companies, and therefore "in the next two decades, industrialized countries will have more job openings than workers to fill them (Autor et. al 2022)." Therefore, is not that robots will reduce the number of jobs available, is that those new opportunities will require a higher level of skills. This begs the

question, is the US doing enough to educate its citizens to be able to transition to these opportunities? In other words, how has the United States government provided a socially responsible solution to automotive automation?

To try to answer this question, I use the STS responsible innovation framework conceptualized by Jack Stilgoe, Richard Owen, and Phil Macnaghten. The responsible innovation framework is defined as “taking care of the future through collective stewardship of science and innovation in the present” (Stilgoe et. al 2012, p. 1570). It is intended to guide, prompt, and open a space for essential discussions aimed at supporting, but not dictating, decisions about the framing, pace, and trajectory of contentious and innovative research. Through this framework, I am able to analyze the current state of automation in the automobile industry, specifically in those frontline workers responsible for the assembly of the car. Additionally, I bring an economic perspective on the argument which allows me to understand how laying American workers affects the US economy. Most importantly, I analyze what the US has done to try to solve this problem from an ethical standpoint.

Methods

The methodology to analyze this question will be through literature. This paper dives into research papers, studies, and conferences, which presents the perspective of businesses, economists, and engineers. Studies from MIT, such as “The Work of the Future or Taxes, Automation, and the Future of Labor,” offer a background on engineering standards in the automation industry as well as up-to-date statistics on the current pace of automation and its impact on the future of labor. On top of that, reports from McKinsey, such as “Jobs Lost Jobs Gained,” give an economic perspective on how automation has and is affecting employment.

Furthermore, I use the Nokia Bridge Program case study to show how Nokia has been able to redesign layoffs by listening to the opinions and perspectives of their manufacturing to make the argument that other American companies can use their approach to adapt to the pace of automation. The methodology used implements some of the most reputable sources of information, to include all perspectives on automation and its effects.

Analysis

To properly analyze automation through the responsible innovation framework, it is important to understand the main four pillars that constitute this framework: anticipation, reflexivity, inclusion, and responsiveness. Analyzing automation, specifically in the manufacturing field, throughout these four dimensions will allow us to conclude if the current pace is responsible, who are the main stakeholders who benefit from automation, and who gets damaged the most.

First Dimension: Anticipation

The United States is facing a significant challenge when it comes to automation; the fact that we have developed a technology that can improve efficiency, quality, flexibility, and innovation while reducing risk and costs, is a huge challenge to face as it can displace millions from their jobs. A report from McKinsey estimates that between 400 and 800 million jobs could be altered by automation (Manyika 2017). These are scary numbers for every worker in the United States, not just those in the manufacturing field, as automation can make rutinary jobs obsolete in any industry. Thus, analyzing automation and the role of the United States through

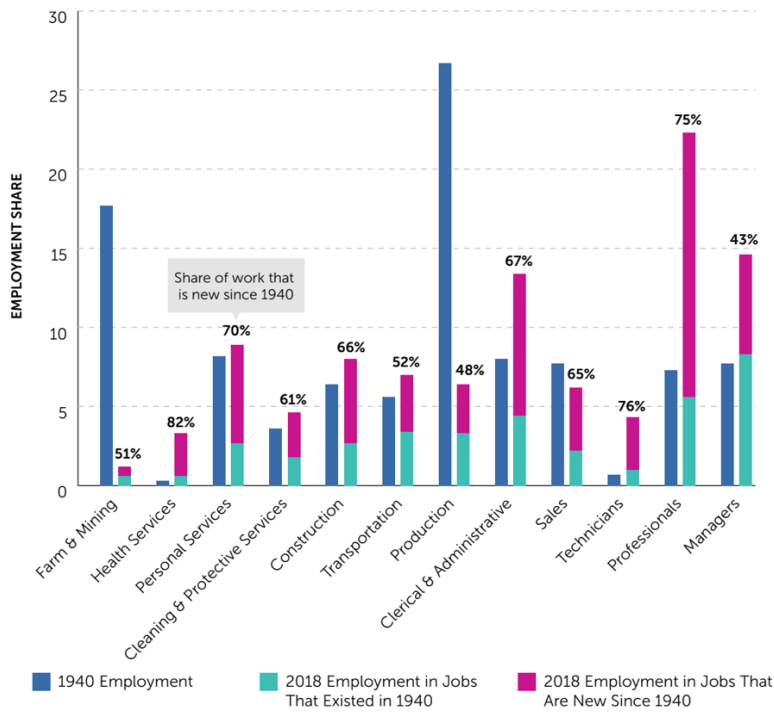
the anticipation dimension is important in order to prevent and mitigate the detrimental implications of automation.

To anticipate the potential impacts of automation, it is important to look at historical data to understand all the previous steps taken to learn how we have gotten here. Studies coming from the Bureau of Labor Statistics show that manufacturing is the field where most workers quit voluntarily, with 58 percent of them quitting compared to other fields like education or healthcare (28%) (Long 2022). This data is especially interesting since, historically, the manufacturing field is known to provide American families with stable jobs and lifestyles (Ramaswamy 2017). On the other hand, the U.S. Census Bureau places manufacturing among the top five employers in the United States today (Goodwin 2022). This disconnect is concerning and more information is needed to understand if the manufacturing field is the problem when it comes to unemployment or if the workers themselves do not want to work in the industry anymore. More importantly, how does automation play a role in this disconnect?

A study from MIT, did a comprehensive analysis with the goal of “understanding the relationships between emerging technologies and work, to help shape public discourse around realistic expectations of technology, and to explore strategies to enable a future of shared prosperity” (Autor 2020, p. 2). In fact, it reiterates that while automation will replace existing work, it will also create new work. In other words, automation in not eliminate work altogether. The MIT Task Force make the point that one should look at automation as a new technological advancement that will only push for new jobs. They support their argument with the following graph seen in Figure 1:

Figure 1

More than 60% of Jobs Done in 2018 Had Not Yet Been “Invented” in 1940



Note. Comparing the Distribution of Employment in 1940 and 2018 Across Major Occupations by Autor, Salomons, and Seegmiller, 2020, *Works of the Future*, p. 10.

Their argument is simple: just as the introduction of the internet, the first computer, and all other technological revolutions seen throughout history, automation will only create new jobs that we have not seen before (Autor et. al 2020). Automation will require our society to be creative and understand the market to create new jobs and positions to work alongside robots and not be replaced by them. While this is a very positive look at automation, it is also important to step back and ask the question, for whom are those jobs being created? Just as back in the day most of our workforce was in the farm and mining industry, the change to the manufacturing field did not come without losses of employment because manufacturing required more

specialized skills. To understand the value systems and theories that shape these technological advancements we must look at automation through the reflexivity dimension.

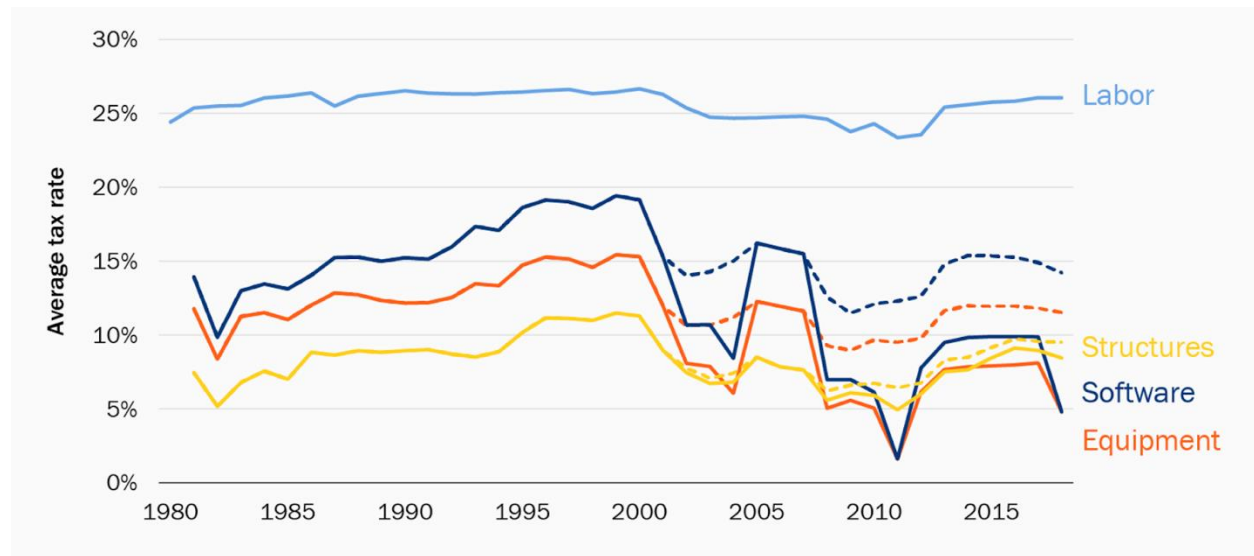
Second Dimension: Reflexivity

While it seems that automation will not end all jobs, it is critical to look at the role the United States government has when easing the transition to automation. Through the reflexivity dimension, the United States can be analyzed by “holding up a mirror to one’s own activities, commitments, and assumptions, while being aware of the limits of knowledge, and being mindful that a particular framing of an issue may not be universally held” (Stilgoe et al 2012, p. 1571). Through this dimension, one can analyze the United States’ reflexivity role in automation from an academic and governmental perspective.

The U.S. government's response to automation has been a subject of ongoing debate and discussion; many have criticized them for not doing enough to address the potential negative impact of automation on jobs and income inequality. It is not news that one of the main reasons that are funding this rapid growth of automation in the United States is the fact that while labor has been taxed at an average rate of 25%, automation has been taxed at a much lower rate of 5% (Eberly 2020). This disproportion can be seen in Figure 2. This is a clear sign that the US tax system encourages any industry, but especially those in the manufacturing field, to buy machines while discouraging the addition of employees. Some might argue that it is the manufacturing companies themselves that should be reflexive but, at the end of the day, those are businesses that run for profit and not run to provide workers with stable jobs.

Figure 2

Effective Tax rates on Labor, Software Capital, Equipment, and Non-Residential Structures



Note. Analyzing the different effective tax rates by Acemoglu, Manera, and Restrepo, 2020, *Does the Tax Code Favor Automation?* p. 25.

In order to combat this disproportionate tax rate, many have jumped on the argument that robots should be taxed just like a worker. The tax news coverage, *Tax News Today*, had two episodes that were featured on *Forbes* discussing the pros and cons of taxing robots. This debate started in Europe, where the UK wanted to regulate the widespread adoption of robots to mitigate unemployment; although the proposal did not specifically focus on tax implications, the proposal was not approved in 2017 (Steward 2022). In the podcast, Ryan Abbott, professor at the University of Surrey and author of *The Reasonable Robot*, argues that taxing robots is important to keep government revenues from shrinking so drastically while using the remaining revenue to help with inequality or help the unemployed. Taxing the robots movement main goal is to disincentivize employers from rendering people technologically unemployed and help ease

the transition at a slower pace. On the other hand, Orly Manzur, tax law professor at SMU Dedman School of Law, argues that it is never a good idea to penalize technological progress as it does more harm than good: can hinder innovations, incentivize businesses to relocate abroad, and create practical issues given that automation does not come in one form (robot, software, algorithm, AI). For these reasons, Manzur believes that the answer comes from educating those at risk of market disruption to adapt to a dynamic labor market.

The conversation on taxes is important because it points out that automation does create a lot of valuable revenue that could be invested back into the country, through education for example, to help ease the transition to automation. If companies would take their additional earnings and create programs throughout their own company to educate their employees to have new roles and not obsolete jobs, the transition to automation would be seen in a much more positive way. Given that the United States government, nor companies are taking this approach, education brings us back to the same question the anticipation dimension got us to: for whom are these jobs being created? Now that we have understood the history and reflected on what the United States is doing, the inclusion dimension will hopefully lead us to an answer to that question.

Third Dimension: Inclusion

While the other two dimensions of the responsible innovation framework have tackled the role of the stakeholders of automation, the United States government, and the manufacturing companies, this lens focuses more on the workers themselves and questions the efficacy of the stakeholders' decisions. As argued before, in the ideal scenario of automation, the government would take revenue from automation and invest it back into technologies that could help match

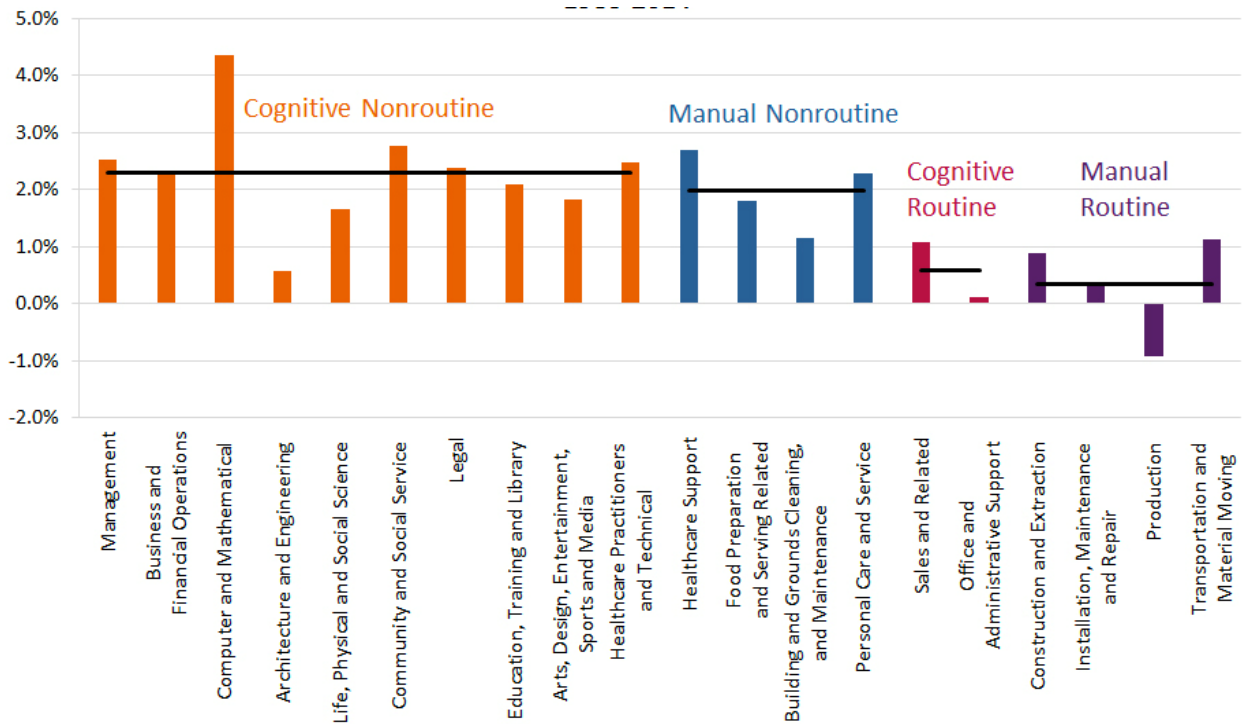
any displaced workers with new jobs that are available in this new economy. Other solutions to incentivize people to increase their education are by reducing interest on student loans, increasing loan limits on federal student loans, or direct spending on free educational programs available to the public.

By looking at how automation is impacting “essential” workers, like those in the manufacturing field, we see that automation requires workers to have a higher set of skills that are often taught in universities or trade schools. A report by General Electric, explains that automation will reduce the demand for current manufacturing skills - “nimble fetching items from a shelf, bolting metal sheets together and navigating an airplane” - while increasing the demand for more technical skills such as “analyzing data, communicating effectively with different audiences and understanding computer numerical control devices” (Hershbein 2016). Economist David Autor has extensive studies on the shift in US employment opportunities and wages over the past 30 years, where he concludes that the market has increased its demand for high-skilled and low-skilled workers, while the opportunities for middle-skilled workers have declined. The skill level is related to the wage rate, as skill increases so does the rate. Autor labeled those in the manufacturing field as middle-skilled workers and concluded that the key contributor to the polarization trend was the automation of routine work. He explained that the need for nonroutine work, either for high or low skilled workers, left those in the manufacturing industry closer to the lower wages opportunities than the higher ones because the higher-wage opportunities often come with a bachelor’s degree (Canon 2013). This trend is depicted in

Figure 3:

Figure 3

Average Annual Employment Growth 1983-2014



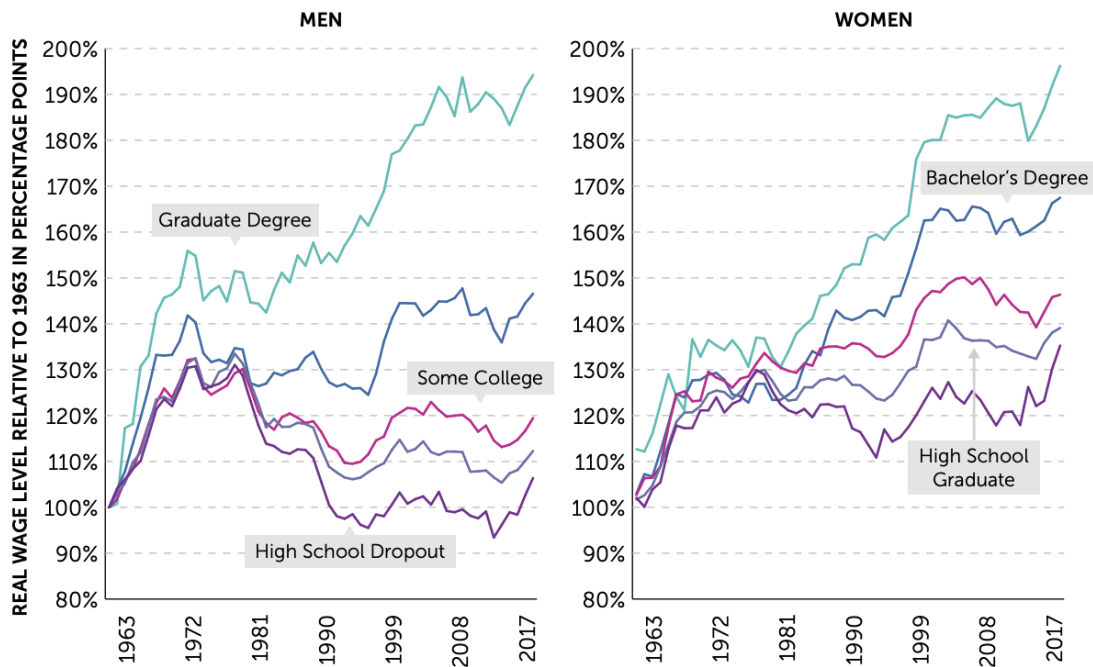
Note. Comparing the average percentage across each job group by Maximiliano A. Dvorkin and Hannah Shell, 2017, *The Growing Skill Divide in the U.S. Labor Market*.

Since the industrial revolution, manufacturing has been the backbone of the United States as it has driven economic growth, technological innovation, and national security (Baily 2014). American manufacturers are crucial in maintaining our standard of living and global competitiveness. Due to the manufacturing industry being so valuable to the United States, their workers have always been compensated as the industry has “historically offered opportunities for workers without college degrees to gain technical skills and climb the economic ladder” (Ramaswamy 2017). Automation is changing this. By shifting to a market where nonroutine jobs are seeing the most growth, wages and benefits in the manufacturing field are decreasing. The

Congressional Research Service state in their report that “average manufacturing wages have declined over time, compared to those in other industries, with the exceptions of retailing and transportation,” and conclude that the old narrative that manufacturing jobs provide better jobs than the rest of the economy is “increasingly difficult to defend” (Levinson 2019). Moreover, the graph seen in Figure 4 shows that education is the driving force for higher wages as wages for college graduates have risen while wages for workers with a high school degree or less have fallen.

Figure 4

Real Wages Have Risen for College Graduates and Fallen for Workers with High School Degrees or Less Since 1980



Source. David H. Autor (2020) “*Work of the Past, Work of the Future.*” p. 14

By analyzing automation and the role the United States government plays through the inclusion dimension of the responsible innovation framework, one can clearly see that automation will create new jobs, but the market is pushing educated individuals at the top while leaving those middle-skilled workers behind. Moreover, the manufacturing field will considerably change over the next decades and will only favor those with college degrees which will make the manufacturing field less reliable for people without a degree. Finally, analyzing automation through the last dimension, responsiveness, will let us understand what the US government is doing in order to provide educational opportunities to those workers.

Fourth Dimension: Responsiveness

By using the three previous dimensions of the responsible innovation framework, the solution to the ethical dilemma of automation, specifically in the manufacturing industry, has come to light. Education is needed for this transitional change to occur in the least harmful way. By looking through the responsiveness lens, we can see and evaluate the actions that the United States is taking in order to help ease the transition in a way that aligns with public values, norms, and ethical principles.

Just at the beginning of 2023, technology companies started to mass lay off people with Microsoft leading the movement by cutting 10,000 employees, about 5 percent, of its workforce. While there are multiple reasons for these layoffs, Microsoft made a \$10 billion investment right after in ChatGPT (Chow 2023). According to Deloitte, the automotive industry is next due to the headwinds including supply challenges and an uncertain economic outlook (Deloitte 2023). Moreover, the strategy Deloitte offers to mitigate risks is to further the investment in automation and smart technologies to open new opportunities in the company. While these massive tech

companies are starting to lay off their employees, manufacturing companies have not yet come to an ethical solution, and it is feared that they will face the same outcome as those employees in Microsoft or Twitter. On the other hand, we are seeing that the United States is taking some initiative by proposing a plan with the American Workforce Policy Advisory Board to “develop and implement a strategy to revamp the American workforce to better meet the challenges of the 21st century” (Owen 2019). Some people on the board are Tim Cook and Jeff Bezos. While it is not yet clear if it will specifically help those in the manufacturing field or educate routine workers in tech companies, it is a good step to ensure students and workers can access affordable and relevant education and job training.

While automation is predicted to mass layoffs in the near future, there is a right way to handle the process. Harvard Business School published a case study by Susan Winterberg and Susan Sucher where they analyzed the telecommunications company Nokia and how they redesigned layoffs. In the case study, they explain that Nokia decided in 2008 to close an assembly plant in Bochum, Germany, where 2,300 employees were laid off. This caused over 15,000 workers and labor officials to protest and boycott Nokia for their “hostile” decision (Gibby 2022). In 2011, due to their competition with iPhone and Android phones, Nokia scheduled to lay off 1,800 workers. As a consequence of the major retaliation back in 2008, Nokia announced their Bridge Program where Nokia would offer their employees training opportunities to find another job within the company. Nokia would even allow their employees to apply for grants to pursue an entirely different career path if they chose to, set career fairs, and created an incubator program that helped employees leverage intellectual property for new business ventures. The program totally redesigned layoffs and started a movement that helped

not just the individual worker but “spurred growth and innovation in the local economies it was exiting” (Mayor 2019).

The Nokia Bridge Program is the perfect example that education can ease the transition to automation and specifically help those displaced workers to find a position of higher value in the company. It is both the role of the United States government and the companies themselves to give the incentives and opportunities to help those that have always been the backbone of the American economy.

Conclusion

No one actually knows how AI and advanced automation will affect future job opportunities, but the predictions are not positive for those associates in the manufacturing industry. As this trend is expected to continue, the growing concern that automation will exacerbate income inequality, as the benefits of automation are often concentrated among a small group of individuals and companies, while the costs are borne by workers who lose their jobs or face downward pressure on wages, requires the need for policy solutions that address the negative impacts of automation and support workers in adapting to a changing economy.

By analyzing the impacts of automation in the manufacturing field through the responsible innovation framework we can see all the different stakeholders and understand their motives as well as realize where the problem lies. By using the first three dimensions of the framework - anticipation, reflexivity, and inclusion - the mainstream concern of automation taking over all jobs was clarified. We understood that automation will make millions of jobs obsolete for the reason of being routine jobs, but it will also push the market to be more innovative and create new jobs which we do not necessarily know yet how they will look like.

On the other hand, the ethical question of who exactly will take those jobs arose. Automation will create new jobs, but those jobs will require a higher skill level that is usually achieved after some college education or trade school. This will make the job market less accessible for those that do not have further education, but on the other hand, it will lead to a much more advanced and educated workforce and society. Last but not least, using the responsiveness dimension of the framework, we were able to analyze the role of the stakeholders, the US government and manufacturing companies, and recognize if they were providing the resources for their citizens or workers to ease into this new market. Through these four lenses, it can be concluded that automation itself is not an unethical process, but the United States and the manufacturing industry need to do a much better job of helping their employees adapt and maintain their value in the company.

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