Analyzing the Effect of Automation on Workers in the U.S. Automotive 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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Automation Versus Auto Workers

Economists have estimated that the addition of one robot to the industrial labor market reduces employment by two to four workers, depending on the extent which the function can be automated (Borjas, 2019). Furthermore, the application of robotics and AI in manufacturing is a growing trend. Thus, it is a reasonable concern that many manufacturing laborers will lose their jobs, or face other negative consequences such as lower pay, and new hazards introduced by robots on the production line. On the other hand, it can also be argued that the new wave of automation is poised to bring about a "manufacturing renaissance" in the United States by providing industries much-needed labor and a competitive advantage (Stuchfield, 2024).

One of the largest and most competitive industries to apply new automation technologies is the automotive manufacturing sector. The goal of this paper is to determine how the introduction of automated manufacturing affects the job market, safety, and quality of life for workers in the United States automotive manufacturing industry. This question will be answered through the framework of technological momentum. The focus on U.S. auto workers is warranted by the fact that they are a large demographic which are among the first to experience the impact of this technology. However, workers in other positions now considered less automatable may be subject to similar impacts in the future as AI and robotics advance.

Methodological Approach

This paper seeks to answer the question of how the introduction of automated manufacturing affects the job market, safety, and quality of life for workers in the United States automotive manufacturing industry. This impact is analyzed through a meta-review of research within the last ten years. The following research includes relevant articles accessible through the UVA library website, such as Web of Science and JSTOR. Some examples of search terms used to find relevant articles are "safety considerations for robots in manufacturing" and "US auto manufacturing job market trends." The research also includes a content review of relevant news stories. Specifically, local news stories from auto manufacturing areas that discuss the impact of automation are considered. News stories about workplace injuries and fatalities also provide insight into safety considerations.

Robots, AI, and Manufacturing

In manufacturing, it is necessary to meet throughput, quality, and cost goals, which has become increasingly difficult due to an increase in the complexity of manufacturing processes as well as changing demands and competitive pressure. It is already well-documented that the use of AI, sensors, and advanced robotics have great potential to revolutionize manufacturing. AI has already been applied to manufacturing, and is particularly useful for analytical tools and optimization, but it still faces challenges because it has limited access to data, and the models used fail to perfectly represent reality (Arinez, 2020). Machines and sensors have the ability to collect large amounts of data. AI tools excel at finding patterns in large bodies of data, so they can provide actionable information to help solve problems and maximize throughput and

efficiency. Such optimization will likely prove very useful in the automotive sector, but many existing production systems do not share data, so auto manufacturers will need to implement systems which collect and share data if they wish to take advantage of these benefits (Minarcin, 2016).

While U.S. auto manufacturers may be seeking to use AI to optimize production lines, there are also incentives for them to use AI and robotics to fill out their labor force. The manufacturing industry has seen an increase in spending due to large private and public investments in recent years, leading to increased demand for manufacturing workers (Magill, 2024). Manufacturers have found it difficult to fill all of these positions, especially those which require more technical skills and education, including roles such as machinery maintenance technicians and semiconductor-processing technicians

Advanced robotics and AI have not yet advanced to the point where they can replace these more skilled positions. However, developments in AI are allowing manufacturing robots to have more flexibility and perform more complex tasks than before. They are able to perform tasks requiring dexterity, precision, and delicacy, such as inserting sheet metal parts into fixtures for chassis assembly on an auto assembly line (Osama, 2024). Even though it is possible for robots to perform such tasks, they may still need further development before they can reliably be used on a large scale for these more difficult jobs.

Technological Momentum and Robotic Manufacturing

This research paper analyzes the automation of the US auto industry through the lens of technological momentum. This framework was developed by historian Thomas P. Hughes as an

alternative to the opposing frameworks of social construction of technology and technological determinism (Hughes 1986). Instead of society only shaping technology or technology shaping society, both society and technology have a changing relationship as the technology gains momentum. When a technology is in its infancy, society has more influence on the technology's development and role. Once the technology has gained momentum, it has more influence on society than the society has on the technology.

Technological momentum incorporates both constructivist and determinist ideas. In the field of STS, technological determinism is generally rejected, and is used to dismiss certain claims (Dafoe, 2015). Dafoe reviewed some popular STS journal articles and found that 76 percent of references were critical. The momentum theory incorporates determinist ideas by following "the logic of sunk costs" (Dafoe, 2015). As more resources are invested in a technology and standards and norms are set in place, future decisions are constrained and the technology's influence expands.

This principle of momentum must be applied to the growing application of AI and automation in U.S. auto manufacturing in order to shape the technology before it becomes so entrenched that it cannot be changed. If the norms and standards of automation in manufacturing are established to intentionally prioritize worker safety and well-being, then the role of the technology will be defined to benefit workers into the future. However, if care is not taken to shape the technology in a way that considers impacts on workers, then it will harm them long into the future.

Results: How Workers Are Going to Be Impacted

Automation is simultaneously a benefit for workers who adapt and transition into new functions, but also a detriment to workers who ultimately lose their jobs. The workers who do not lose their jobs will likely have higher paying jobs that are less physically strenuous. The quality of life and safety of these workers depends largely on whether manufacturers and developers of automation technologies prioritize worker safety and well-being as automation gains momentum. It is vital that safety features and healthy norms are put in place and the safety of the human workers is held paramount while this technology is in its early stages because it will be much harder to change once it becomes more established and widely adopted. This paper will first analyze the impact of automation on the job market and wages for American autoworkers, and then there will be a discussion of safety concerns and policies that will need to be implemented to prevent workplace injuries, and finally there will be an analysis of the impact of automation on the mental well-being of the workers.

Employment and Wages

One of the most apparent ways that the introduction of robots could harm U.S. auto workers is by reducing their employment opportunities. In the past, many saw an influx of immigrants into the workforce as a threat to the employment and wages of American workers, but now it seems that robots hold the potential to replace many more workers. One economic study which considered robots shipped to manufacturing industries as a supply shock to the labor market found that the introduction of a single robot reduces employment by two to as many as four workers, depending on how well the task can be automated, and reduces wages as well

(Borjas, 2019). The study also compares this effect to the impact of the addition of an immigrant to the labor market and found that a robot's effect was significantly more.

Another study analyzed the impact that robots had on the U.S. job market as a whole in the years following the Great Recession, during which there was steady job growth, and the use of robots also expanded (Rodgers, 2019). The study found that Midwestern states have the highest intensity of robot usage in the workplace and experienced the most growth of robots, and also measured an adverse effect on employment for young, less-educated workers in Midwest manufacturing industries, such as automotive manufacturing. An increase of one robot per thousand workers resulted in a 3.5% reduction in employment and a 4-5% reduction in wages. Those numbers are valid reason for concern for auto workers, especially those without much education. Automakers are seeking ways to reduce costs and increase throughput, so if they can do so by replacing much of their workforce, they will. As the technology becomes more affordable and reliable, automakers will replace more jobs with it. Through the framework of technological momentum, it is apparent that once this technology is established, workers will not have much say in whether they get to keep their jobs. It is vital that autoworkers are educated and given a chance to work with the new automation technology while it is still growing so that they can keep working for the auto industry when many of the currently existing jobs are replaced by robots.

Physical Injuries and Safety

Another pressing concern for autoworkers is whether adequate safety measures are being taken to prevent injuries and ensure their physical safety. The history of auto workers being

injured by automated systems goes all the way back to 1979. In fact, an auto worker was "the first human in history to be killed by a robot," (Young, 2018). Robert Williams was tasked with climbing a shelving unit to count parts at a Ford Motor Company casting plant in Flat Rock, Michigan and was struck in the head and killed instantly by a robotic arm that was tasked with retrieving parts. This accident is often attributed to the fact that the robot was silent and was not designed to change its behavior because of the presence of a human.

It would be easy to dismiss this tragedy as an artifact of long past days when AI and robotics were not advanced enough to respond to the environment in the same way that they can now. However, there have been more recent cases of injuries inflicted on auto workers by robots. In 2021, a software engineer at a Tesla factory in Austin, Texas was attacked by a robot designed to move aluminum car parts (Zilber, 2023). While the engineer was programming two other robots that were disabled, the robot in question was left on and "pinned the engineer and sank its metal claws into his back and arm, leaving a trail of blood along the floor." It is worth noting that Tesla has been accused of cutting corners when it comes to safety, and the Austin factory's overall injury rate is estimated to be one out of twenty-one workers compared to the industry median injury rate of one in thirty workers (Zilber, 2023). Thus, it may not be completely fair to say that an injury from a robot in a Tesla factory is representative of the entire industry, but at the very least this story serves as an example of how automation in automaking can go wrong when proper precautions are not put into policy and carried out. As automakers rapidly adopt automation at scale while simultaneously attempting to cut costs, it is easily conceivable that they could cut corners and fail to adopt norms and safety features to adequately protect their workers.

There are varying levels of automation that are being developed and adopted in manufacturing, ranging from completely autonomous robotic manufacturing to robots that need assistance from humans. The types of robots that collaborate with humans are particularly interesting because they are currently more technically feasible than full automation because more delicate or complex parts of assembly tasks can be done by humans while taking advantage of automation to do tasks which require more force or repetition. According to a study that analyzed different cases of assembly stations in which humans and robots collaborate, the type of safety considerations that need to be implemented vary depending on many factors, including the type of robot, how much force the robot needs to apply, the characteristics of the workpiece, and the process used (Michalos, 2015). One finding common to every case was that to ensure safety assembly stations need to incorporate either space between the humans and robots or advanced sensors to prevent collisions. Visual, tactile, and audio interfaces are also needed for humans to interact with these safety features. The manufacturing engineers who design automated assembly lines need to prioritize worker safety by implementing these safety features as appropriate. They need to avoid cutting corners not only because the lives of workers currently on that assembly are at stake, but also because they are setting a precedent that will influence future assembly lines as automation gains momentum. From the viewpoint of technological momentum, it will become more and more difficult to change these practices as momentum grows.

However, there is also a solid argument that automation, if properly implemented, will have a strong positive impact in preventing workplace injuries. After all, if robots take on the more physically demanding or hazardous tasks, then there is less chance of human workers being injured from physical strain or accidents. One study on the effect of industrial robots on workplace injuries in the U.S. found “that a one standard deviation increase in robot exposure

reduces work-related injuries by approximately 16%," and this result was mainly from manufacturing industries (Gihleb, 2020). Therefore, it may actually be in many workers' best interests for manufacturers to pursue automation for many auto assembly tasks, but it is important that worker safety is made a priority in this process. While this study finds encouraging results pertaining to workplace injuries, it also notes that in the U.S. increased use of robots is correlated with increased drug and alcohol related deaths and mental health problems associated with labor market impacts. This mental health impact is measurable and worth investigating further.

Mental Well-being

One effect of automation in manufacturing that has not been documented in detail is the potential harm on the mental health of those working with robots. One article points out that we do not yet know what kind of psychological impact human-robot collaboration could have on workers (Fletcher, 2019). It argues "that ethical and psychological requirements that may be crucial to industrial human–robot applications are not yet being addressed in safety standards or by the manufacturing sector." Some of the psychological concerns mentioned include trust, acceptance, safety, and comfort. It makes sense that it may be mentally and emotionally straining to work all day in collaboration with an impersonal machine which applies large forces and could potentially harm or kill the worker. Depending on how closely the worker collaborates with other humans, such tasks done with robots could be socially isolating as well. It will go a long way to mitigate the mental strain of working with robots to incorporate safety features that the workers can perceive through sight, hearing, or feel so that they can have assurance that they will not be harmed by the robots.

Another potential source of mental and emotional hardship for workers is job insecurity. A study on the impact of automation on mortality found that "increases in automation over the period 1993–2007 led to substantive increases in all-cause mortality for both men and women aged 45–54." It finds that automation leads to declining jobs in the manufacturing sector and also causes depressed wages, which in turn lead to "deaths of despair" such as drug overdoses and suicide, though there are many other factors which need to be accounted for (O'Brien, 2022). This increase in deaths is tragic and a valid cause for concern for the well-being of auto workers in an increasingly automated industry. Even if some workers are not replaced, it is possible that concern for their job security could have a harmful psychological effect. Working alongside robots could make a worker feel like they only serve a mechanical function and are no more valued than a robot and could easily be replaced by a robot. The scale of these effects is not well known and demands more intense research so that engineers can mitigate these harmful impacts as the technology becomes more widely adopted.

Limitations

The scope of this thesis is limited by the data available. There is not much research that has been done specifically on the effect of automation on U.S. auto workers, so there is a limited pool of data to be used. Many of the conclusions are made from more general data sets that are not specifically about auto workers, though they seem to be justified. Future research could incorporate more rigorous methods such as surveying auto workers about how they are impacted and collecting quantitative data on workplace injuries and deaths related to automation on car assembly lines. It may also yield helpful results to do a case study on a specific community that is highly impacted by automation.

Impact and Significance

While automation in automotive manufacturing has great potential to boost productivity and efficiency, while also reducing workplace injuries by helping with physically difficult tasks, it is also going to come at the cost of employment and wages for many less educated workers who currently make a living off the industry. It could also be harmful to auto workers who remain in the industry if adequate safety measures are not built into the robots and put into policy while the technology is still in its early stages of adoption. Once it gains momentum and is established it will become much more difficult to change. This is important not only because auto workers are a large population and an important part of the American economy, but also because many of these same principles will apply when automation starts to replace other jobs. It is vital that the safety and well-being of those affected is prioritized whenever technologies that drastically impact the job market are implemented.

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