THE BALANCE BETWEEN HUMAN INTERACTION AND AUTOMATION TECHNOLOGY ON ASSEMBLY LINES IN AMAZON WAREHOUSE DURING THE COVID19 PANDEMIC.

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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:

Automation is a defining feature of the modern world, enabling the speed and efficiency at which the planet runs. While automation has been incredibly beneficial for many industries, it also has presented many challenges to human interaction within labor. This leads me to the central focus of my STS Research which examines the use of automation technologies in engineering, manufacturing, and packaging, with a specific focus on how these systems have affected the automated and human worker balance during the COVID 19 Pandemic.

For My STS research problem, I will be investigating how and why Amazon's automated systems in California warehouses during the COVID 19 Pandemic outpaced human labor leading to increased rates of injury and exhaustion and among Amazon staff. California being the largest state in the country by population felt the effects of the pandemic more deeply than other parts of the nation. Often dependent on entertainment, tourism, and technology, California shifted its economy to more consumerism throughout the pandemic, with e-commerce playing a key role largely guided by automation.

Traditionally, automation is designed to increase speed and efficiency, but the human counterpart necessary for maintaining these systems can only keep pace for so long. This dilemma became even more clear during the COVID 19 Pandemic, Which affected not only individual health, but also reshaped how many different industries conducted operations. As people moved indoors for unprecedented periods of time, online marketplaces became the most reliable modes of shopping for most people in a world living in fear of physical interaction. As demand for online products surged, Amazon intensified its relationship to automation, inevitably exacerbating strain on labor. My research will explore how and why Amazon's automated systems outpaced human labor during the pandemic, which led to increased worker fatigue and

rates of injury. By addressing the technical and human aspects of automation, this research will help to shed light on the larger implications of automation in industry settings. Understanding these relationships is critical for directing labor policy in the future as well as assuming technological advancements primarily support workers in industry settings.

The Background & Context section:

My investigation is centered on how and why Amazon allowed automation to outpace its warehouse staff in California during the COVID 19 pandemic, leading to significant strain on warehouse workers. This question will also explore the broader interaction between humans and automation technology. According to a report from the Center for Investigative Reporting (BBC 2020), warehouses that utilized automation co-working with human staff experienced significantly higher rates of injury among employees when compared to those without. This trend was consistently observed nationwide, but it was especially alarming for employees in California where rates of injury were found to be "more than four times the national average" in 2019 (Human Impact, 2021, p. 7). These spikes in injury were particularly acute around dates of major company wide sales such as Black Friday or Cyber Monday (Peters 2020). The primary issue that arises is the physical exhaustion that Amazon warehouse employees experience while working under these demanding conditions. This challenge is further exacerbated by the presence of numerous automated systems, which often operate at a faster pace than the workers, intensifying the strain on the workforce.

While most people may think that automation will simply displace human labor, the truth is a little more complicated. Most manufacturing warehouses in the United States can best be characterized as a co-working relationship of humans and machines. A human component is still necessary to run many of the secondary functions of manufacturing involving critical thinking,

unexpected situations, and complex tasks. Automation is generally utilized when performing simpler tasks in quick succession. This would include, but is not limited to: packaging stations, sorting systems, Amazon Kiva Robots, and Conveyor Belts. As a result warehouse employees were often expected to perform at the rate of automation, leading to higher levels of reported injury and physical exhaustion. At the same time, any attempt to push for a healthier labor force while sacrificing efficiency wasn't so simple because "robotic automation would be required to maintain competitiveness" (Bogue, 2022). The reliance on automation indicates the challenging relationship that Amazon needs to balance between improving working conditions and maintaining efficiency.

The difficulty of this relationship has become more severe since e-commerce has grown in popularity. Amazon has relied on e-commerce for nearly 25 years to drive its business (Altrad, A., et al. 2021), and the pandemic merely intensified business trends that had already been developing over time. At first most automated systems present in warehouses were small (Bogue, 2022), but to facilitate e-commerce in the early 2010s Amazon expanded its use of automation. By the pandemic, there was a heightened need for faster and more reliable automation to keep up with the surge in demand. This is only likely to increase as the products consumers want have grown more varied. Many people simply have a more diverse taste in the products they want (Pilati, et al. 2022). The desire for more specific product tastes in recent years has also led to a surge in the development of automation. This surge in automation has led to an increase in

workplace related injuries. If Amazon fails to effectively address these concerns, it will negatively impact on other aspects of company efficiency. For instance, Amazon often prides itself on its 24-hour Prime delivery service. However, if employee well-being is not prioritized

then the speed and reliability at which this service operates will be jeopardized.

After some thought I began to view the relationship between automation, Amazon, and its staff as an extension of "Technological Momentum." It is the theory that as a piece of technology is established it only becomes more powerful with time and increasingly more difficult to reverse its progress. (Nye (2006, pp. 52-56), Hughes (1969)). In the case of Amazon and its automation, it's become more than just a tool of mere convenience, but it has also become a significant component of the operational model. Inevitably, as time goes on automated systems become more integrated, replacing traditional sources of human labor in the pursuit of efficiency and cost reduction that automation provides. This trend is compounded, data driven decision making on the part of Amazon, since once Amazon had seen how efficient automation can be used when utilized correctly, human dependent processes simply become obsolete. At some level Thomas P. Hughes, Author of the Technological Momentum Theory, argues that there will be a "point of no return" where the Technology becomes self-sustaining and the adopters of the technology will permanently orient themselves around it. The only question is has the point already been reached or not?

To answer that question of whether or not the "point of no return" has been reached I found it valuable to look at the theory of "Technological Determinism", which presents the idea that as technology develops completely independently of society and that technology influences social forces/changes. This idea can clearly be seen in the relationship Amazon has with its labor. In other words, until automation began to be implemented into a variety of labor settings and overtake roles given to lower skilled labor its purpose was taken for granted by most of Amazon's staff. It is only after these automation had grown in efficiency that Amazon staff have demanded for social changes. Sally Wyatt explains:

"It (technology) persists in manifold theoretical and abstract accounts of the relationship between the technical and the social; it persists in the responses of policymakers and politicians to challenges about the need for or appropriateness of new technologies; and it persists in the reactions we all experience when confronted with new machines and new ways of doing things." (Wyatt (2008, pp 167)) Amazon's labor relationship closely mirrors this pattern-Technological change disrupts then forces society to react to these changes. As automation continues to affect the industry, labor and social consequences will follow, not by choice, but as inevitable consequences to these changes.

These changes are explained well through the realm of Technological Politics. This is the theory that technology (in this case automation) has political qualities beyond its immediate technical function. In other words, technology is measured not only by its practicality but also the power or authority that such technology brings about. (Winner, 1980, p.1) Utilizing this theory, my analysis will explore the relationship between the Amazon warehouse employees, the company of Amazon, and the automation technology itself. Despite how automation should be used, it is actually used as a tool of labor control by Amazon to keep their employees working within a standard that they have developed. While the automation technology used in these warehouses is not inherently political, its use as a tool of dominance has expanded well beyond its original purpose. Additionally, since Amazon was ground central for much of the warehouse automation during the Pandemic, the circumstance gave the company enormous leverage over its employees.

Methods:

To address my research question, I utilized a mixed method approach, collecting qualitative and quantitative data evidence that reflected both the technical and the personal costs

related to the use of automation in Amazon warehouses. A combination of raw data and anecdotal information provided me with a multifaceted source of information allowing a pattern to develop to determine why, and how Amazon allowed for this "relationship" between its staff and automation technologies to develop.

To begin my investigation, I collected raw data with a strong focus on examining rates of staff reported injuries from warehouses in California, comparing the period before, during, and after the COVID 19 Pandemic. This involved statistical analysis of warehouse industry trade group data to review broader industry trends, technological developments, and changes in workforce conditions. Additionally I reviewed data from groups like the National Employment and Law Project (NEIP), and the National Library of Medicine (NIH), and the U.S. Bureau of Labor (DOL). After synthesizing this information, my investigation determined if there is at least a correlation between the COVID 19 Pandemic and increased rates of injury among human labor.

In addition to quantitative data, I found first-hand accounts were also important for gaining insights into the impact of automation because they offered me a personal and more emotional testimony to the workplace standards of Amazon. I also found a variety of employee testimonies available including written interviews found on websites like Quora or Reddit. I found that there are many employee stories that go unnoticed by the media and these sites give former employees an added level of anonymity while allowing them to speak honestly when expressing their concerns of Amazon's work culture. Oftentimes these reviews are only open to those already involved on these websites while remaining hidden to all other individuals.

Additionally, I researched numerous social media websites like Twitter and Facebook. These websites often included further employee testimonies under specific hashtags. One hashtag that was popular among many Amazon employees during the pandemic was

#WeAreNotRobots. This hashtag was used by Amazon warehouse employees who were attempting to stress their humanity and protest Amazon treating them like Machines in the midst of the Pandemic. While this Hashtag was particularly popular in Minnesota it also reflected larger trends present across the United States. Many staff fear that by being honest about their experiences, Amazon will react with dire consequences, creating a dilemma where Job security is often a priority over workplace safety. Given the pace of the work set by the automated systems at Amazon few people have time to react clearly. This situation allowed for greater frequency of injuries while at the same time making staff difficult to recover from without financial setbacks.

Aside from employee experiences, it was also valuable for me to consider the public statements made by company officials who developed automation technology, particularly Amazon Robotics. As Amazon uses robots built by this subsidiary extensively in its warehouses, these robots are tested annually in competitive settings to optimize efficiency (Corbato, 2018). Insights from these statements helped me address why and how automation in Amazon warehouses in California has been able to outpace human workers.

After I collected and compared a variety of sources through the lens of each of the theoretical frameworks, I then identified recurring patterns to support my argument. For example, if an employee testimony comments they are living in fear of potential consequences that could result from legal action against Amazon. I then considered it as an example of "Technological Politics." It would also highlight to me a lack of agency of the part staff members leading to unequal consequences for the employees. This is because Amazon would in theory pose disproportionate leverage over its employees through automation. After I determined which theory was most relevant to each piece of evidence, I developed a pattern and timeline which

indicated why the situation with automation escalated to the degree it did. Identifying patterns like these were the key to answering my research question.

Results:

After a thorough review of three separate organizations I was able to discover a pattern that indicated increased warehouse related injuries across the United States. In the case of the state of California, warehouse related injuries hit a peak in early 2021. According to the American Journal of Industrial Medicine, "Total injury rates peaked in 2021, with 5.87 injuries per 100 workers." (Beckman, S., Andamel, N., & Harrison, R. ,2025) At the same time COVID 19 hit a peak in worldwide fatalities in early 2021. Similarly in the state of Massachusetts workers at Amazon warehouses were recorded to have injuries at nearly twice the rate of the other warehouse workers in Massachusetts, "In 2021, the injury rate for Amazon's warehousing and logistics facilities in Massachusetts was 1.8 times the injury rate at non-Amazon warehousing and logistics facilities in Massachusetts." (Tung, I., & Tufano, A. ,2024, April 28) I found this trend to be very similar on the national level. According to a September 2023 Report from the U. S. Department of Labor's Office of the Inspector General:

"As of 2021, warehouses made up less than 1 percent of the 8 million worksites that OSHA oversees nationwide. However, the 2021 injury and illness rate in warehouses—5.5 incidences per 100 workers—is more than double the rate of 2.7 incidences per 100 for workers across all industries......the number of reported cases of injury and illness in warehouses nearly doubled from 42,500 in 2016, to 80,500 (or 89 percent) in 2021, an increase that well exceeds the growth rate of warehouses (14 percent) during that period." (U.S. Department of Labor, Office of Inspector General. , 2023) While this information does not directly link the experiences of Amazon employees to Automation, it does indicate a correlation between warehouse related injuries and the timeline of the Pandemic. To shed light on the effects of technology on warehouse employees I found personal testimonies to be the most insightful. One Amazon employee experience in California illustrates how common workplace injuries were at Amazon:

"I hurt my hand, and . . . the following day I couldn't work. . . . A lot of people that I know have hurt their back and they don't want to say anything because they don't want to lose money, time. . . . I wanted them to send me to a doctor so that I could get a good checkup because I couldn't work. . . . I was afraid that they were going to fire me." (Human Impact Partners, 2021, January)

This testimony makes clear the difficult decision most Amazon employees had to make when dealing with workplace injury. Consequently, many Amazon employees have moved to websites like Reddit to voice their concerns in anonymity. While these websites cannot 100% be fully verified they do offer important windows into daily operations and workplace culture at Amazon. One former Amazon employee on Reddit explains, "It's exhausting non-stop, repetitive work for 10 hours straight and the "pick and stage" part is a nightmare, especially for skinny girls like myself, but it is what it is: A means to an end." (u/IniMiney, 2024) Even when facing potentially dangerous working conditions, staying at Amazon still seemed like the more practical choice for many employees. The situation that the warehouse employees found themselves involved in highlights the broader ethical concerns related to automated focused labor settings, where well being is sacrificed to prioritize efficiency and maintain financial stability. It also indicates how keeping up with automation was not always a physical fear but sometimes highlighted a deeper

truth present at Amazon. In an interview with a former Amazon employee from the U.K., Darren Westood, illustrates how automation was used as a tool of fear "If the robots have an issue, the company pays for them to be serviced, whereas if we drop below certain targets multiple times, we can be fired – we have to sort it out or get out.....The company's profits shot up during Covid." (Westwood, 2023) This pattern is not specific to California and Westwood's testimony illustrates a broader fear worldwide of the implications of Robotics technologies. For Amazon's part, they have done little to calm the fears of their employees.

According to Amazon's own reports automation is critical to their current operations. Julie Mitchell the director of Amazon's Robotic sortation technologies explained it like this, "It's not a matter of having robotics take over but making it one system of humans and robots working together to accomplish the goal of shipping the product" (Hadero, November 25, 2024). This statement illustrates that Amazon Robotics views humans as the weaker link in the relationship between man and machines. It's clear a balance is needed on the part of humanity to fully implement robotic technologies, but while Amazon has acknowledged there is indeed an imbalance there has been little to concretely address how to improve human relations with automated systems. Additionally, company records from Amazon collected from The Center for Investigative Reporting indicate, "While the reports show a committed drive to improve processes with technology or design changes, they don't propose reducing the intense workload for Amazon's warehouse employees, which is what helps drive Amazon's speed" (Evans, September 29, 2020). In a business like Amazon speed and efficiency are keys to success. However, even if Amazon does want to genuinely help its staff in more concrete ways. It's important to realize that this whole situation isn't even entirely the fault of Amazon, but it's a development that had been building for many years.

Discussion/Analysis:

The circumstances that lead to this situation are varied but they are not strictly complex. There are both quantitative and qualitative factors that I found that contributed to the labor imbalance at Amazon. Using the research I have gathered I was able to find examples within my sources that reflected parallels to each theoretical framework.

First, The quantitative data I collected from the three credible organizations seem to point toward a specific pattern. This pattern is a correlation between the COVID 19 Pandemic and rates of injury at warehouses, both in and out of Amazon. While I couldn't find any data that directly linked injury rates to automation specifically. I argue that the pattern seen of increased injuries is most reflective of "Technological Momentum." I say this because the statistics seem to imply that once a technology, in this case automation, has been implemented, trying to adjust the speed or progress of the technology is incredibly difficult. Consequently, I then would expect statistics like these to be especially common around periods of increased business traffic such as the COVID 19 Pandemic. Despite these trends companies like Amazon have done little to reverse course on the adoption of automated technologies. To put it another way, even while confronting clear workplace injuries which dramatically increased with the speed and efficiency of automation, Amazon has done little to shift away because systems like this are hard to remove because they are too integrated into the broader work culture.

Statements from numerous Amazon employees indicate that while there were both mental and physical stresses, most employees were too concerned with the possibility of losing their jobs if they spoke out, leading to a culture of ignorance both outside and within Amazon. These testimonies are clearly examples of "Technological politics." Amazon wanted to increase

their speed and efficiency as a company and Automation has an important purpose for that, but nearly every employee experience also viewed automation with skepticism and even fear for the very same reasons. Each Employee saw their job "as a means to an end," that they worked because they "didn't want to lose money," but "if we drop below certain targets multiple times, we can be fired." Statements like these imply a work culture of fear of automation, corporate censorship, and limited labor rights. In other words Amazon labor is at the crossroads of business, politics and technology.

The statements from Amazon Officials seem to confirm this finding, but also reflect an attitude of "Technological Determinism" and "Technological Momentum." In Julie Mitchells statement she seemed to imply that the use of automation is the obvious future and that the question now is how to implement "making it one system of humans and robots working together." While this does not directly imply that "a point of no return" had already been reached, this does indicate that Amazon Officials are more fixated on how to integrate human labor into Automated work culture which has already been developed. Additionally, the lack of action found within company reports also imply that automation is a fact of company life because "the intense workload..... is what helps drive Amazon's speed", while at the same time delivering hollow words of comfort to the health concerns of warehouse labor. Not only are statements like these reflective of "Technological Momentum," but they also help promote it because Amazon is actively stimulating automation growth. With respect to "Technological Determinism" by words or by action Amazon implies that Technology like this is unstoppable. Julie Mitchell indicates that "it's not a matter of having robots take over," because they have already taken over, but rather how should it be done. While at the same time Technology will naturally fix itself. Additionally, the company records also imply that Amazon is simply ignoring

workplace injuries in practice because they don't seem to fit their vision of what role of Technology should be. While I believe the beliefs held by Amazon are false, they do reflect a broader feel of "Technological Determinism" present within Amazon's corporate culture.

Conclusion:

My research explored how and why Amazon automation outpaced its warehouse staff in California during the COVID 19 pandemic, putting significant strain on its employees. By investigating the factors driving Amazon's swift adoption of automated technologies, I found the reasons for Amazon's rapid adoption of automation, the negative effects this has had on employee wellbeing, and how these factors were exacerbated during the pandemic. With this in mind, I have determined three specific recommendations that I believe should be implemented to mitigate the overstretch of automation in the workplace.

Firstly in terms of practical measures, every employee's workloads should adjust to meet their level of mental and physical ability. Both the national and state governments already set aside rights for employees with mental and physical barriers to be protected from employment termination on the basis of their own speed or efficiency. While the Amazon employees are generally healthy, the work that they engage in demands additional levels of care which Amazon often ignores. I recommend extended and specifically timed employee breaks mandated by law for shifts dealing with increased exposure to automated technologies. This will allow employees to conserve energy over longer periods and contribute to every shift with the necessary speed and attention to keep up with Automation. If however, these measures are taken lightly I would recommend fines be issued from the Federal government and injury data to be collected by force of law. This would ensure that there will be consequences to ignoring the importance of labor safety.

Mandatory constant supervision by independent human automation reviewers would be another measure that could be taken to avoid an overstretch of automation. This because it's clear most Amazon officials see this as a problem that will eventually solve itself, but this is a view born of ignorance because as business traffic has gotten more intense like during the pandemic rates of injury and exhaustion has skyrocketed. As for my recommendation, I often like to think of industry warehouses as a giant machine in which humans are simply part of the design. As with many machines someone will often be assigned to monitor systems until they are deemed appropriate to operate independently of human interaction. I believe the warehouse operations should be operated in a similar manner. If future operations are implemented like this it will inevitably lead to a fairer and more balanced working environment.

Finally, greater transparency on the part of Amazon for disclosing the capabilities of their automation. In other words before even applying for a position at an Amazon warehouse employees should be disclosed on the possible risks involved with that kind of work. More often than not employees enter into the company without understanding all the implications of the technologies that they will be working alongside. If Amazon had to disclose the rates of injury in the jobs that potential employees would work under, most people would think more deeply about entering into that position. Additionally, if Amazon

In conclusion, overcoming automation's hold over Amazon warehouse workers in California will be difficult, but certain measures can be taken to address this. Policies I believe would have an impact would be mandatory employee breaks, mandatory human supervision over human/automation relationships, and greater transparency on the part of Amazon while increasing penalties for lack of transparency. However, if none of these policies or any policy for that matter is implemented then "Technological Momentum" will continue unrestrained while

Amazon employees will continue to live in a state of fear defined by "Technological Politics" while working for a company operating under "Technological "Determinism." But it doesn't have to be this way. If there is a willingness to confront insurmountable odds there will always be a way to do it. The only thing needed now is the courage to confront it.

References

- Altrad, A., et al. (2021). Amazon in business to customers and overcoming obstacles. In
 2021 2nd International Conference on Smart Computing and Electronic Enterprise
 (ICSCEE) (pp. 175–179). Cameron Highlands, Malaysia.
 https://doi.org/10.1109/ICSCEE50312.2021.9498129
- BBC. (2020, September 30). Amazon Warehouse Robots "increase staff injuries." BBC News. https://www.bbc.com/news/technology-54355803
- Beckman, S., Andamel, N., & Harrison, R. (2025). California Warehouse Industry Worker Injury Rates in the Occupational Health and Safety Administration's Injury Tracking Application, 2018-2023. *American journal of industrial medicine*, 68(3), 295–303. https://doi.org/10.1002/ajim.23697
- Bogue, R. (2022). Warehouse robot market was boosted by Covid pandemic and technological innovations. The Industrial Robot, 49(2), 181-186.
 https://doi.org/10.1108/IR-11-2021-0270
- Corbato, C. H., Bharatheesha, M., van Egmond, J., Ju, J., & Wisse, M. (2018).
 Integrating different levels of automation: Lessons from winning the Amazon
 Robotics Challenge 2016. IEEE Transactions on Industrial Informatics, 14(11),
 4916–4926. https://doi.org/10.1109/TII.2018.2800744

Hadero, H. (2024, November). As Amazon expands use of warehouse robots, what will it mean for workers? Associated Press.
https://apnews.com/article/amazon-robots-warehouse-automation-workers-6da0e5ed0273
ed15ec43b38b007918df

- Hughes, Thomas Parke (1969). "Technological Momentum in History: Hydrogenation in Germany 1898-1933".
- Human Impact Partners. (2021, January). The public health crisis hidden in Amazon warehouses. Human Impact Partners. https://humanimpact.org/wpcontent/uploads/2021/01/The-Public-Health-Crisis-Hidden-In-Amazon-Warehouses-HIP-WWRC-01-21.pdf
- Peters, J. (2020, September 29). Amazon's use of robots in warehouses is linked to higher injury rates, report reveals. The Verge.
 https://www.theverge.com/2020/9/29/21493752/amazon-warehouses-robots-higher-injury-rates-report-reveal
- Pilati, F., Lelli, G., Regattieri, A., & Ferrari, E. (2022). Assembly line balancing and activity scheduling for customised products manufacturing. International Journal of Advanced Manufacturing Technology, 120(5/6), 3925–3946. https://doi.org/10.1007/s00170-022-08953-3
- Tung, I., & Tufano, A. (2024, April 28). Amazon workers are injured almost twice as often as other warehouse workers in Massachusetts. National Employment Law Project. https://www.nelp.org/insights-research/amazon-workers-are-injured-almost-twice-as-ofte n-as-other-warehouse-workers-in-massachusetts/
- u/IniMiney. (2024, March 29). Amazon warehouse employee experience [Online forum post]. Reddit.

https://www.reddit.com/r/amazonemployees/comments/1auegvt/amazon_warehouse_emp loyee_experience/ U.S. Department of Labor, Office of Inspector General. (2023). OSHA can do more to ensure warehouse workers are protected from industry hazards (Report No. 19-23-013-10-105). https://www.oig.dol.gov/public/reports/oa/2023/19-23-013-10-105.pdf

Westwood, D. (2023, February 28). Amazon warehouse robots are striking – but not for 50p more pay. The Guardian.
https://www.theguardian.com/commentisfree/2023/feb/28/amazon-warehouse-robots-striking-50p-pay-jeff-bezos

Will, E. (2020, September 29). Amazon's Dupont, Washington, warehouse has highest injury rates of any fulfillment center in the U.S., report shows. The Seattle Times. https://www.seattletimes.com/business/amazons-dupont-washington-warehouse-has-high est-injury-rates-of-any-fulfillment-center-in-the-u-s-report-shows/

Winner, L. (1980). Do artifacts have politics? Daedalus, 109(1), 121-136.

Wyatt, S. (2008). Technological Determinism Is Dead; Long Live Technological Determinism. In
E. J. Hackett, O. Amsterdamska, M. Lynch, & J. Wajcman (Eds.), The handbook of
science and technology studies (Third, pp. 165–180). MIT Press.