# Humanoid Robots: A Socio-Technical Study of Their Effect on the Automotive Manufacturing Workplace

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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***

In manufacturing, time is money and efficiency is key. Many manufacturing jobs are focused solely on increasing efficiency through process optimization. This is shown through methodologies known as lean manufacturing and six sigma; both provide organizational tools to increase productivity with the express goal of making more products and thus more money (Gould, 2022). One of the main ways to increase efficiency in a manufacturing line is by automating processes with consistent and streamlined tasks (*Humanoid Robots Are Getting to Work - IEEE Spectrum*, n.d.). Operators in manufacturing assembly lines tend to be repeating the same process for their entire work shift. Not only does this make the work day very menial, but it can cause a large strain on workers' bodies when moving around heavy parts. Manufacturing lines are designed to reduce this strain on workers' bodies, but sometimes it is unavoidable. As a result, companies are allocating the more tedious, time-consuming tasks from humans to automated solutions, namely robots. Not only does this make the manufacturing process go by quicker and more safely for humans, but it frees them up to do tasks that require the creativity of a human mind and the human eye for error, such as product inspections.

As more robots get incorporated into manufacturing and work alongside humans, it is important to study how the humans and robots will interact and affect each other. We must also study how both humans and robots, separately and together, affect the efficiency of the plant operations and the manufacturing processes. Using actor-network theory, we will analyze the relationships between all of these human and non-human actors, and use the network connections in order to answer the research question. The research question of this paper is: how does the incorporation of humanoid robots in automotive manufacturing affect the work environment?

This paper will outline the benefits of humanoid robots over larger more industrial robots because of their maneuverability and size, and how that increases efficiency and money flow in manufacturing. On the flip side, the paper will discuss the negative effects of humanoid robots, mainly the Uncanny Valley effect that causes robots to scare humans, as well as the threat robots pose to job security (*What Is the Uncanny Valley?*, n.d.). Overall, this paper will determine how humanoid robots can be incorporated properly in order to work well with humans, and find solutions that benefit human workers as much as the industry overall.

## ***Background and Significance***

The development of robotics for manufacturing has shifted focus in the last few decades. In most manufacturing plants you will see large industrial robots that can lift heavy loads but do not interact with and respond to human factors. As manufacturing has gotten more complex, more flexibility has been needed in automated solutions. This has caused a shift toward more intelligent robotic systems that are more adaptive to the work environment with humans (Garcia et al., 2007) More recently companies have been developing collaborative robots; these robots respond to human touch which makes it safer for operators to work directly with them. There has been a further shift to develop humanoid robots, which have a human-like appearance. This factor detracts people from wanting to work with robots as they create a strange sense of the Uncanny Valley Phenomenon, which describes the way people feel when they encounter something almost human but not quite (Berns & Ashok, 2024). There is an additional fear of robots replacing humans and taking away jobs for operators (Dekker et al., 2017). This fear of humanoid robots and artificial intelligence is reflected in and played up by horror films dating back to the 1920s. The robots present in this media are typically not reflective of the scientific

capabilities of the present, yet they can stir more distrust from the public. As a result of this, designers have to be very intentional in the way they design the robots to make them work well with humans and facilitate their incorporation into the manufacturing line.

This research is extremely relevant due to the large market for humanoid robots. While robotics has always been a large market, the market for humanoid robots specifically is estimated to be $38 billion by 2035 (*The Robots Are Here*, n.d.). This market spans across manufacturing, healthcare, retail, logistics, and education and research. Manufacturing is one of the most relevant industries in regards to humanoid robots, with automotive manufacturing taking up a big part of that. Many automotive companies have already or are in the process of developing humanoid robots to be incorporated into their manufacturing processes. BMW successfully deployed a Figure AI robot in their Spartansburg plant, having the robot successfully inserting sheet metal parts into fixtures. Tesla is designing their own humanoid robot, Optimus, to handle repetitive and physically demanding tasks in many of their Gigafactories. Mercedes-Benz partnered with Apptronik, a robotics firm, to test humanoid robots in its production facilities, evaluating their human-like dexterity (*The Robots Are Here*, n.d.). Hyundai even purchased Boston Dynamics, one of the most notorious robots companies, back in 2021 (*The Rise of Robotics in the Auto Industry | IBM*, 2024). While none of these robots have been fully deployed in a real manufacturing environment with all human workers present and interacting, that is likely to happen within the next few years. This shows why researching human-robot interaction is so important right now in order to determine the best ways to incorporate robots into manufacturing, making sure to do so in a way that humans will accept and work well with them.

One of the biggest reasons there is backlash against humanoid robots is the impact that will have on the job market in manufacturing. Humanoid robots are very beneficial for the

manufacturers. They increase efficiency, reduce wages, and streamline production. However, in the same ways that it is good for the company, it is harmful for the employees. The way that humanoid robots streamline processes typically do so in a way that reduces the headcount needed in a sector of the production line. This means that overall, when humanoid robots are introduced, it reduces the amount of jobs available for humans, and lowers wages for the jobs that exist. With nearly a third of all jobs at risk of automation in the next decade, it is a natural reaction for workers in the automotive manufacturing industry to be afraid of robots coming in and "stealing" their jobs (Autor & Salomons, 2018). However, to some extent this fear is misplaced due to labor shortages. Studies suggest that in the automotive market alone "there are 10 million unsafe, undesirable, and unfilled jobs in the US" (*Automating Automotive Manufacturing: How Humanoid Robots Are Moving onto the Production Line | Imaging and Machine Vision Europe*, n.d.). This is one of the motivators for automotive companies to develop humanoid robots, in order to address the labor shortages. Thus, though robots do reduce the number of jobs available, there are more jobs than are needed currently, which will help the industry grow. Humanoid robots open up the possibility for new jobs in less traditional manufacturing areas. Robots require more technicians and engineers focused on automation and robotics. The jobs for line operators decrease, but workers have the potential to move into a more specialized role supporting some aspects of the robots. Robots take over the more tedious and labor-intensive jobs that humans complete, which means they might be able to manage more tasks that can earn them higher wages (Autor & Salomons, 2018).

The second biggest issue when incorporating humanoid robots is the uncanny valley factor. The Uncanny is a term defined by Freud as something that is familiar and alien at the same time. This idea was further developed by Masahiro Mori who applied this idea to robots

and computer generated characters. This feeling is evoked by technology that is humanlike but not quite human, either in their features or their movements (*What Is the Uncanny Valley?*, n.d.). One of the biggest issues with humanoid robots is in their movement, which is limited by existing technology and thus often very stiff and jerky. The other is the facial features placed on the robot; many features that humans focus on, such as eyes and smiles, end up looking creepy on robot faces. This is something robot developers are constantly trying to tackle. It causes humans to not want to interact closely with robots, especially if they have more uncanny characteristics, which affects how a human-robot workplace would function. Studies show that human-robot interactions are more reflective of human-animal interactions (Lace, 2022). By incorporating more robots into manufacturing, you are reducing the amount of human-to-human interaction, which can have a severe impact on relationships built and the general culture of a plant.

## ***Methodology***

This section will describe how the research will be conducted. This is important because actor-network theory is used as a lens for analyzing the interactions between humans, robots, and other entities to determine how humanoid robots affect the work environment in automotive manufacturing. In order to answer this question, we must first acknowledge that there are many consequences, intentional or not, that come from humanoid robots being in manufacturing. Some of these consequences are good, and some are bad, and both affect human workers and manufacturing as a whole in different ways. We must recognize all of these consequences and view the problem from every perspective involved in order to reach an accurate conclusion. This is why actor-network theory is a useful framework to conduct this research under.

Actor-network theory is a sociotechnical framework that views everything within a system as an actor with agency (Crawford, n.d.). Actors can include human and non-human entities, and both are interconnected in a network of relationships and play critical roles in shaping outcomes in technological settings. The networks and relationships that have an effect on these outcomes will continuously shift and change, but the shifts are caused by actors within the network, and no outside elements can change this network. This framework is useful for this research because there are so many nonhuman actors in manufacturing that are affected by and affect the lives and work of human operators. The main nonhuman actor we will be studying is the humanoid robots themselves. Other nonhuman actors in this research include processes, efficiency, plant layout, and many more. Actor-network theory will help to understand the relationship between humanoid robots and human workers within the broader system of automotive manufacturing.

This research will use qualitative research methods with a focus on literature reviews. This will allow for an in-depth exploration of the topic and identifying themes relevant to the research question. The goal of literature review is to gather data from secondary academic and industry sources, in order to explore all previous studies, theories, and findings related to humanoid robots in manufacturing environments. One of the difficulties with this approach is the quantity and quality of existing literature. Because humanoid robots are a newer field within the last 10-20 years, there is not a history of literature on them the way there is for industrial robots.

The literature review will focus on some major themes to explore. First, we will explore literature that gives overviews on current technology of humanoid robots. This includes what actions they are capable of and how that is applied to automotive manufacturing specifically. This review will include potential future robotic applications and what jobs could be replaced in

the coming years. Secondly, we will study the impact of robot integration on workers' roles, job satisfaction, and productivity. Viewing what roles are replaced by robots and what roles those human workers can move into can help us determine if this is a beneficial change to human workers. This will also involve studying how worker productivity changes and how these changes overall affect job availability and wages. Thirdly, we will look into the impact of the humanoid aspect of these robots specifically. Seeing how the uncanny valley effect affects how humans interact with robots. Lastly, literature will be reviewed on how humanoid robots affect the automotive industry as a whole. Based on some of the positive impacts of humanoid robots on efficiency and process optimization, it goes to say that humanoid robots tend to be good for the industry and the companies, even if they have negative effects on the human workers and the work environment.

Additionally, though many automotive companies have been developing humanoid robots, none have been able to fully implement them into the manufacturing environment. Due to this, it is difficult to fully understand the impact humanoid robots have on human workers. In order to understand the humanoid robot and human interaction better, the research will be supplemented with literature review of humanoid robots in other fields, namely healthcare. This will help to understand the dynamics better and see what reactions can be expected from humanoid robots in manufacturing.

In order to get more quantitative data on how robots impact manufacturing, this research will also include a study of a case where humanoid robots have been implemented, specifically in the BMW plant in Spartanburg, South Carolina. The goal is to obtain real-world, context-specific data about how humanoid robots are currently integrated in manufacturing and other industries to understand the effects on workers, production processes, and organizational

culture. The focus on BMW's humanoid robots will provide context on automotive manufacturing as a whole. The data gathered through company reports, which include information from company executives as well as manufacturing personnel will help to determine if humanoid robots are overall beneficial to a manufacturing plant.

## ***Literature Review***

Humanoid robots provide manufacturing with huge improvements in efficiency. They are able to move faster and more precisely than humans, which helps to increase productivity. Additionally, they don't require any rest time or breaks. This means they can work around the clock without fatigue which helps when there are tight deadlines to meet (*THE IMPACT OF HUMANOID ROBOTS ON THE PRODUCTION WORKFORCE*, n.d.). Robots also feature advanced sensors that allow a level of consistency that humans cannot need. With fewer errors, there is less need for rework, repairs, and quality inspections (*Revolutionizing Manufacturing: How Robots Boost Productivity, Quality, and Safety*, 2023). Not only does it increase efficiency overall, but it makes jobs for human workers easier and safer. Robots automate tasks that are repetitive, boring, and place a large strain on human workers, such as carrying heavy loads. By reducing their physical workloud, robots help to alleviate stress injuries in manufacturing (*THE IMPACT OF HUMANOID ROBOTS ON THE PRODUCTION WORKFORCE*, n.d.). Robots can also perform tasks in environments that are hazardous to humans, which helps increase safety. One common example of this in automotive manufacturing is working around the large industrial robots. In automotive manufacturing, humans are protected by safety fences and light screens, which shield workers from sparks, welding flashes, and other scraps that could fly out. When working inside the light screens with industrial robots, humans have to follow an intensive

LOTO, lockout tagout, procedure. This includes shutting off power to all robots, letting them come to a standstill, and then placing a physical lock on the door and power button to stop the robots from being turned on while you are inside or near them (*Lockout Tagout*, 2021). This is one example of where humanoid robots can improve efficiency and safety. If humanoid robots were able to work around the industrial robots without enacting a LOTO procedure and shutting the robots off, this would save time and make the whole process more smooth.

Several automotive manufacturers have begun implementing humanoid robots to enhance efficiency. In August 2024, BMW had a successful test of their Figure 02 robot in the Spartanburg plant. This robot performed a variety of human-like tasks, with a focus on placing sheet metal parts into special fixtures. They found the robot to be faster and more consistent than the human workers, with a "capability to handle components with millimetre accuracy" (*The Robots Are Here*, n.d.). The plant also noted that the robot worked in support of plant employees by performing the ergonomically awkward and exhausting tasks to take the strain off of human workers (*The Robots Are Here*, n.d.).

While humanoid robots are decisively good for automotive manufacturing from the standpoint of the company, lots of existing literature focuses on the impact of humanoid robots on human workers. As mentioned earlier, robots can help take some of the physical strain and risk off of human workers, but they present other psychological and economic effects. First is the threat of job insecurity. In a study performed by Eric Dahlin, a sociology professor, he determined that "overall, our perceptions of robots taking over is greatly exaggerated" (Stahle, 2022). Out of a study pool of 2000, 14 percent said that they have been displaced due to robots. While this is not specifically in the automotive industry, it shows that automation does present a threat to human jobs. However, the study also found that people exaggerate how much of a threat

this is. The population that had been displaced predicted that 47% of jobs have been taken over by robots. Those who hadn't been displaced predicted that 29% of jobs were taken over (Stahle, 2022). This shows that even if it is a threat, fears of job losses due to automation are grossly exacerbated by personal robot biases as well as media portrayal of robots.

Literature also shows that rather than job elimination, humanoid robots present the possibility for job creation. Robots open up more jobs in the fields of robotics engineering, AI development, and robotics training. Roles shift more toward robot maintenance and supervision. This creates new opportunities for automotive manufacturing workers, but it also necessitates retraining much of the workforce (*THE IMPACT OF HUMANOID ROBOTS ON THE PRODUCTION WORKFORCE*, n.d.). New training and skills will need to be developed for collaboration between humans and robots.

Within automotive and in other industries that work with humanoid robots, there are varying levels of acceptance from the human workers. A study performed in the hospitality industry found that employee confidence is directly related to their perception of adopting robots (Parvez et al., 2022). If employees fear job security they are less receptive to robots in the workplace. With some employees, this uncertainty creates lots of anxieties that can produce technophobia, which makes employees unwilling to receive robots. Not only does their attitude towards robots change with their confidence and perception of job security, but it is affected by how management implements robots. In a recent study performed by Van Looey, it was determined that "employees' perception of robots reflects the management's trust in adopting and implementing robots in the organization" (Parvez et al., 2022). Thus, much of the success of humanoid robots relies on the company's management introducing them in a way that garners support rather than apprehension.

The Uncanny Valley is another factor that plays into the impact of humanoid robots in manufacturing. The Uncanny Valley Effect was introduced by Masahiro Mori to describe the effect that as robots pass a certain level of human-ness, they tend to elicit feelings of strangeness, unease, and scariness (*What Is the Uncanny Valley?*, n.d.). This discomfort is created with robots that appear "almost human" but not quite. One example of this is with robotic hands; with prosthetic hands that may appear real, humans will still be unsettled when they shake it to find the hand to be limp and cold, and thus the hand becomes uncanny (*What Is the Uncanny Valley?*, n.d.). This effect presents unique challenges in the design of humanoid robots as it is a delicate balance between a human-like robot and a robot in the valley. The most important thing in design is to not cross the human/non-human divide. If designers are making a fully human-like robot, they have to make sure to match movement fluidity, facial features, and tone of voice to that of a real human (*What Is the Uncanny Valley?*, n.d.). If they can not successfully achieve this, it is better to stray from human-like features, especially in the texture of robot skin. Robots that fall in the valley will impact the manufacturing environment because they change how humans interact and work with them.

Overall in the automotive industry, humanoid robots have significant economic benefits for companies. As discussed in previous literature, robots lead to increased output, reduced errors, and overall improvements in efficiency, all of which help reduce production costs. A study from the International Federation of Robotics claims that robots led to a 16% increase in productivity in the automotive industry between 2010 and 2016, allowing us to predict that the impact of humanoid robots in the near future will be significant (*Revolutionizing Manufacturing: How Robots Boost Productivity, Quality, and Safety*, 2023). A study from Boston Consulting Group also claims that robots lead to a ten to thirty percent reduction in production costs

(*Revolutionizing Manufacturing: How Robots Boost Productivity, Quality, and Safety*, 2023). This shows how impactful humanoid robots are on the automotive manufacturing industry. Robots allow individual companies to save money while meeting the growing production needs. However, robots produce unique challenges in implementation. The initial cost barrier and integration difficulties makes widespread adoption difficult. Part of these difficulties stem from the manufacturing of the robots themselves, which requires sophisticated production capabilities, and could take years to scale up for large quantities (Iain, 2024). Though the long-term benefits are likely to outweigh the short-term financial investments, few companies have had humanoid robots in effect for a significant amount of time. It is beneficial for companies to perform pilot studies to see how humanoid robots would fare in a smaller scale manufacturing environment that is more controlled than real-world. This will provide valuable insights and help companies fix any risk and uncertainties that come up before fully putting humanoid robots to the test (Iain, 2024).

## ***Discussion/Results***

The research question is how does the incorporation of humanoid robots in automotive manufacturing affect the work environment? Literature shows that incorporating humanoid robots affects the quality of life of manufacturing workers through its various effects on their physical and psychological well being, which impacts how they go through their jobs. It also shifts tasks and jobs for human workers, which presents new opportunities through further training and skills workshops, but also introduces new threats to job security. It reduces human interactions, which affects the workforce in positive and negative ways.

Quality of life in manufacturing work is determined by a combination of factors including physical well-being, job satisfaction, job security, and workplace culture. Work tasks and the job environment overall can affect employee morale, which in turn impacts how well people perform in their jobs. Humanoid robots improve the worker quality of life from a physical standpoint through reducing physical strain. Robots take over tasks that involve heavy lifting and repetitive motion; one example is how the humanoid robots are lifting sheet metal parts at BMW (*Humanoid Robots for BMW Group Plant Spartanburg*, n.d.). From a psychological standpoint, the impact of humanoid robots tends to be negative. Robots increase new technological anxieties due to job uncertainty, which leads to resistance among workers. However, the studies show that perceived automation threats are often higher than actual job losses, which means that the right introduction of robots could help minimize the psychological effects (Stahle, 2022). Job satisfaction is another important consideration, and something that is impacted as robots change job roles. Tasks for human workers shift from boring, repetitive tasks to more technical and supervisory roles. Some workers embrace this by learning new skills, but others feel displaced as their roles become obsolete (*Revolutionizing Manufacturing: How Robots Boost Productivity, Quality, and Safety*, 2023). This creates a conflict between overall efficiency and personal satisfaction in a job. More broadly is the question of how humanoid robots will change future job prospects as they have the potential to either eliminate or transform jobs. Humanoid robots create a new set of roles in technicians, programmers, and supervisors, which suggests that robots cannot fully replace human labor, but rather will augment it (*Robots*, n.d.).

Humanoid Robots cause a large shift in human work tasks, moving the labor responsibilities from manual labor to technical oversights. This presents challenges for the employers as further training is required to complete these newer job tasks. Upskilling is needed

to manage robot-human interaction effectively. For people with existing backgrounds in technology, these skills might be easier to acquire, but manufacturing is an industry that leans more heavily on manual labor than educational experience. Only 17.2 percent of workers in automotive manufacturing earned a college degree (*The Stakes for Workers in How Policymakers Manage the Coming Shift to All-Electric Vehicles*, n.d.). Many of the newer jobs directly related to humanoid robot implementation require intensive technical training, training that may require a college degree. This presents a barrier for employees to move positions into something more advanced. Some workers may feel relieved and excited to get into a more rewarding technical role, but many workers will feel displaced by the labor shift. This divide demonstrates the need for specialized programs to reskill and upskill existing workers to accommodate the labor demands (Laurel, n.d.).

Beyond the job tasks and responsibilities, the workplace culture is transformed by humanoid robots due to social interactions. Automation reduces the human-to-human interactions and collaboration, shifting the workplace to human-robot collaboration. This leads to less socialization and communication at work, but a more structured flow on the manufacturing floor. Robots will simply shift the connections in the network of manufacturing. Robots can never fully eliminate human interactions, so the network will always remain intact, but with an added connection between humans and robots. Companies incorporating humanoid robots will feel a split between the workers of acceptance versus resistance to robots (*(30) Manufacturing's Future - Humanoid Robots | LinkedIn*, n.d.). This research shows that initial resistance is expected as workers are fearful of being displaced by humanoid robots. Media portrayal of robots plays into this resistance. However, it is probable that gradually, workers will change their perspective on humanoid robots to more acceptance. In order to ease this transition, companies

should have training programs for humans and robots to work on collaboration. Workers should also be consulted in the decisions for how humanoid robots will be implemented. As workplaces shift towards more hybrid environments with robots and humans collaborating, some of these concerns will be erased.

By treating the automotive industry as a case study for robot implementation, this research could have implications on many other industries, especially ones where humans and robots will be interacting in close quarters. In the automotive industry, humanoid robots had economic benefits due to increased productivity, cost savings, and workplace safety. However, these benefits need to be balanced with worker well-being to find a solution that will support the industry in the long run. Future studies should focus on how robots impact the job market in the long run as well as considering at what point efficiency outweighs employee care.

## ***Conclusion***

How does the incorporation of humanoid robots in automotive manufacturing affect the work environment? This research shows that humanoid robots enhance productivity, but can only be fully successful if the workforce is able to adapt in the necessary ways. Robots present some outright job losses, but more so shifts in skills that require the workforce to go through additional training, and maybe further education, in order to complete the new jobs. Robots also present changes to the quality of life of human workers, both positive and negative. With robots, human interactions in manufacturing are evolving, which means workplace culture is changing.

The burden to ensure the success of humanoid robots in automotive manufacturing lies with the companies and management to incorporate them well. Companies need to present the robots in a way that allows the workforce to adapt to them and in a way that eliminates

unnecessary psychological and economic effects for the workers. Hosting workshops for the workforce to understand on some base level how the robots work can help to eliminate technological anxieties. Providing necessary training that is required for robot maintenance, programming, and supervising can ease job uncertainty concerns for the workforce and make employees more eager to shift into their new roles. These factors make the workforce more willing to accept humanoid robots into their work environment, and make them more willing to collaborate in a hybrid work environment.

Future research should explore hybrid work models in order to determine the best ways for humans and robots to coexist in industry. A hybrid work environment is the future of manufacturing, so it is imperative that companies learn the best way to bring humanoid robots into a human workforce. There should also be a focus on long term robot integration. It is crucial to see how workers' quality of life changes over time in a hybrid environment with humanoid robots. This also includes how willing humans are to collaborate closely with robots.

## References

*The robots are here: How humanoids are changing auto production*. (n.d.). Automotive Manufacturing Solutions. Retrieved March 24, 2025, from https://www.automotivemanufacturingsolutions.com/automation/the-robots-are-here-how-humanoids-are-changing-auto-production/46690.article

*The rise of robotics in the auto industry | IBM*. (2024, September 10). https://www.ibm.com/think/news/ai-robots-auto-industry

*Automating automotive manufacturing: How humanoid robots are moving onto the production line | Imaging and Machine Vision Europe*. (n.d.). Retrieved February 20, 2025, from https://www.imveurope.com/article/automating-automotive-manufacturing-how-humanoid-robots-are-moving-production-line

Lace, J. (2022, July 8). The Future of Robotics: Staying out of the Uncanny Valley. *Medium*. https://medium.com/@jessicaboyce1993/the-future-of-robotics-staying-out-of-the-uncanny-valley-18e61876f2aa

*THE IMPACT OF HUMANOID ROBOTS ON THE PRODUCTION WORKFORCE*. (n.d.). Automate. Retrieved March 24, 2025, from https://www.automate.org/robotics/news/the-impact-of-humanoid-robots-on-the-production-workforce

Content, S. (2023, July 1). *Revolutionizing Manufacturing: How Robots Boost Productivity, Quality, and Safety*. The Robot Report. https://www.therobotreport.com/revolutionizing-manufacturing-how-robots-boost-productivity-quality-and-safety/

Stahle, M. C. T. (2022, November 9). *Robots are taking over jobs, but not at the rate you might think says BYU research*. News. https://news.byu.edu/intellect/robots-are-taking-over-jobs-but-not-at-the-rate-you-might-think-says-byu-research

Parvez, M. O., Öztüren, A., Cobanoglu, C., Arasli, H., & Eluwole, K. K. (2022). Employees' perception of robots and robot-induced unemployment in hospitality industry under COVID-19 pandemic. *International Journal of Hospitality Management*, *107*, 103336. https://doi.org/10.1016/j.ijhm.2022.103336

*What Is the Uncanny Valley? - IEEE Spectrum*. (n.d.). Retrieved March 24, 2025, from https://spectrum.ieee.org/what-is-the-uncanny-valley

Iain. (2024, July 1). *Humanoid Robots in Warehouses: A Pilot Study Approach*. Manufacturing Today. https://manufacturing-today.com/news/humanoid-robots-in-warehouses-a-pilot-study-approach/

*Humanoid Robots for BMW Group Plant Spartanburg*. (n.d.). Retrieved February 20, 2025, from https://www.bmwgroup.com/en/news/general/2024/humanoid-robots.html

*Robots: Helpers or Substitutes for Workers?* (n.d.). Retrieved March 24, 2025, from https://www.stlouisfed.org/open-vault/2024/sep/are-robots-helpers-or-substitutes-for-workers

*The stakes for workers in how policymakers manage the coming shift to all-electric vehicles*. (n.d.). Economic Policy Institute. Retrieved March 24, 2025, from https://www.epi.org/publication/ev-policy-workers/

Laurel, C. T. U. 11301 S. R., & Md 20708 888.522.7486. (n.d.). *Robots in the Workplace: Learning New Ways to Harness the Future | Capitol Technology University*. Retrieved March 24, 2025, from https://www.captechu.edu/blog/robots-workplace-learning-new-ways-harness-future

*(30) Manufacturing's Future—Humanoid Robots | LinkedIn*. (n.d.). Retrieved March 24, 2025, from https://www.linkedin.com/pulse/manufacturings-future-humanoid-robots-jay-uhm-7azjc/

*Lockout Tagout: Meaning & Procedure*. (2021, November 5). SafetyCulture. https://safetyculture.com/topics/lockout-tagout/

(2022, March 2). *Lean Manufacturing vs. Six Sigma: Which is Right for You?* Stephen Gould. https://www.stephengould.com/lean-manufacturing-vs-six-sigma-which-is-right-for-you/

*Humanoid Robots Are Getting to Work—IEEE Spectrum*. (n.d.). Retrieved April 15, 2025, from https://spectrum.ieee.org/humanoid-robots

Garcia, E., Jimenez, M. A., De Santos, P. G., & Armada, M. (2007). The evolution of robotics research. *IEEE Robotics & Automation Magazine*, *14*(1), 90–103. IEEE Robotics & Automation Magazine. https://doi.org/10.1109/MRA.2007.339608

Berns, K., & Ashok, A. (2024). "You Scare Me": The Effects of Humanoid Robot Appearance, Emotion, and Interaction Skills on Uncanny Valley Phenomenon. *Actuators*, *13*(10), Article 10. https://doi.org/10.3390/act13100419

Dekker, F., Salomons, A., & Waal, J. van der. (2017). Fear of robots at work: The role of economic self-interest. *Socio-Economic Review*, *15*(3), 539–562. https://doi.org/10.1093/ser/mwx005

Crawford, T. H. (n.d.). Actor-Network Theory. In *Oxford Research Encyclopedia of Literature*. Retrieved April 15, 2025, from https://oxfordre.com/literature/display/10.1093/acrefore/9780190201098.001.0001/acrefore-9780190201098-e-965

Autor, D., & Salomons, A. (2018). *Is Automation Labor-Displacing? Productivity Growth, Employment, and the Labor Share* (No. w24871; p. w24871). National Bureau of Economic Research. https://doi.org/10.3386/w24871