Exploring the Reluctance of Adopting New Technologies and How that Impacts the Food Waste Issue Using Actor Network Theory

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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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STS Research Paper

Introduction

The issue of food waste has become as much of a technical issue as it is a social issue in today's society, resulting in about 1.3 billion tons of food being wasted every year through the supply chain (Ishangulyyev et al., 2019, p.297). In an era defined by the rapid development of technology, manufacturers were able to address the issue of food scarcity through the use of Genetically Modified Organisms (GMOs). Now, when the food waste issue is at hand, entities responsible for managing excess food distribution, such as grocers and nonprofits, have been reluctant to use new technology such as artificial intelligence to solve this problem. In order to combat this issue, many societal efforts including the "AI For Good" movement have been established to achieve the sustainability goals set forth by the United Nations (Cowls et al., 2021).

This research paper addresses the central issue of how reluctance to adopt new technology hinders efforts to reduce food waste. To investigate this hesitancy, the study utilizes the Problem Definition and Solution process proposed by Downey, alongside the Actor Network Theory (ANT) STS frameworks. These approaches examine the relationship between the impact of new technologies, such as AI, on food waste reduction and how being weary to embrace these technologies impacts solving the problem.

Methods

The research question being answered in this paper is exploring how the reluctance of adopting new technology impacts the food waste issue. It will primarily be conducted with network analysis using document analysis. A survey of sources that describe human behavior as it relates to using new technology will be important to analyze in order to gain a holistic understanding of the problem including research papers published by International Journal of Production Research and articles by Forbes. Furthermore, case studies from companies like Pacific Coast Collaborative will be used to understand the implications current use cases of modern technology have on food waste. Key words to help gather the data include "supply chain systems," "technology adoption," and "food waste." The data collected will be mapped using Actor Network Theory and then put in context using Downey's Problem Definition and Solution Process. This will allow a discernment of how businesses, especially grocers, currently view the success of their supply chain management and their thoughts on improving it.

Background

A significant portion of food waste can be attributed to inefficiencies in managing the food supply chain including poor packaging practices and substandard harvests (U.S. Government Accountability Office, 2019, What GAO Found). Consequently, poor supply chain management leads to grocers ordering too many items, resulting in food being spoiled due to a lack of consumption. This is not only a significant financial burden on retailers, but is underscored by the problem of food insecurity, impacting 815 million people worldwide in 2016, and about 12.8% of households in the United States in 2022 (Onyeaka et al. 2023, p.10482; EPA 2024, EPA's Wasted Food Scale).

To understand the rise of food waste, it is imperative to look at the socioeconomic conditions faced by people throughout the past century. During the 1930s, poor economic conditions attributed to the Great Depression resulted in American families not having enough food to eat (Skip Shapiro Enterprises, 2024). This led to the first Food Stamp Act initiative in 1939 (O'Brien et. al., 2004). However, with the introduction of the refrigerator in the and the rise of consumerism following World War II, more Americans were able to save food for longer periods of time. Consequently, people were buying more food, resulting in larger amounts of waste as it was not fully consumed (Skip Shapiro Enterprises, 2024).

Eventually, starting in the 1980s, an era of sustainability began, calling for entities to take action to reduce food waste. Those actions included composting food, the passing of the Bill Emerson Good Samaritan Food Donation Act, allowing people to donate food to organizations without any liabilities, and finding ways to remove inefficiencies in the food chain using new technology (Skip Shapiro Enterprises, 2024). During this timespan, there was a rapid development and evolution of computers, mobile devices, and connectivity across the globe (Paige, 2024). This is most notably addressed with the creation of the internet, allowing people to share information from their own homes.

Today, the technology that is being sought after is AI: Artificial Intelligence. This can be described as technology that can mimic human behavior and complete tasks by learning from data, thus allowing a computer machine to complete tasks, often off the basis of predictive behavior (IBM, 2023).

With advancements in Artificial Intelligence, retail grocers and nonprofits that deal with food reallocation can enhance their supply chain management to help reduce food waste due to unprecedented access and analyzing of data, yet are not choosing to, contributing to 750 billion dollars worth of food being wasted (Onyeaka et. al, 2023, p.10482). In parallel, only 11% of nonprofits admitted that they used technology in meaningful manner (Yale Insights, 2018). Furthermore, many business entities are wary of sharing their information with the artificial intelligence systems in fear of their data being accidentally shared with unauthorized parties (Brintrup et al., 2023, p.3-6).

To understand the correlation between technology adoption and food waste, it is imperative to analyze the systematic relationship and thought processes between all entities that contribute to the problem. This can be achieved by facilitating a discussion using two central frameworks essential to STS: Actor Network Theory (ANT) and the Problem Definition and Solution Process. Actor Network Theory pertains to mapping all entities, both human and nonhuman, that connect and impact each other in a sociotechnical system, whereas the Problem Definition and Solution Process discusses how engineers should address finding answers to problems through a holistic approach via communication, collaboration, and assessing the implications of every potential answer before choosing one.

Actor Network Theory and Problem Definition and Solution

To understand the correlation between technology adoption and food waste, it is imperative to analyze the systematic relationship and thought processes between all entities that contribute to the problem. This can be achieved by facilitating a discussion using two central frameworks essential to STS: Actor Network Theory (ANT) and the Problem Definition and Solution Process.

Actor Network Theory (ANT) is a framework to understanding the complex relationships between components that make up sociotechnical systems and discovering to what extent they work together. It is used to create a mapping between seemingly unrelated actors to build a web of relationships that depict how different parts of a sociotechnical system play a large role in the grand scheme of certain issues (Venturini, 2009). In this framework, actors represent entities, both human and nonhuman, that impact each other in a sociotechnical system. These stakeholders are able to shape the structure of an issue through diverse, hierarchical interactions.

Moreover, the actors involved may not be aware that such interactions exist, especially as they may not be direct.

ANT is relevant to engineering practice because it can help engineers define problems as it helps us understand how different actors influence each other and change over time, giving us a holistic view of necessary steps to take when solving problems, including helping us find missing connections. However, ANT is difficult to explain and understand because it is a time consuming process, requiring engaging in deep thought and research to find underlying associations between different actors and processes. Engineering practice relies on understanding these associations. To better understand how ANT is articulated by scholars, it is imperative to analyze Tommaso Venturini’s article, “Diving in Magma,” and Bruno Latour’s “Missing Masses.”

Venturini's "Magma" serves as a strong source for describing ANT for engineering practice, demonstrating how engineers can comprehend the complexities of the world by observing their surroundings and understanding controversies from diverse perspectives, all while relating it to popular engineering challenges. Venturini argues “objectivity can be pursued only by multiplying the points of observation” (Venturini, 2010), serving as a reminder to use ANT to explore obscure relationships to find how seemingly unrelated actors are connected in the same problem. He also argues controversies encompass any actors in the system, not just humans. Together, this is applied in the global warming conflict to observe how dissimilar actors such as butterflies, business leaders, and jet engines are involved in the same conflict. This expands the importance of observation because it allows you to understand how different courses of actions can impact each actor when solving problems. This includes understanding the impact of not using jet engines to reduce carbon footprint of planes will impact butterflies’ existence, as well as the financial status of business leaders. This offers a practical application of ANT for engineers by exploring how different actors play pivotal roles in each other's existence, while also using this framework to define problems using multifaceted viewpoints.

"Missing Masses" offers a great introduction to how ANT works through mundane examples, but its main focus is on how nonhuman actors shape society, and doesn't fully expand the use of ANT to modern engineering applications. For instance, Latour's discussion of a door's functionality, describing it as "a wall hole, often called a door... hinges upon the hinge pin" (Latour, 2018), provides an illustration of ANT by showing how various actors worked together to allow a door to operate. This extends to how nonhuman actors, like signs on doors, influence human behavior, offering a clear depiction of ANT's principles in everyday instances. Although this highlights the basic principles of ANT, it does not apply it to a broader engineering context like "Diving into Magma" as it provides limited insight into applying ANT within engineering projects, and solely focuses on rudimentary examples. This is further exemplified in the discussion about how the presence of a traffic light versus a cop impacts human behaviors. It merely helps you understand the components of a small-scale system, but it does not help you learn the discovery and observation skills to connect contrasting actors to each other, a core component of ANT outlined in "Diving into Magma." This shows how "Missing Masses" offers an alternative explanation for engineers to understand, focusing more on nonhuman developments that impact humans, not how all actors are impacted by each other, especially as it relates to society's modern problems.

In the food waste issue, a human actor includes executives at non profit organizations that work on helping reallocate wasted food. They are influential leaders whose decisions funnel down throughout the organization and impact how they go about solving the issue. Similarly, a nonhuman actor would include the current supply chain management systems used by grocers. While it doesn't make the final decision about how much food to allocate to these businesses, it offers calculated advice used by the human actors when making financial decisions. Using Actor Network Theory, these actors can be connected across the sociotechnical problem outlined above to provide a holistic understanding of the issue at hand, visualizing how these interactions contribute to possible gaps found in the system, helping discover current challenges that were not clearly apparent.

Another important framework to analyze is the Problem Definition and Solution Process (PDS) by Gary Downey. Downey outlines four steps to this process including but not limited to defining the problem, collaborating with others, and assessing the implications of the approach. These steps allow for a systematic approach on how to solve modern engineering problems. By defining the problem, it allows for engineers to have a clear, working knowledge of the issue at hand. Moreover, it is imperitive to work with others to identify the correct problem and create solutions as to have diverse perspectives. Doing this allows for a holistic approach to allow people to identify possible missing gaps that some people may not have noticed at first glance, similar to ANT. Lastly, Downey's approach also allows one to take their potential actions' consequences into action, allowing the authors of solutions to understand if their approach will truly by a comprehensive solution (Downey, 2005, p. 589-592). This can be used with this research topic to understand how industry leaders plan for reducing food waste and learning how they weigh the benefits of adopting new technology.

A use case of PDS occurs in "Measuring Change over Time in Sociotechnical Thinking: A Survey/validation Model for Sociotechnical Habits of Mind," a study that judges how students uses community perspectives when solving problems. The study was able to use this approach to help design questions that were more clear and succinct, making it easier to gather information in their surveys as well as gain further insight into students' thinking processes. This allowed the organization to take sociotechnical perspectives into account in their study (Leydens et. al, 2018).

Results and Discussion

Currently, there is a disconnect between the entities that produce food and the tools used to coordinate the procedure to distribute the excess production primarily due to responsible parties not upgrading their technology or engaging in open communication to help find ways to dispense wasted food. Food manufacturers in the supply chain industry are reluctant to modernize their analytic tools to help predict the amount of food they should make primarily due to concerns of not understanding how the technology works and because of security concerns of how much data machine learning systems collect and how such data may be accidentally shared with other parties. Such reluctance leads to overproduction of food products, much of which is later wasted. Consequently, being in a state of overproduction leads to an exacerbated amount of wasted food due to a lack of communication between actors responsible for food distribution and excess food collection. This issue is compounded due to no construction of a cohesive infrastructure to outline and analyze potential solutions and their benefits to increase communication between such entities.

Actor Network Theory

The food waste issue is comprised of several actors, both human and nonhuman, that are all connected through diverse relationships. Each actor impacts each other, whether directly or indirectly, in a way that has consequences for the amount of food wasted in our society.

Human Actors

Human actors are the individuals people and organizations that produce an impact in the sociotechnical system of the food waste problem. In this scenario, the first human actor to look at are the supply chain companies and their executives. In the United States, there are approximately 4,694 supply chain management companies as of 2023 (IBISWorld, 2024). These are firms that are responsible for providing logistics for how much inventory to order for other actors in this system including grocers, and providing the technology to do so.

The next actor in the system are developers. Developers are the programmers who help supply chain management firms build software that help them assist clients when making decisions about ordering food inventory. These clients include farmers and grocers, the actors who are responsible for distributing food to consumers as there are approximately 1.89 million farms and roughly 62,000 grocers in the US (IBISWorld, 2024; USDA, 2024). Lastly, nonprofit organizations and their leaders are the last set of human actors that will be analyzed as these actors are important to the state of food redistribution when overproduced and oversupplied by farmers and grocers.

Nonhuman Actors

Although they are not individual people, the nonhuman actors within the sociotechnical system play just as important of a role as their human conterparts. These are the components that directly impact the decisions the human actors make. In this system, one important nonhuman actor includes the food itself, as the rise of food waste is the call to action that triggers the human actors decision on how to properly allocate unused portions. The next nonhuman actor is the supply chain management system, or more specifically, the technology it is comprised of. This includes the software algorithms behind the current systems, as well as new machine learning and AI algorithms that are being developed to help innovate the current software.

Analysis

To fully understand how human and nonhuman actors relate to each other and the food waste issue, it is imperative to understand their interactions relative to each other within a singular system. First, it is important to recognize that issues in the supply chain cause roughly 936 billion dollars worth of annual waste (Ishangulyyev et al., 2019, p.297). The food is wasted in each of the four stages of the supply chain: Production, Processing, Retail and Food Services, and Consumer (U.S. Government Accountability Office, 2019, What GAO Found).

During the Retail section of the supply chain, grocers and their supply management leaders must adequately plan for the amount of food to order from the farmers to satisfy customer needs. The amount ordered is optimized using specific supply chain algorithms such as demand forecasting, using previous consumer patterns to make decisions (Oracle, 2023).

With emerging technology such as machine learning and aritifical intelligence, supply chain managers have the opportunity to adapt their current methods to improve food ordering with faster, more predictive technologies. However, the executives are afraid to make this change out of habit. According to the CEO of the Center for Advancing Retail & Technology, Gary Hawkins, "In many traditional retailers, it's those established beliefs and ingrained practices that are preventing traditional retail from really fully benefiting from all this new innovation, all these new capabilities." Here, he is referring to grocery retailers reluctance to adapting to new technology in a society where technology is changing faster than ever before (Grocery Dive, 2024).

Furthermore, when companies decide to take the initiative to upgrade their systems, they are unaware of how to effectively use the software. Since companies have to break tradition and navigate the industry using new tools, many of these businesses will face technical debt, or lost time to maintain the new system. This technical debt comes with problems for retailers as they do not know how to navigate the technology and have to rely heavily on developers. The fear of the unknown exacerbates the reluctancy to reimagine how to manage the grocery supply chain as leaders fear failing and are not as risk prone when a proven method exists (Grocer Dive, 2024).

Moreover, companies have a further reluctance of adopting to AI based supply chains as 44% of companies in a LeanDNA survey say they lack data that would help provide real time data for day to day operations. Furthermore, they say the need to analyze the data increases the barrier to entry for these businesses as 55% of the companies in the survey state they do not have the existing technological framework to provide reinforcement for data analysis, nor do they have a staff that is trained to use such frameworks. These companies also cite that providing for such a drastic change would cause significant financial burdens as well (Forbes, 2024). This reinforces the conflict the human actors that are executives face in the network with nonhuman actors of technology due to the distrust of new technology significantly improving the business state with minimal repercussions.

Conversly, grocers and their supply chain management staff have years of data they currently use to make their orders and can supply them to developers to make a larger AI algorithmic model. However, these leaders are concerned with data privacy at the software level due to many companies having access to the same algorithm. This concern is known as Digital Supply Chain Surveillance (DSCS). The concern is based on the fact that since AI systems have access to an unprecedented amount of data, an AI system that has access to multiple supply chains may mix data, giving unauthorized suppliers access to another supplier's data without their consent, causing financial repercussions in future negotiations (Brintrup et al., 2023, p.3-6).

Consequently, companies continue to use their current software practices, leading to 35% of food not being purchased and 1.49 million tons of food being spoiled in grocery stores as of 2019 as shown in a case study by Pacific Coast Collaborative. If AI solutions are adopted, "an estimated 1.1 million tons of food waste and 2.8 million tons of CO2 emissions could be avoided," (Pacific Coast Collaborative, 2022, p.12). This again shows how the nonhuman actors of software influence the decisions the human actors, the executives, make as it relates to food supply chain management.

A lack of communication between the two actors of supply chain and nonprofit executives is apparent in the sociotechnical system as there is no succinct method of communication between the two parties. The lack of communication results in a higher amount of wasted food because of the reluctance to adapt to new technology that shares data about how much food inventory grocers have and nonprofits need. The reluctance is again related to the negative perception of newer technology because of their security concerns and the leaders' limited knowledge on how to set up such digital systems (K, et al., 2023, 1544-1547).

Using Downey's Problem Definition and Solution Process, the gap in the system can be bridged by increasing channels of communication. Currently, the human actors lack coordination with each other on how to implement new solutions due to a lack of expertise. This is heightened when only 89% of nonprofit organizations believed they used technology ineffectively (Yale Insights, 2018). Executives in both supply chain management and with nonprofits need to first define what the specific problem they face with technology and pinpoint what exact features make them uncomfortable for its adoption. For issues related to DSCS and unathorized data sharing, this includes finding ways to isolate their data. This facilitates executives to work with developers to propose software solutions that take their concerns into action and offer an answer to reduce food waste within the realm of AI technology. Then, with the proposed solutions, the team of engineers and executives can discuss the implications of each to determine the best course of action to take, including to take no action at all (Downey, 2005).

Limitations

While this research captures a broad trend exploring the views of leaders in grocery and supply chain management industries as it relates to using technology to reduce food waste, it could be further enhanced by looking at current attempts by major retailers to implement such technologies in their current practices. However, due to it being the early stages of this AI implementations, many of the current use cases are not available to the public at the moment. Furthermore, for researchers that want to continue diving into the relationship between the actors and their role in the food waste issue, it would be highly effective to conduct a long term case study comparing the effectiveness of AI solutions in supply chain management to current technological solutions. It would also involve a risk analysis of how much data is exposed to unathorized parties and to what extent measures are taken to prevent such a breach in confidentiality. Such a study allows executives to apply this data about vast actors when strategizing ways to improving their supply chain when using Actor Network Thoery and the Problem Definiton and Solution Process.

Conclusion

When exploring how the reluctance to adopt new technology significantly contributes to the issue of food waste within the supply chain industry, it was found that the hesitation of food manufacturers and supply chain executives to embrace modern analytic tools, primarily due to concerns about data privacy and lack of understanding of new technologies, leads to overproduction and inefficient distribution of food. Using Actor Network Theory, the relevance of technology adoption is put in context with management teams as it relates to finding ways to reduce food waste.This underscores the need to increase communication and technical literacy among all stakeholders in the sociotechnical network, including supply chain, grocery retail, and nonprofit executives. Only when these challenges are addressed can an effective food distribution system that minimizes waste be created.

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