Faster Fast Food

Since 1921 and the opening of the first White Castle fast-food chain in Wichita, Kansas, American's have been enamored with getting their burgers and fries quickly. Americans love fast-food. Fast-food restaurants have become integral parts popular culture and have made life easier on dual working families unable to make home-cooked meals on a daily basis. They have changed the travel landscape of America and now line highways and interstates providing speedy alternatives that get travelers on the road quicker. Fast-food once an iconic feature of United States' (US) culture has expanded to global adoption. The franchise model of fast-food is being applied to menus that now extend well-beyond burgers and fries and can be tailored to nearly any culture or diet. The transformative power of fast-food has been seen in global economics and politics. For years the fields of international relations and economics followed anecdotal evidence first set forward by economist Thomas Friedman in 1996 that no two countries containing McDonald's ever went to war against one another (This is no longer true).

The impact of fast-food has been international news. For example, following the fall of the Soviet Union the opening of a McDonald's on Pushkinskaya Square in Moscow on January 31, 1990, marked a transition from a communist government operating a command economy to a new democratic government with a market economy. The first McDonald's opened in Moscow hosted more than 30,000 customers on its first day. Its grand opening was carried by western news outlets as a sign of democratization and openness. Fast-food is a global powerhouse industry worth and estimated 875.26 billion US Dollars in 2019 and expected to grow to near one trillion US dollars over the next decade.

In the fast-food industry, the cost of labor accounts for approximately 20% all costs associated with the operation of a franchise. Since the start of the Covid-19 Pandemic maintaining labor pools to sufficiently staff many fast-food franchises has been a persistent challenge. Combined with collective mobilization by employees and a push by multiple state governments to increase the minimum wage within states and federally, the labor costs of franchises are expected to increase. One particularly, strong movement in the US that is pushing for increased wages is the *Fight for 15* campaign which seeks to raise the wages of all fast-food employees to $15/hour a near 28% increase in the median employee salary. While the cost of labor can be partially offset through increased prices there is a limit on the ability of franchises to increase costs for fear of driving customers to other brands. Brands as diverse as McDonalds, Burger King, Taco Bell and others are actively seeking ways to reduce the labor costs of running their franchises. Initially the process of reducing labor costs sought to increase individual labor productivity through efficiency gains in the preparation and delivery of food through improvements in packaging, processes, and customer facing systems such as cashiers. Yet as the labor productivity of each individual employee has been maximized the franchise owners have become increasingly vocal in pressuring their brands to seek out further ways to reduce labor costs.

The US Bureau of Labor Statistics found that in 2020 more than 3.45 million Americans were employed as "Fast Food and Counter Workers". The majority of fast-food workers are women (slightly over 50%), and the average age of workers are individuals in their late twenties to early thirties. There has been a distinct demographic change in the fast-food industry by age as the number of older employees has increased. The racial demographics of the industry are more uniform with the population at large with slight over representation of Hispanic and African Americans. Fast-food franchises are a major source of employment in the US and are heavily comprised of individuals with less than a college degree. These jobs are typically poorly paid and according to the Bureau of Labor statistics the mean annual wage of fast-food employees is $24,540/year which is $1,960 below the federal poverty line. Although these jobs are below the federal poverty line, they offer a much-needed source of income for many individuals.

Although the fast-food industry is a large employer, it also suffers from extremely high and expensive turnover rates that by some estimates exceeds 150% turnover annually. Combined with an inability to find workers the industry is in a bind over how to maintain revenues and reduce costs. As of 2018 there were approximately 247,000 fast-food restaurants in the US all facing similar problems but with slightly different variations. The challenges faced by the industry are forcing innovation beyond efficiency gains in human processes, human procedures, and physical packaging. An increasing number of engineers and computer scientists are entering the fast-food industry. Most do not have any professional culinary experience, rather they are interested in breaking down the complexities of the culinary process in ways that can be replicated by machines.

The drive to incorporate robotics into the kitchen is catalyzing as a new field of research and development. McDonalds was estimated to have spent more than $1 billion on automated kiosks in 2019 alone. Yet innovation in the fast-food industry is not limited to automating point of sale interactions with customers. In 2017 Miso Robotics received more than $40 million in venture capital funding, followed by another 10 million a year later. As of fall 2020 Miso Robotics had released Flippy Robot-on-a-Rail capable of flipping hamburgers on fryers with machine like efficiency for a starting price of $30,000. For additional money the robot can be enabled with features that have it clean the fryer. The system has been rolled out to several Major League Baseball parks, CaliBurger and now to 11 White Castle locations. Other restaurant chains have focused their efforts on innovations through robotics as well including Spyce, Creator, and CafeX among others.

In the United States the fastest growing segment of the fast-food industry is Chick-fil-A. Chick-fil-A has managed to achieve nearly double-digit revenue growth year-on-year and by 2018 had reached nearly $10.5 billion in revenue. Chick-fil-A's rapid growth, increasing dominance, and importantly constrained menu make it an attractive potential client for advanced automation. In

2017 FeedMeAI, a start-up by a combination of engineering and computer science students at Virginia Tech, began work on a machine to automate all interactions at Chick-fil-A locations world-wide. The FeedMeAI team was not under contract with Chick-fil-A but wanted to try and identify whether it was possible to rearchitect the entire fast-food industry process. The team of professors and graduate students began by breaking down every part of the fast-food industry process of a Chick-fil-A.

Rather than try and remove singular tasks from employees such as frying burgers or automating kiosks they team started by rethinking how the raw ingredients entered the location to the eventually delivery of final products to customers. They also considered how the facilities were cleaned and managed. Their goal was to construct a replica Chick-fil-A that needed only one employee per shift, to serve simply as an overseer of machine operations. The intent was to reduce the daily number of employee shift hours from approximately 120 to 24 an 80% reduction in labor costs. This would reduce the number of daily employees from 15 to 3. Such a cost reduction would improve the efficiency of Chick-fil-A locations and dramatically increase each individual franchise's profitability.

Engineers and computer scientists started at the distribution centers and the packaging structures of the incoming raw materials. By redesigning the packaging in which raw materials were delivered to the franchise locations they could make their storage, sorting, opening, and disposal more efficient and automated. They started by standardizing the size and shape of packages. Next, they altered the orientation and storage arrangements of goods within each package so that they could be identified using computer vision algorithms and barcodes. They even changed where the food entered each restaurant. Rather than having a single back door through which all raw materials entered the facility, they designed a highly efficient "goods entry portal" through which all boxes entered the facility and were then automatically sorted and stored according to perishability by robots designed for the lifting, maneuvering, and stacking of the specially designed containers. Redesigns of the refrigeration systems were also undertaken to make them more robot friendly and less anthropocentric. They even developed a system whereby the trucks that delivered the boxes of raw materials simply had to back up to the goods entry portal and automated conveyor belts in the truck fed the boxes through the portal to the waiting robots. These activities substantially reduced the time intensive process of stocking goods in the restaurant. It allowed the stores to open later and resulted in a 10% reduction in electricity consumption.

Next the team broke down the tasks associated with the cooking of each item on the menu and developed a universal chef bot that that worked with the stock bots to feed raw materials into the line of operations for food production. With the depletion of each box of raw resources, the stock bots would automatically feed the compressed box out the packaging exit port to an automated compressor to create bales of carboard which could then be picked up when sensors

determined the bale was complete. Because the chef bot did not need the same dimensions the spacing and orientation of a human, the robotics was redesigned to accomplish culinary tasks with maximum efficiency. This resulted in a square footage savings of 25% and reduced building construction costs by 10% over the standard store. The reduction is store square footage reduced electrical needs by a further 15%.

Computer vision algorithms and new sensor arrays checked each component of products for defects in all perishable and non-perishable menu components. Any item deemed to be below quality threshold was delivered to an automated composter which blended organic waste and deposited it into eco-friendly drums which when full were unloaded by truck and transported as organic compost to local farms. Chick-fil-A's primary menu included approximately 100 items in total. The step-by-step production of each item was programed into the chef bot or the food delivery bot (for prepacked items). Raw materials were automatically transferred by stock bots when ordered into the chef bot line and the process fed these materials to the delivery bot at the other end of the line. The delivery bot would then load the items into a bag, place the requested condiments and fill the drink requests of the customer on a tray which would then be delivered through a cubby to the customer either through the drive through window or in a locker style system in the main dining room.

When a customer enters the restaurant, they use a kiosk to enter their order. They are asked to confirm their order and its contents. Drive through customers have their order taken by the automated AI speech recognition system. Their order is then presented on the screen, and they are asked to verify their order. At the initial point of order customers using the drive through may request their order in one of 10 different languages and the AI will automatically adapt and display their order in their language of choice on the screen. Inside customers can select one of 10 different languages or request accessibility assistance with their order. Requesting accessibility assistance will alter the indoor kiosks to accept voice commands and questions regarding the menu to aid the visually impaired.

Trash receptacles in the restaurant are automated and when full lock their door to prevent overflow. When the restaurant's sensors detect a decline in foot traffic the trash receptacles open and self-maneuver themselves to the waste closet where they automatically discharge their contents into and are cleaned and sterilized. The receptacles then automatically return to their original location when sensors indicate it is safe to do so. The waste is automatically fed into a waiting dumpster with sensors that assess the weight and volume of the dumpster used and alert the waste services provider to come prior to reaching maximum capacity.

From order to delivery, the automated process of food delivery time was reduced from 5 minutes down to 3 a 40%-time savings. The increased speed of food delivery had the added benefit of increasing the potential customer service volume by 15%. With higher customer order fidelity

due to order verification costs associated with mistaken orders reduced costs a further 2%. Each of the bots was also provided with programming to clean and sanitize their workspaces to maintain kitchen standards what would exceed A level department of health requirements. Due to the influx of individuals inside the main dining room cleaning of that room was reserved for the remaining human employee or franchise owner. Because of reduced alternative work requirements, they were able to keep public spaces 40% cleaner.

After sustained testing an evaluation the team determined that the uptime of the robotics and machinery was 480 hours of uptime for every hour of maintenance required. They also determined that with system wide purchasing the pricing implementation of the robotics system would add an additional $1 million on top of the estimated $342,000-$1.5 million estimated building and construction costs for conventional restaurants. The team further estimated that savings on human labor costs would be recovered in approximately 18 months based on 30 employees at $25,000/year.

The FeedMeAI team recognizes that the solution they have developed is entirely tailored to one potential customer with a more limited menu than other competitors in the market. This test and evaluation case was designed to show that it was possible to increase the efficiency and profitability of a restaurant system by shifting away from ad hoc modifications to anthropocentric structures. The team presented its findings in a series of papers presented at ACM and IEEE conferences and demoed their product for a number of Chick-fil-A franchisees. The reception of their system and its ability to increase the profitability of franchises is very attractive to franchise owners.

There is concern however within the company that automation of the franchise to such a high degree will irrevocably change the corporate culture of Chick-fil-A. The company has often prided itself on unique culture among fast-food employers and has one of the highest retention rates in the industry. Chick-fil-A is also concerned about the potential negative blowback about being one of the first movers in a new industry and changing a formula that has been demonstrated to work well over the last several decades of corporate success and expansion. Chick-fil-A has also engaged in a variety of community outreach programs over the years and used its restaurant staff to assist in promotional activities at schools and university campuses. These activities are part of the overall marketing strategy of the company and would be disrupted with a significant decline in employees. Chick-fil-a has also prided itself on achieving the highest customer service marks in the industry. It is common for Chick-fil-A employees to say: “it’s my pleasure” in response to customer requests. They have a lingo in response to nearly all aspects of their customer service process from clearing tables to referring to each other as “teammates.” There is a great deal of concern that the automation of the firm while on paper increasing efficiency and reducing costs would change what Chick-fila-A considers its “differentiating factor.”

Discussion Question #1

Free market systems incentivize innovations that foster efficiencies in production. These efficiencies have been undertaken across many industries ranging from printing to automotive manufacturing. Efficiencies lower the aggregate costs of production including the associated labor costs. In the case example above the FeedMeAI team has developed a system that dramatically increases efficiencies across a range of metrics from labor costs to utility usage to food delivery times. Their prototype of a fast-food chain operating with minimal human intervention is presently beyond the cutting edge of what is possible, but it is on the horizon. What are the consequences of privileging algorithmic efficiency at the expense of human labor? Are there any? Is there a difference between privileging the utilization of machines using AIs in restaurants than on the assembly line of a factory manufacturing automobiles?

Discussion Question #2:

In capitalist systems the corporation has been argued to have a principal responsibility to its shareholders. The implementation of AI infused robotics enable corporations to substantially reduce their dependence on human labor. This reduction in labor dependence can markedly increase the profitability of companies. Do corporations have a responsibility to their labor forces? Should they forego efficiencies to maintain a workforce? If so when, and why should they do so? Should the government disincentivize through taxes or regulatory policy the implementation of AIs that reduce or eliminate human labor to maintain labor markets?

Discussion Question #3

The increased possibility of robotics and AI in workplaces as diverse as fast-food chains places might place downward pressure on labor wages as corporations can threaten to substitute robotics and AI for labor if labor doesn't accept lower wages. Individuals with less than a college education constitute the vast majority of labor in fast-food chains. Does the introduction of robotics and AI systems which are developed and maintained by individuals with a college education or higher foster class cleavages and increased economic inequality? What can be done to safeguard wages as labor is increasingly offset by technology?

Discussion Question #4

The above case example highlights just one industry where automation is being actively studied and implemented. The increasing automation of jobs is concerning for a number of economists who highlight that many jobs once commonly thought resistant to automation are now the targets of engineers and computer scientists with powerful AI systems. What are the primary challenges that will be faced in the labor market in the coming years? What type of education will be required to secure employment? How should individuals, local, state, and federal governments respond to the increasing automation of jobs? These are all questions that are important to consider and address as advances in AI and engineering make everything from automated assembly lines to robot run restaurants possible. What concerns should college

students have when preparing for a future in which they are not only competing against other workers in the labor market, but also AI enabled machines?

Reflecting on Faster Fast Food

The team at FeedMeAI identified what they consider a problem, the cost of labor and the inefficiencies of running a fast-foot franchise. The example above leverages the traits of the well-known firm Chick-fil-A, but really the technologies are applicable to any and all similar firms. The engineers and scientists broke apart the production lines of the Chick-fil-A and reconsidered the entire process of fast-food from a new angle. By redesigning the physical space for AI enabled machines rather than people they were able to find efficiencies and improve processes of taking raw materials and delivering them as a final product. What the team failed to fully appreciate was the difference between improving efficiency and profitability in the abstract and serving a client. Although automotive assembly lines have become increasingly automated the customer buying a car is not buying from a machine but a salesperson at a dealership either in the physical world or online. The intermediation between the mode of production and consumption remains human in the automotive example but not in the restaurant.

Existing implementations of AI and robotics in restaurants have focused on the efficiency gains of existing employees. Flippy the burger flipping robot is not meant to eliminate human jobs, but to free those humans to do other tasks and improve service. Even Creator a California-based burger joint with an entirely automated burger making machine still relies on employees to load and service the machine and provide customer support. The implementation of robotics while increasing the consistency of the products it produces over time also increases the customer service experience by freeing its staff to focus on the quality of the ingredients and the care of customers. Where automation appears to be taking jobs in the present are in CafeX's which have automated all parts of the coffee and specialty drink making process on its menu. CafeX's still require human operators to reload components and provide maintenance, but the system clearly reduces the need for some human labor.

The balance between innovation, efficiency, and labor is an ongoing process. It is clear that the technologies described in this hypothetical case example are improving rapidly. While entire restaurants are not run by robots yet, it is a distinct possibility that increasing robotization and automation with the aid of AI is likely. This looming change requires forethought on issues of inequality, accountability, legitimacy, and dehumanization.

Inequality: It might be difficult to identify from the case study presented above, but the automation of jobs is in many ways an issue of inequality. The system was designed by individuals with higher education, often graduate degrees and was designed to eliminate the jobs of individuals with lower education levels. The economic argument for fostering this AI – Labor

offset is efficiency, but the outcome is greater inequality. If implemented the fast-food chain of the future described above is more likely to be staffed and managed by individuals with higher levels of education. The benefits of increased efficiency accrue the owners of the franchises and the corporation itself, as well as the software and hardware engineers. Customers might also benefit from faster fast food and potentially lower prices or higher quality ingredients. But the loss of jobs is not without consequence. A reduction in jobs available to individuals with lower levels of education can take away income from families and perpetuate cycles of poverty. Fewer jobs can also hurt communities and other employers. Automating fast-food chains is unlikely to have the same effect as automating automotive assembly lines, but it will still be impactful. The changes presented above benefit one group and harm one group. This fosters economic, social, and political inequality. The tradeoffs are not straightforward and are likely to lead to substantial disruptions.

Accountability: The safe and healthy distribution of food requires a high-level of accountability. Restaurants are required to maintain certain health and safety standards to prevent illness and disease. In the example above the AI takes over responsibility for determining the quality of goods to go into the products to be served to customers. The AI is built on rules that help it to identify when produce is good quality and when something is spoiled. Yet these rules are not all encompassing and often chefs will find something that is spoiled or that isn't quite right and remove it from the production process. Such decisions are often abstract and done based on experience and through a variety of sensors that are still in development for robots and AI systems. Senses such as touch and smell combine with visual cues to help chefs determine the freshness of food. In certain examples such as CafeX such precautions are limited to a few highly perishable products. But as menus expand to include more perishable items the potential for spoiled ingredients to be accidentally overlooked increases. Who is responsible for food poisoning at a fully automated restaurant, the franchise owner, the corporation that provides the raw goods to the franchise, or the AI and robotics firm whose system failed to detect an anomaly? Sorting out accountability to meet the necessary requirements for health and safety are challenging even under the best of circumstances.

Legitimacy: Briefly mentioned at the end of the case study above was the abstract notion that the company had a corporate culture and that this corporate culture permeated its interactions with its customers. Will food produced, packaged, sold, and delivered by a machine have the same level of legitimacy as food produced by humans. Will customers feel the same way about food and services delivered exclusively by a machine? Understanding how customers feel about a product or service is important. Is a restaurant good because its chef is talented and produces good food, or is it good because its machine produces consistent meals? Does the end product conform to customer expectations? Cooking is often referred to as the "culinary arts." Does this only pertain to fancy restaurants, or does it extend to fast-food restaurants as well? These questions help us to frame the concept of legitimacy surrounding the production of food. While

it is rare to complement the chef at a fast-food joint it is not uncommon at Michelin Star restaurant to convey compliments to the chef. What makes a meal a good meal, its artistry, flavor, its chef? Food like many things experienced every day conforms to norms or expectations and when the underlying framework upon which those expectations changes so too does the legitimacy of the framework itself.

Dehumanization: It is hard to think of a profession more human than cooking. While humans have utilized a wide array of devices to aid in cooking from fire to microwaves the process itself has always involved human hands mixing ingredients to achieve an outcome. As machines increasingly invade human tasks they seemingly take away their imbedded humanity and make them algorithmic. The introduction of increasing automation enabled by AI removes the human in the loop and sterilizes the interactions of businesses and their customers. It reduces human capital and offers in its place a human-machine interaction devoid of humanity. Does the automation of fast-food dehumanize the employees who work there? Yes, because it sees their role as automatons whose sole purpose is the end product. It starts by reducing their agency down to even simpler repeatable tasks which are then subsequently replaced as AIs and engineers improve their algorithms and robots. It takes a human endeavor – cooking and makes it a purely mechanized process. In the fast-food industry the final result might be the same, a burger and fries or a chicken sandwich, but the act is fundamentally different.