# Utilizing AI and ML Techniques to Fight Rising Food Costs

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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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**Technical Report**


## ABSTRACT

The mission at SWARM Engineering is to help agrifood businesses save millions of dollars in operational costs to, in turn, lower end-costs of the foods provided. SWARM operates a SaaS platform allowing clients to run AI and ML algorithms on their own data in the cloud. I work on a small piece of SWARM's vast architecture, the Solution Engine, utilizing Python, Docker, Kubernetes, Git, Agile Development, and other tools and techniques. SWARM clients saw 100+% ROI within the first year for most optimizations. Because SWARM is a startup, future work will likely include developing additional ground-breaking and cost-effective solutions to common agrifood operational problems in order to gain and retain clients.


## 1. INTRODUCTION

In September of 2022 the price of food items in the United States like eggs, milk, and flour were 11.4% more expensive than the year prior (Wiener Bronner, 2022). These drastic price increases were alarming to many as food is so integral to who we are as humans. This 11.4% price increase that Americans experienced seems miniscule to the daunting food inflation rate increase that Argentinians are experiencing of more than 40% in a single year (TradingEconomics, 2023). The price of food has always had many dimensions which increases volatility; however, the recent spikes have revealed the weaknesses in such a complex system.

The price spikes seen today can be the result of production issues or global events. An outbreak of Avian Flu was the cause of the recent increase in egg prices. The current crisis in Ukraine has disrupted global supply of agricultural products. Long-lasting challenges in supply chain management on a micro and macro scale delay delivery of products and can create a shortage of supply (U. S. GAO, 2023). Climate change is also an expanding issue, wreaking havoc on the agricultural industry. Extreme temperatures and rainfall can prevent crops from growing altogether. Warmer temperatures increase the growth of pests and weeds, costing the farmers additional fertilizers. Higher levels of CO2 are shown to decrease the nutritional value of the products (EPA, 2023). All of these events have played a role in the overall price of the food we buy at the grocery store.

The impact of these price spikes is felt nationwide. From 2021 to 2022, the same period of time the 11.4% inflation occurred, 2.6% less households were food secure across the country (USDA ERS, 2023). As people are forced to spend more money on food, they spend less on other commodities and risks, in turn slowing down the economy. Not to mention that access to food is essential to promote the health and well-being of humans. This means the hike in food prices has some type of impact on each and every person. Businesses feel the impacts of these spikes, as well. From 2021 to 2022, prices of groceries jumped 13.5% and restaurant menu prices increased 8% (Wiener-Bronner, 2022). Citizens and businesses alike want to see a decrease in volatility and price of food products.

The current food supply infrastructure is fragile; these problems are multifaceted and extremely complex. However, some of these complex problems can be solved by utilizing various machine learning and artificial intelligence techniques. This brings me to the company I have been interning with for almost eleven months, SWARM Engineering. SWARM is a software as a service company focused on utilizing AI/ML techniques to provide optimizations in agri-food processes.

## 2. RELATED WORKS

Coming into this internship, I had never done anything closely related to agriculture. This called for much needed research about agrifood to better suit my role in the company. Coble, et. al. (2018) does a great job in laying out the landscape for what technology in agriculture consists of. Coble details different types of hardware and software solutions for the problems at the time. The most important information I gained from this article was around the topics of political, economical, and sustainability implications for big data in agrifood. This information was vital for me to understand the company's position from many different perspectives, and use that in my communication with others inside or outside the company.

While onboarding, I needed to view examples of our product in action alongside extensive documentation in order to get a full grasp of how the existing system operated. One example that was perfect for this was SWARM's Delivery Planning solution. This optimization uses a VRP (vehicle route planning) algorithm by Google that calculates the minimized single route distance for a delivery. Google (2024) developers provide extensive documentation for this algorithm. The documentation, as well as my coworkers, helped to guide me in understanding what is happening in the algorithm, and how that piece plays its role in the Solution Engine's architecture.

## 3. SWARM PRODUCT PIPELINE

The SWARM Engineering platform has a variety of products to assist clients in generating savings tailored to their specific needs. The different products can be divided into two groups: Challenge Engineering and Solution Engineering.

### 3.1 Challenge Engineering

Challenge Engineering can be most efficiently illustrated using Einstein's famous quote "If I were given an hour to do a problem, I would spend 40 minutes studying it, 15 minutes reviewing it and 5 minutes solving it." (Quote Investigator, 2014) Assessing the entire business as a whole and understanding where inefficiencies lie yields better results than attempting to solve one specific issue with tunnel-vision. This is the approach SWARM utilizes.

One of the key issues for our clients is that it is hard to identify where savings can be made inside of their business. Our clients have complex operational dynamics and can be multifaceted, operating in many stages of a specific business at once (vertically integrated). This is a multivariable problem too difficult for a human to solve, as there is an extensive amount of data at hand. This problem, the identification of operational challenges inside complex businesses, is why SWARM created the Challenge Modeler, the client's first step in their journey with SWARM. Here they will start by choosing from our array of predefined challenges for which we have solutions. These challenges are organized as a series of Mad Libs style cards that are filled out by the client. The client fills in blanks for information about their business that pertains to applicable solutions. Once the client has filled out all blanks on all cards in the Challenge Definition, their challenge is reviewed with a member of the SWARM team to assess possible pain points in their business and identify solutions. The creation of a Challenge Definition is essential to bridge the gap between SWARM's agrifood savings expertise and the client's knowledge of their business.

Another product that has just recently launched to aid in Challenge Engineering is SWARM's AI assistant AVA. AVA is designed to conversate with users about

agrifood topics and other business items. Her main goal is to facilitate the client's ability to fill out Challenge Definitions in a conversational setting. This allows AVA to have a more free flowing conversation with the user to draw out the necessary information for filling out the challenges. AVA can also be tasked by a client to set up meetings with internal employees to gather information for challenges. AVA was actually one of the first action items I was tasked with when joining SWARM. The proof-of-concept version was built in Python and hosted on my local machine, using a simple UI library, tkinter. This simple version of AVA was tasked with generating a JSON structure containing answers the user provided to a list of questions. The list of questions was initially manually assembled by converting each line of the Challenge Definition into a question. This list of questions was then fed to OpenAI's gpt-3.5-turbo model using the OpenAI Python library. This version of AVA, although rudimentary, was essential to proving that ChatGPT was capable of filling out Challenge Definitions in a conversational format.

### 3.2 Solution Engineering

Solution Engineering is the application of challenge engineering to yield savings for the client. The first product that aids in doing this is the Operator Dashboard, or OpsDash, where clients will run their optimizations. Here clients can edit their datasets, modify input parameters, and run the algorithm. The algorithm will run and once finished, the results are published to a page where the client can view the output of the optimization. OpsDash was intended for accessible modification to complex algorithms with no code changes involved. This allows non-tech-savvy operators inside the client's business to use the dashboard with little training required.

Arguably the most important piece in the entire pipeline, and the one I worked on the most, is the Solution Engine. The Solution Engine goes to work as soon as OpsDash starts an optimization run. OpsDash is a front-end application that, at the start of optimization run, publishes a message to indicate a user wants to start a run. This message travels along a distributed messaging service (like Apache Kafka) and is received by a Docker container running a message listener on the backend. This Docker container, running the "Flagent" microservice, is specifically built to assemble, coordinate, and run machine learning solutions. Flagent must grab datasets in real time, clean and modify to OpsDash specifications, assemble data with correct metadata about the optimization, run the solution, and return the results to OpsDash. As the specifications/requirements of our clients and solutions change, so will Flagent. Constant bug fixes and feature additions are required to maintain Flagent's ability to compute solutions. Keeping Flagent operational and expanding is key to SWARM's success.

## 4. RESULTS

SWARM Engineering has been successful in providing cost-savings to its customers. This is evident in the fact that we have produced millions of dollars in revenue and are currently going through Series A funding. Investors see lots of potential in our current successes and want to expand our efforts even further. Another indicator of our success is the low client churn we have. Once we build an optimization for a client, they are soft locked into a contract, as canceling our services would mean they go back to their old, expensive way of doing things. SWARM has shown 3-10x ROI for certain solutions, which is extremely lucrative savings for the customer (SWARM Engineering, 2023). SWARM can also help the client save lots of

planning time, as computers can solve in seconds problems that would take humans hours. Overall, SWARM has shown large savings in time and money for our clients which demonstrates our continuing success as a startup.

## 5. CONCLUSION

The world needs more companies like SWARM. As problems with human planning, supply chain, and logisitics all get worse, humans will need to produce solutions. Especially with how vital food is to being a human and to our society as a whole. SWARM's holistic approach involving both Challenge and Solution Engineering is what sets us apart. We are not just trying to sell you a solution. We want to work with your business to squeeze every last drop of savings out of it. This is the reason SWARM has been so successsful in attaining and retaining our clients. While also saving them millions of dollars in the process, so they can provide food at lower costs to their customers.

## 6. FUTURE WORK

Since its inception, SWARM has been centered around finding solutions to hard problems. Additional work to be added to what was discussed in these findings includes new optimizations. There are new problems emerging everyday as well as new solutions to older problems. Staying up to date with current issues in agrifood and making sure SWARM is one step ahead of our clients' problems is key to securing customers. New optimizations can be created by implementing older algorithms into newer problems or vice versa. SWARM is always prepared to attempt to solve any problem the customer throws at us, which builds our ever growing library of solutions.

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