

Modeling Surplus Food Partnerships Using Game Theory: When Does Food Become Surplus?

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Summary

Purpose and importance of study for the UAE

Large-scale and industrial production and distribution of food results in a significant portion of it going to waste. Not only does this amount to a significant waste of resources, but it also negatively impacts the environment through waste sent to landfills and greenhouse gas emissions released into the atmosphere. This comes at odds with the fact that a significant portion of the population does not have reliable access to daily nutritional sustenance.

This work aims to reduce this waste through rescuing and redistribution of food surplus through business partnerships between food supply chain nodes (producers, distributors, and retailers) and charitable organizations (governmental and non-governmental). Food surplus can occur when a food product is not suitable for normal sale channels but is still perfectly useful for human consumption.

We target with this study some of the UAE's priority areas such as corporate social responsibility, public private partnership (PPP), and sustainability.

Methodology

We propose a decision support and analysis model for food recovery and redistribution using a business partnership that involves food producers and distributors, charitable organizations coordinating redistribution efforts, and the beneficiaries. The approach utilizes game theory to analyze this partnership, which allows us to better manage the factors that drive various decisions made by the partners involved. Ultimately, it enables the design of optimal, mutually beneficial, and long-term partnerships, resulting in a significant and sustained redirection of food surplus to the beneficiary populations, who may not otherwise have reliable access to such items.

In the model, a supplier in a commercial food supply chain realizes that some of its inventory is likely to end up as waste. The supplier's decision options at this point are 1) to continue to push the food items through normal sales channels, hoping that the generated profit will offset the losses, 2) to dispose of the

items incurring losses, or 3) to rescue and redistribute the items for human consumption. The goal of the supplier is to maximize profit, by reducing its cost obligations related to food waste.

In the third option, the supplier partners with a food bank that takes on the coordination of collecting rescued food surplus for redistribution to beneficiaries. The food bank will decide the amount of food surplus to accept from the supplier. Like the supplier, the food bank is also concerned with uncertain product age estimates, and the fact that a portion of it could still end up in a landfill due to spoilage. Finally, the beneficiaries demand the items made available by the food bank. Any unmet beneficiary demand must be satisfied through purchases from the market at a fair market price. The goal of the food bank is to maximize its service to the beneficiaries using its limited donation-based budget.

Study Key Points

We solve the game theoretical model and use experimental results to highlight the impact of uncertainties and costs as well as operational parameters on each of the partners' decisions and the overall outcome for the supply chain. The results enable us to provide food supply chain practitioners with strategic insights and guidance to help minimize food waste and optimize the cost and benefit of partnerships between charitable organizations and commercial food supply chains.

Government, semi-government, and commercial entities that may be interested in these results include social welfare organizations, food suppliers, regional food banks, charitable foundations, and environmental agencies. To our knowledge, this study is the first to propose a game theoretical approach to investigate business relationships between food suppliers and food redistribution charitable organizations.

Findings and Recommendations

The sensitivity of the partnership outcomes to cost and operational factors are exposed using numerical results. The factors include donation vs. bargain sale decisions, food prices, supply chain costs, demand and supply imbalance, shelf-life requirements, and lead time requirements.

The proposed approach presents a way to optimize business relationships to serve populations with food insecurities. This can be of significant impact as relatively few market players, sometimes referred to as "Big Food", are responsible for a large percentage of the food supply chain. Therefore, a targeted deployment of this business partnership model may produce significant gains.