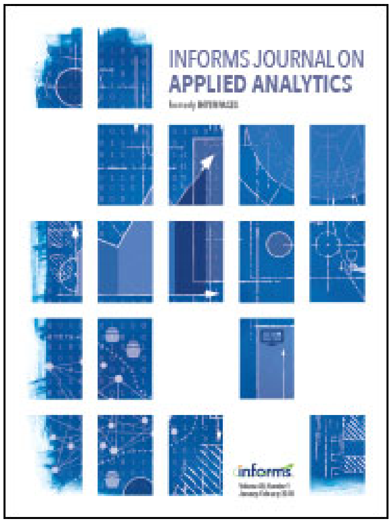

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Harvest Hope Food Bank Optimizes Its Promotional Strategy to Raise Donations Using Integer Programming

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Abstract. Harvest Hope Food Bank (HHFB), based in South Carolina, serves primarily donated food to people in need in 20 counties across the state. It distributed 28 million pounds of food and fed over two million individuals in fiscal year 2014–2015. However, this constituted only 40 percent of the annual meal gap of about 70 million pounds in its service area. One of HHFB's major strategic goals is to efficiently utilize its operating budget and its human and technical resources to increase food and dollar donations, which it raises through events corresponding to various promotional initiatives. We worked with HHFB management and staff to develop resource-capacity bills (i.e., the consumption of each resource per event), and calculated the expected food and (or) dollar donation yield per event. We then developed an integer programming optimization model to determine the optimal number of events of each initiative per year with the objective of maximizing the total annual meals yield (i.e., the number of meals that could be served using the food and dollar donations), subject to resource constraints and the allowable number of events of each initiative as advised by HHFB management. With our recommended optimal strategy, HHFB can provide 1.72 million additional meals per year (an increase of 41 percent) from these promotional events within the existing resource limits, which can help bridge the meal gap in its service area. HHFB has embedded the optimization model in its strategic planning of promotional events, and the allocation of resources to support these initiatives, to ensure that it can meet its 5- and 10-year meal-coverage targets. Additionally, HHFB is disseminating the value of this integrated framework to its peer food banks within the national Feeding America consortium.

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Keywords: food bank operations • nonprofit organizations • resource allocation • integer programming

Food banks are a vital link between food waste and hunger, and they serve as an interconnected lifeline to the hungry (Global FoodBanking Network 2017). They collect excess food from sources such as government agencies, farmers, corporations, and individuals, and distribute it to the needy. A recent study by Feeding America® (FA), which is a network of 200 food banks across the United States, reveals that not all people facing food insecurity qualify for federal nutrition assistance, thus reflecting the important role of charitable hunger-relief efforts (Feeding America 2014). Harvest Hope Food Bank (HHFB), based in South Carolina and a member of FA, serves primarily donated food to people in need across 20 counties of South Carolina in the Columbia, Florence, and Greenville regions, where 16.7 percent of the population reportedly struggles with hunger (Feeding America 2014). HHFB distributed 28 million pounds of food and fed over two million individuals in fiscal year 2014–2015 (Harvest Hope Food Bank 2017). Still, this constituted only 40 percent of the annual meal gap of about 70 million pounds in its service area. Any efforts to cost-effectively bridge this meal gap contribute directly to HHFB's core mission of fighting hunger in South Carolina.

HHFB receives almost 97 percent of its food supply through donations from the U.S. Department of Agriculture (USDA), national retailers, local and regional farmers, and manufacturers and wholesalers. FA serves as the umbrella organization at the national level to lobby Congress to make food available through various hunger-fighting programs, and develops corporate-level donation initiatives with major food retailers such as Walmart, Kroger, Publix, BiLo, and Target. However, HHFB (like other food banks) is responsible for the logistics of the donations, including transportation of supplies into its warehouses, storage and handling, and making them available to charitable agencies for pickup and delivery to the final customers. For some meal programs, HHFB also supplies food packets to drop-off locations across the state.

National statistics by USDA define one meal to consist of 1.2 pounds of food (National FFA Organization 2017). FA guidelines suggest that a $1 donation can provide four meals but recommend that local food banks develop their own conversion ratio based on the cost of living and other factors. This conversion corresponds to the cost of managing the transportation, storage, and handling of the donated food from the source to the customers. HHFB uses an estimate of 1.3 pounds per meal and five meals distributed per dollar of operating cost. Based on these standards, any efforts to boost HHFB's operating budget enhance its ability to serve more meals to the hungry people of South Carolina. With this goal in mind, HHFB proactively executes diverse promotional initiatives to enhance food and dollar donations from local private and public sources (i.e., organizations) and individuals. These initiatives reach potential donors using events that promote only food donations (e.g., food drives), only dollar donations (e.g., 5K runs), and both food and dollar donations (e.g., media events). The initiatives differ in both the food pounds and dollars that they can raise and in the amount of HHFB resources they utilize.

Our project focused on helping HHFB to optimize the mix of its promotional initiatives to maximize the total annual meals yield from food and dollar donations. In collaboration with HHFB's chief executive officer (CEO) and senior functional managers, we developed a linear integer programming (IP) optimization model for allocating resources and capturing all strategic and operational considerations and priorities. HHFB has embraced the model's recommendations for realigning its operational and promotional strategies for 2016 and beyond. With the refined strategies emanating from our work, HHFB can provide 1.72 million additional meals per year, representing a 41 percent increase over the current levels, within its existing resource limits. HHFB management is also using this integrated framework to understand the contribution that each resource (e.g., marketing staff, warehouse personnel) makes to its hunger-relief mission and determine how conscious trade-offs improve overall outcomes. Finally, HHFB is using the model to develop strategic plans for promotional initiatives and operational resource requirements to meet its 5-year and 10-year meal-coverage targets.

Literature Review

The World Food Programme (WFP) describes eradicating hunger and malnutrition as one of the greatest challenges of our time, where one in nine people across the globe still go to bed on an empty stomach each night (World Food Programme 2017). Eradicating poverty and hunger is also one of the United Nations' main objectives to achieve its millennium development goals (United Nations 2015) and its sustainable development goals (United Nations 2017). Accordingly, topics related to food security, such as food and supply distribution, resource allocation, and food bank operations, have received increased, but still limited, attention in the operations management (OM) literature (Çelik et al. 2012). Most literature on food bank operations has focused on logistics problems associated with food distribution (Wallace 2009, Balcik et al. 2014, Ekici et al. 2014, Solak et al. 2014, Davis et al. 2014, Lien et al. 2014, Orgut et al. 2016). Conversely, fundraising issues for disaster relief and long-term humanitarian development are an under-studied area in the OM literature. In this paper, we study the challenges that food banks face to raise food and dollar donations, and we summarize the work related to food-supply and fundraising issues.

Epstein et al. (2002) develop a linear IP model to determine how to optimally grant contract awards in one of the largest government auctions held in Chile to provide school meals for 1.3 million students from low-income families. Using this model, the government of Chile realized a savings of $40 million a year, equivalent to the cost of feeding 300,000 children, while providing more nutritious food. Olivares et al. (2012) follow up with an empirical study to further investigate these large-scale combinatorial auctions and determine how package discounts affect bidding behavior and how to diversify the supplier base to promote competition. Rambeloson et al. (2008) use linear programming to develop recommendations for the optimal types of food mix that French food banks should distribute to meet the government's nutritional diet guidelines. Motivated by the recent directives by WFP and the United Nations (United Nations 2017) toward developing long-term, sustainable solutions that rely more upon local resources and capacity, Kretschmer et al. (2014) propose a theoretical supply chain management framework that can support development-aid logistics and sustainable program design for feeding in schools.

Bekkers and Wiepking (2010) present a comprehensive literature review based on more than 500 articles from multiple disciplines to investigate why people donate money to charitable organizations. McCardle et al. (2009) develop a decision analysis tool for charitable organizations to evaluate the effectiveness of tiered donation structures, which may help generate larger donations. Because relief items are typically in-kind donations, this presents challenges such as high uncertainty on the content and the timing of the supplies that will be received, perishability issues, and unnecessary or unwanted donations (Çelik et al. 2012). Toyasaki and Wakolbinger (2014) develop optimization models to compare two fundraising modes—with and without the option of earmarking donations to a specific disaster-relief fund. The challenge is that disaster-relief projects are typically limited in time and scope; thus, earmarked donation projects may lead to raising excessive funds for certain projects but not enough for others. Aflaki and Pedraza-Martinez (2016) study a similar problem incorporating uncertainty of the donations using a newsvendor framework, and they model the strategic interaction between the aid agency and its donors as a Stackelberg game. Ryzhov et al. (2016) study another challenge in disaster relief, donor cultivation and retention, and they analyze the effectiveness of several design approaches for direct-mail campaigns using a large data set from the American Red Cross.

To the best of our knowledge, our work is the first to study the operational and resource-allocation challenges related to the promotional initiatives that food banks use to raise donations, which are critical for their food-distribution capabilities. In addition, humanitarian OM research has not yet included much collaborative work between academia and practice. Recently, there have been several calls for more work with practitioners. Starr and Van Wassenhove (2014, p. 930) emphasize: "Partnerships between cross-disciplinary researchers and with humanitarian organizations like the World Food Program should be actively sought," while Pedraza-Martinez and Van Wassenhove (2016, p. 7) make a plea for the way forward: "work closely with practitioners on the pressing problems they face, validate your results and help them integrate your methods in their day-to-day operations." Our work is the product of successful collaboration with practitioners, and its value is confirmed by the direct implementation of our methods in practice.

Project Background

Our project team consisted of a process-improvement expert, an operations research (OR) modeling expert, and five OR analysts. HHFB demonstrated its commitment to the project by making several staff members available on a regular and as-needed basis. The client team and stakeholders consisted of HHFB's CEO, operations director, marketing manager, donor-relations manager, administrative manager, and information systems (IS) manager. We first needed to collect the data required to build our optimization model. Accordingly, through several working sessions, we identified HHFB's historical and planned promotional initiatives, and the expected food and dollar donations and resource requirements per event. We utilized a combination of multiple sources: secondary data from past reports pulled by the IS manager and the operations director, primary data, and expert judgment. Specifically, expert judgment and guidance were necessary throughout the project to generate reasonable estimates for cases in which data were not readily available and (or) were incomplete, and to identify managerial priorities and strategic objectives. After the construction of an optimization model, we conducted additional sessions with the executive team to discuss and validate the model's recommendations and implications, and refine it as necessary. The final stage of the project consisted of a formal presentation of the model and its recommendations, and development of an action plan to deploy these recommendations as a part of HHFB's 2016 annual operations plan and future operations plans.

Model Development

HHFB aims to optimize the mix of its promotional initiatives to maximize the food and dollar donations that it can raise in a year given its resource constraints. We next describe each component of the optimization model and the associated data-collection process.

Promotional Initiatives and the Meals-Yield Metric

The optimal mix and frequency of promotional initiatives (i.e., the number of events of each promotional initiative held per year) constitute the set of decision variables of the optimization model. Thus, as the first step of our project, we identified 34 unique promotional initiatives that HHFB had employed in the previous five years to raise food and dollar donations across its 20-county service area. These initiatives include food drives, which HHFB defines as "a concentrated effort to collect non-perishable food in a certain time period" (Harvest Hope Food Bank 2017), as well as promotional events sponsored by major television stations, music and sports events, and some innovative initiatives such as a local realtor donating a percentage of each home sale. Table 1 provides the full list of initiatives.

Each initiative yields different amounts of food and dollar donations. For example, HHFB averaged 2,000 food drives per year over the past five years. The average food donations raised from each food drive were about 300 pounds with no direct dollar donations. The 5K run on Thanksgiving (5K Run II), by contrast, raised no food donations; however, it raised an average of $13,000 per event. Some events yielded both food and dollar donations (e.g., the zoo event yielded an average of 3,000 pounds of food and $400 in donations). Thus, we calculated the expected food and (or) dollar donations per event based on historical data with inputs from HHFB management and staff.

Because HHFB aims to ultimately serve food to people and uses "meals served per year" as a performance metric, we converted the food and dollar donations from each promotional initiative into a final meals-yield metric. Per HHFB's guidance, we used the conversion standard of "one meal = 1.3 pounds of food = a dollar donation of 20 cents" to calculate the meals yield per event, which constitute the objective function coefficients in the optimization model. As an example, the meals yield for the zoo event is about 4,310 meals per event [(3,000 pounds of food ÷ 1.3) + ($400 ÷ 0.2)]. See Table 1 for the meals yield per event of each initiative.

Resource Requirements and Constraints for Promotional Initiatives

Each promotional initiative requires various technical, financial, managerial, staff, and volunteer resources. HHFB conducts its operations of raising donations as well as receiving, storing, and distributing the acquired food donations using these human and technical resources. Moreover, HHFB's operating budget should be able to support these activities based on the mix of promotional initiatives that it decides to implement in a year.

We identified 13 resource pools that are involved in the implementation of promotional initiatives (Table 2). Some of these are human resources, for example, the number of marketing manager hours spent in activities such as preparing posters, thank-you letters, and social media updates; some are equipment resources, for example, forklift machine-hours required to handle the food. We derived the total annual capacity available for each resource through detailed analysis and discussions with HHFB staff and management. We determined the number of resources available and each resource's individual time availability for supporting each event at an annual level. For example, the paid-staff resource pool has 12 HHFB staff members (allocated to support the promotional initiatives) who work 40 hours per week for 50 weeks a year at 90 percent utilization, which yields 21,600 person-hours per year.

Promotional initiatives differ not only in the food pounds and dollars that they can raise, but also in the amount of resource units that they consume. Through a data-collection process using both historical data and domain-expert judgment as necessary, we next derived a resource capacity bill for each promotional initiative to represent the consumption rate of each resource per event (i.e., a matrix of $34 \times 13 = 442$ data points). For example, based on the data that the administrative manager provided, we found that the number of volunteer hours required for holding one event of a live auction with dinner (Auction I) was the highest among all initiatives, while a local realtor's sales drive (Sales Drive II) did not require any volunteer hours. We used the resource capacity bill matrix to derive the resource capacity (knapsack) constraints in the optimization model. Table 2 includes two examples of initiatives. Accordingly, the total annual resource-pool capacity and the consumption rates of each resource

Table 1. Harvest Hope Food Bank (HHFB) Implements 34 Promotional Initiatives, Which Differ in the Food and Dollar Donations Raised per Event

Event name	Event description	Average food pounds raised per event	Average dollars raised per event ($)	Meals yield per event	Maximum no. of events in a year
Food drives	Any event with food collection as the exclusive goal	300	—	231	4,200
Church drives I	Multilocational food drive organized by churches	128,000	8,897	143,045	9
Church drives II	Churches sell vouchers to help purchase turkeys	—	825	4,125	3
Media event I	Event with major TV station *X*	20,000	100,000	515,400	3
Media event II	Event with major TV station *Y*	8,000	750	9,910	2
Auction I	Silent and live auction with dinner	—	58,721	293,605	3
Auction II	Summer auction and lunch event	—	1,200	6,000	3
Auction III	Silent auction with food, drinks, and shopping	—	5,000	25,000	1
Auction IV	Company organized silent auction with dinner	—	4,500	22,500	12
Dinner and blues event	Dinner and music event with a silent auction	—	15,000	75,000	1
Dinner and jazz event	Dinner and music event	—	22,618	113,090	3
Concert event I	Food donations collected for discounted tickets	2,500	—	1,925	3
Concert event II	Food and dollar donations collected for discounted tickets	600	2,548	13,202	4
Concert event III	Concert organized to raise food and dollar donations	2,042	12,015	61,647	3
Zoo event	Food and dollar donations collected for discounted tickets	3,000	400	4,310	18
5K run I	5K run/walk	—	18,000	90,000	2
5K run II	5K run on Thanksgiving	—	13,000	65,000	3
5K run III	5K run	—	3,384	16,920	6
Golf tournament I	Golf tournament in city A	—	10,000	50,000	3
Golf tournament II	Golf tournament organized by a corporation	—	4,005	20,025	1
Company event I	Company event of a full day of employee activities	—	3,723	18,615	8
Company event II	Coordinated company event to raise donations	125	300	1,596	36
Retail event	Local company sells merchandise to raise donations	—	1,500	7,500	3
Matching gift	Local company matches what their customers give	—	20,000	100,000	3
Sales drive I	Local dealership donates a percentage of each sold car	—	200,000	1,000,000	10
Sales drive II	Local realtor donates a percentage of each sold house	—	4,586	22,928	6
Food competition I	Local restaurants compete in city A to raise donations	—	3,000	15,000	2
Food competition II	Local restaurants compete in city B to raise donations	—	5,000	25,000	1
Social media drive I	24 hour social media fund drive	—	26,000	130,000	1
Social media drive II	24 hour social media fund drive	—	1,500	7,500	1
Social media drive III	Social media drive to promote certain products	—	14,700	73,500	12
Pledge event I	Annual ask event in city A	—	5,085	25,425	12
Pledge event II	Annual ask event in city B	—	82,000	410,000	2
Pledge event III	Annual ask event in city C	—	65,000	325,000	1

Note. We converted these donations to a common metric of meals yield per event, calculated as [(food pounds $\div$ 1.3) + (dollars $\div$ 0.2)].

Table 2. HHFB Uses 13 Resource Pools with Finite Annual Capacity to Execute Its Promotional Initiatives for Raising Donations

Resource pool	Unit of measure	Total resource pool capacity per year	"Food drive" capacity bill	"Media event *I*" capacity bill
Paid staff	Person-hours	21,600	3	138
Volunteers	Person-hours	30,000	5	0
Chief executive officer	Person-hours	400	0	16
Marketing manager	Person-hours	1,000	0	25
Information systems (IS) manager	Person-hours	500	0	14
Events coordinator	Person-hours	5,400	1	25
Donor relations coordinator	Person-hours	800	0	25
Board members	Person-hours	1,200	0	6
External equipment	Truck-hours	3,600	1	14
Internal equipment	Forklift-hours	4,500	1	667
Supplies cost	Dollars	100,000	10	220
Storage/Handling cost	Dollars	200,000	57	3,800
Prepared meals for crew and volunteers	Dollars	25,000	0	400

Note. Each initiative consumes the resource pools in different amounts, which we capture by a capacity bill (i.e., consumption rates of each resource per event).

per event (i.e., capacity bill) correspond to the right- and left-side parameters of the knapsack constraints, respectively.

Minimum and Maximum Allowable Number of Events per Promotional Initiative

HHFB management determined that each promotional initiative showed both short- and long-term merits to reach donors from different geographical locations (e.g., upstate, midlands, east coast) and demographics (e.g., age, economic status). Thus, the management team's consensus was that there was value in annually holding at least one event of each initiative, which corresponds to a lower bound of one event per year for each promotional initiative, except food drives.

HHFB management puts food drives into a separate category, because it realizes that food drives are typically organized by enthusiastic local organizations and groups around town, without requiring much promotional effort by HHFB. Individuals, schools, churches, and businesses donate food to HHFB each year through a variety of corporate, civic, and holiday food drives. These drives consume logistical resources in collecting, receiving, and storing the food donations but do not generate any associated dollar donations; therefore, this might cause the optimization model to push the recommended number of food drives to unacceptably low levels. HHFB's CEO shared her insights on why food drives matter regardless of their resource requirements or lack of immediate dollar donations: "While food drives—if overdone—can take away HHFB resources from other more effective initiatives to raise funds, they actually help other initiatives in the long run due to their ability to raise the empathy among food drive donors. So, we don't want them to be drastically reduced or discouraged." Hence, based on benchmarking information from similar food banks under the FA umbrella, HHFB conservatively determined that food drives should not be allowed to fall below 95 percent of the current level of 2,000. Thus, we included a lower bound that constrains the number of food drives in a year to be at least 1,900.

Similarly, HHFB management provided an upper bound on the number of events of each promotional initiative that could be held in a year based on specific domain expertise and contextual criteria over the next five years. For example, Auction IV, which is a silent auction with dinner prepared by local chefs, has been organized by one corporation in the state to raise monetary donations. However, HHFB estimates that it could be replicated by other major corporations in the state so that one event of this initiative could be held every month. Thus, we incorporated an upper bound that constrains the number of Auction IV events in a year to be 12. See Table 1 for the upper bound of each initiative.

Promotional Resource-Allocation Integer Programming Model

The objective of the optimization model is to maximize the total annual meals yield (i.e., the number of meals that can be provided using the food and dollar donations collected across promotional events in a year). We formulated this aggregate resource-allocation problem for donations as a linear IP model (see Appendix A), which represents a multidimensional bounded knapsack problem (Kellerer et al. 2004). Our decision variable is the number of events of each promotional initiative held per year, where only integer values are permitted, and the frequency of each event is subject to the lower and upper bounds advised by HHFB management. Knapsack constraints enforce that the recommended mix of promotional initiatives is implementable within the existing resource limits.

We developed the optimization model in close collaboration with HHFB. Our goal was to ensure that the optimization framework would be easy to understand by HHFB managers, who typically had no formal OR background, so that they would be willing to adopt this framework and the recommended strategies on an ongoing basis. As Starr and Van Wassenhove (2014) describe, "modifying practice requires us to create tools and guidelines that make sense in the field" (p. 928). Thus, our modeling choice was driven primarily by our collaboration with HHFB, and it represents the simplest nontrivial model that can provide informative results and meaningful insights to help HHFB with its promotional planning. For example, a multiperiod stochastic dynamic programming framework could have captured the timing of events, such as the holiday season when resources may be more constrained because of the increase in the number of events and less constrained at the beginning of the year. However, this would lead to a complicated framework, which HHFB would find hard to understand and adopt. Therefore, we chose instead to provide an aggregate planning model with a one-year horizon and enable HHFB to schedule the timing of these events at its discretion, constrained by the availability of its staff. Nevertheless, we carefully validated the model's output with HHFB to ensure that the recommended change in the mix of initiatives could be implemented, and we incorporated uncertainty into the model via parametric analysis.

Model Results and Parametric Analysis

We solved the IP model in the OpenSolver platform for Excel (v2.8) with the COIN-OR branch-and-cut engine (Mason 2012). We compared the model's recommendations vis-à-vis the actual mix of promotional initiatives HHFB executed during 2014–2015. HHFB executed 2,000 food drives and one event of every other promotional initiative during this period. Using the meals-yield estimates per event (Table 1) for a direct comparison with the recommended strategy, we found that the current mix of promotional initiatives gave a total annual meals yield of 4,154,769. The optimization model, however, recommended 1,900 food drives with a higher frequency of events for 6 other initiatives, which led to an expected gain of 1.72 million additional meals yield per year—a 41 percent improvement. This gain corresponds to a 13 percent increase in the food donations (despite fewer food drives), and a 46 percent increase in the dollar donations raised in a year through promotional initiatives (see Table 3). Note that food donations can be directly used to close the

Table 3. The Optimized Frequency of Promotional Initiatives Leads to an Expected Gain of 1.72 Million Additional Meals Yield per Year for HHFB

Promotional initiative	Current annual frequency	Optimal annual frequency
Food drives	2,000	1,900
Church drives I	1	2
Dinner and jazz event	1	3
Company event I	1	8
Sales drive I	1	2
Sales drive II	1	6
5K run II	1	3
Other initiatives	1	1
Total annual meals yield	4,154,769	5,875,839
Improvement (meals/%)	1,721,070/41%	
Total food donations	764,267	862,267
Improvement (pounds/%)	98,000/13%	
Total dollar donations	713,257	1,042,379
Improvement ($/%)	329,122/46%	

existing meal gap, while monetary donations are primarily used to cover the distribution and operational costs incurred to serve the food.

When we presented these results to HHFB managers, they were pleased to see the substantial level of improvement in the food and dollar donations that they could raise. Once we explained the dynamics of the recommendations, it became clear to them that the optimization model pushed the number of food drives to the lower bound of 1,900 to enable HHFB to reallocate resources toward initiatives with more "return (of meals) on investment (of resources)" (e.g., Company Event I, 5 K Run II, Sales Drive II). According to the CEO, the model also provided HHFB with a range of options to scale back the food-drive efforts toward 1,900 drives per year in an acceptable manner, thus allowing it to enhance the total annual meals yield by up to 41 percent within its existing resource limits.

We also helped HHFB management to understand other tactical and strategic uses of the model. First, the model provided information on bottleneck resources (i.e., resources fully utilized by the optimal strategy) and slack in resources that are not bottlenecks. We found that human resources were generally more constrained than equipment resources. We identified marketing manager as the bottleneck and IS manager as a close follower; these resources were almost fully (~99 percent) consumed. Additionally, donor-relations coordinator and CEO had only 15 and 27 percent slack remaining, respectively. Conversely, HHFB had more than enough internal-equipment capacity (i.e., forklifts and other material-handling equipment) utilized at less than 30 percent and could instead invest money in acquiring additional human resources.

Second, we used the model to show HHFB management alternative ways of improving the total annual meals yield. For example, if HHFB could reduce the resource requirement of each initiative from the bottleneck resource, this could have an impact similar to adding capacity to the bottleneck resource pool. To illustrate, it might find more efficient and effective, and less time-consuming, tactics for marketing managers to use to raise awareness and secure initiatives that organizations would sponsor.

Finally, the optimized mix of initiatives showed that these promotional initiatives would generate sufficient monetary funds to pay for the distribution of the food donations raised. That is, the estimated distribution cost of the total food pounds raised (at 20 cents per meal) is less than the total dollars raised. Appendix A includes a detailed discussion on this. Thus, HHFB could use the remaining funds to purchase additional food and cover the distribution and operational expenses of other food supplies.

Parametric Analysis and Modeling Variations

We conducted a thorough parametric analysis to understand the effect of various problem parameters and model assumptions on our results and gain further insights into the model dynamics. In this section, we refer to the optimized mix of initiatives in Table 3 as the base model results. We use the percentage improvement in the total annual meals yield, relative to the actual mix of initiatives in 2014–2015 (current annual frequency in Table 3), as the main performance metric. Specific changes to the main model to execute these variations are summarized in Appendix B.

Effect of Varying the Allowable Number of Events per Initiative. Our first analysis focuses on the effect of the allowable number of events per initiative. Although HHFB found the optimized mix of promotional initiatives reasonable to implement, the recommended increase in the number of events for some initiatives seemed ambitious; for example, Company Event I has a recommended increase from one to eight events per year. Implementing such an increase over several years and initially using a more conservative upper bound, such as a maximum of two to three events in a year, may be more realistic for HHFB. Similarly, although HHFB did not want to cancel any of its current initiatives, it was important to understand which initiatives were the least valuable for HHFB and would be recommended by the model for cancellation. We conducted this analysis with 16 scenarios (see Table 4) using two levels of the lower-bound parameter (cancellation of initiatives allowed or not allowed), four levels of the upper-bound parameter (capping the maximum allowable number of events per initiative to 1, 2, 3, and HHFB-set limits given in Table 1), and two levels of the lower-bound parameter for the number of food drives (the original 2,000 versus the relaxed 1,900).

We find that even if HHFB can hold at most two to three events of each initiative per year, it can realize an increase of 36–38 percent in yield of total annual

Table 4. HHFB Can Realize a Gain of 36–67 Percent in the Total Annual Meals Yield Even If It Can Hold a Maximum of Two Events of Each Initiative per Year and a Reduced Number of Food Drives at 1,900

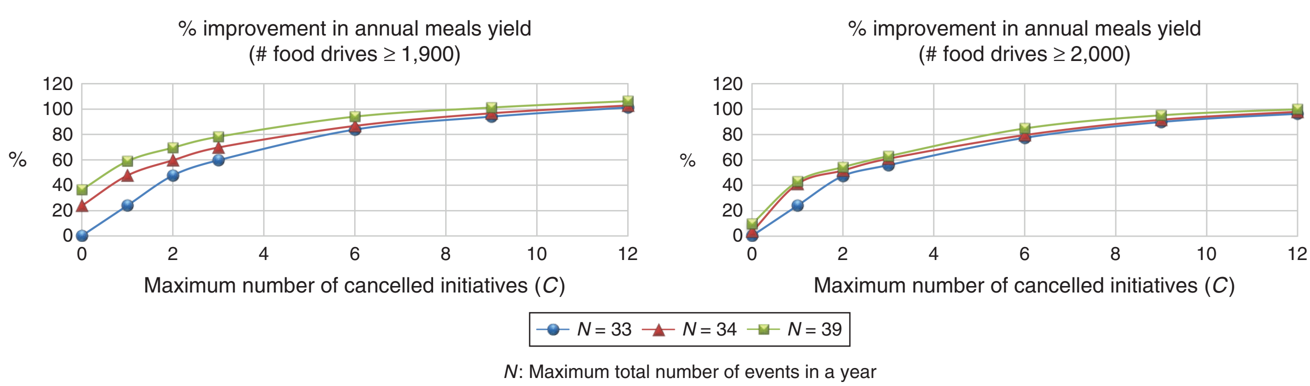
Minimum allowable no. of food drives	Cancellation of initiatives	Maximum allowable no. of events per initiative			
		1	2	3	HHFB-set
2,000	Allowed	0.4%	64%	102%	219%
	Not allowed	Current	8%	11%	13%
1,900	Allowed	0.4%	67%	108%	234%
	Not allowed	0.2%	36%	38%	Base: 41%

meals with a reduced number of food drives at 1,900. The gain is relatively moderate (8–13 percent) if HHFB continues its current practice of holding 2,000 food drives per year. Furthermore, if some initiatives with less return on investment can be cancelled, the gain in the total annual meals yield even exceeds 60 percent. In this case, the number of food drives no longer significantly affects the outcome as a result of the released resource capacity from cancelling resource-heavy initiatives that provide low yield.

Although the flexibility of cancelling some initiatives can release some resource capacity and significantly increase the total annual meals yield (by increasing the number of other initiatives that provide more return on investment), HHFB was concerned about cancelling too many initiatives. Specifically, for the scenarios presented in Table 4, the optimization model recommends between 4 and 23 initiatives for cancellation based on the maximum allowable number of events per initiative. For example, to achieve the 108 percent increase in the total annual meals yield with at most 3 events per initiative, 16 initiatives need to be cancelled; however, HHFB was unwilling to cancel so many initiatives. Another concern relates to the total number of events across all initiatives (excluding food drives) that can be held in a year. In its current mix of initiatives, HHFB implements one event of each initiative—33 events per year. However, the base model recommends 51 events per year to achieve the 41 percent increase in the total annual meals yield, which suggests that HHFB should hold an event almost every week. Thus, we next analyze the effect of limiting the total number of events held across all initiatives in a year by N (i.e., maximum number of total events held in a year) and limiting the total number of cancelled initiatives by C (i.e., maximum number of cancelled initiatives); see Appendix B for modeling variations. For this analysis, we also limit the maximum number of events per initiative to three for a more conservative estimate (see Figure 1).

We find that with a reduced number of food drives at 1,900 (left panel of Figure 1), if HHFB can hold 1 ($N = 34$) to 6 ($N = 39$) additional events per year, compared to its current practice of 33 events, the total annual meals yield can increase by 20–40 percent, even if none of the current initiatives are cancelled ($C = 0$). Conversely, if HHFB continues to enforce 2,000 food drives (right panel of Figure 1), the gains in the total annual meals yield are relatively smaller (compared to the case of

Figure 1. (Color online) HHFB Can Increase the Total Annual Meals Yield by 40 Percent by Holding 6 ($N = 39$) Extra Events per Year, Compared to Its Current Practice of $N = 33$ Events, with a Reduced Number of Food Drives at 1,900, Even If No Initiatives Are Cancelled ($C = 0$)



1,900 food drives) because resources are more constrained, particularly when HHFB holds an increased number of events in a year ($N \geq 34$) without cancelling many initiatives. In both panels of Figure 1, we observe that although the flexibility to cancel initiatives can significantly increase the total annual meals yield, the gains diminish as the number of cancellations increases; that is, the marginal increase in the total annual meals yield is highest for up to two cancelled initiatives ($C \leq 2$). Upon further investigation, we find that the same two initiatives are chosen for cancellation in most of our scenarios: Auction I and the zoo event are two of the most resource-intensive initiatives but do not provide a high enough return for the resources they consume. When we shared these results with HHFB managers, they were not surprised and confirmed the model's findings—that those events were time consuming and created a burden on the highly constrained human resources.

Effect of Varying Resource Capacities and Resource Requirements per Event. Our findings from the first analysis lead us to our second analysis to understand the effect of resource capacities and requirements per event on the total annual meals yield. The base model indicates that the bottleneck resource (i.e., marketing manager) and the second most-constrained resource (i.e., IS manager) substantially drive the optimal mix of initiatives. For example, the reason that the frequency of events for initiatives such as Company Event I and Sales Drive II are pushed to the upper bound (eight and six events per each initiative, respectively) is because they generate a high dollar return per event, but they do not use many constrained human resources. In particular, Sales Drive II uses only an hour of the IS manager's time per event but none of the marketing manager's time, while Company Event I does not use either resource. To see the effect of increasing the availability of these resources, we start with the marketing manager and find that if we increase the availability of this resource by five percent (or, equivalently, decrease the requirement of each initiative for this resource by five percent), the improvement in the total annual meals yield with 1,900 food drives increases from 41 to 87 percent. Although this increase is lower for 2,000 food drives (from 13 to 34 percent) because of higher resource usage, if HHFB can also increase the availability of the IS manager by five percent (which becomes the next bottleneck resource after the availability of the marketing manager increases), the improvement in the total annual meals yield increases up to 63 percent. Finally, if both resources can be expanded by 10 percent, the improvement in the total annual meals yield could increase up to 138 percent (111 percent) with 1,900 (2,000) food drives, which further indicates the critical impact of these two resources on the effectiveness of promotional efforts.

Effect of Diminishing Donations Raised per Additional Event. Our third analysis is on the objective function coefficients (i.e., the expected food and dollar donations and the associated meals yield that could be raised per event of each initiative). We first consider the possibility that the marginal increase in donations per additional event of the same initiative could potentially decrease because of a saturation effect. Although we assume a linear relationship between the amount of donations raised per event of an initiative and the frequency of events, diminishing returns could result from holding more events of the same type. We can easily incorporate this aspect into our model using a piecewise linear objective function. Upon further analysis and discussion with HHFB, however, we decided that this would not be a significant concern for HHFB for two reasons. First, the types of initiatives to which this concern applies are those with high recommended frequency, such as Company Event I and Sales Drive II. However, these initiatives do not use much of the constrained human resources; therefore, even if HHFB could raise only one percent of the average meals yield per event, the optimization model would continue to recommend the same frequency of events under diminishing returns. That is, this modeling variation would not significantly change the optimized mix and frequency of initiatives. Second, such initiatives are organized by a company or a local business to raise donations for HHFB; therefore, they do not consume many HHFB resources. One of HHFB's strategic goals is to motivate other companies or businesses to hold similar events. Thus, allowing a higher frequency for such initiatives does not necessarily imply that the same company or business will organize additional events; others of similar size and domain will likely organize such events. Hence, we decided that using a stricter bound on the maximum allowable number of events per initiative, as we describe in the first analysis, would be more relevant for HHFB's operations than incorporating diminishing returns per event. Per HHFB's guidance, as more events of the same kind are held, HHFB staff can gain more experience, and the collection and distribution operations will become more efficient.

Effect of Uncertainty in Donations Raised per Event. Finally, we consider the potential uncertainty in the donations raised per event. While we assume deterministic objective function coefficients based on the historical average of donations per event of each initiative, HHFB could potentially realize lower food and (or) dollar donations in some events but higher donations in others. Thus, we investigate the robustness of the optimized mix of initiatives using the Monte Carlo simulation tool @Risk (v7.5) (Palisade 2017) for Excel. We present the results from one of these simulations in which we use a minimum number of 1,900 food drives and limit the maximum number of events per initiative to three for a more conservative scenario; this corresponds to a 38 percent improvement in the total annual meals yield without uncertainty (see Table 4). We use two uniform distributions to represent uncertainty: In $U(0.9, 1.1)$, we perturb the food pounds and dollars raised per event by 10 percent symmetrically on the positive and negative side for all initiatives. That is, both food and dollar donations per event can fluctuate 10 percent around the historical average. In $U(0.75, 1.1)$, we use a perturbation of 25 percent on the negative side, representing a more pessimistic scenario in which HHFB may raise as low as 25 percent less than the historical average food and dollar donations per event (see the simulation results of 500 replications in Table 5).

We see that even under the pessimistic scenario, HHFB can expect to improve the total annual meals yield by an average of 27 percent with a range of 4–50 percent. Although the expected food donations may decrease by up to 15 percent in the extreme case, dollar donations are still expected to improve by 6–56 percent. These results suggest the robustness of the optimized mix of initiatives (Table 3) and gave further confidence to HHFB to proceed with the implementation of our recommendations.

Table 5. Even if the Food and Dollar Donations Raised per Event Can Be as Low as 25 Percent Less Than the Historical Average ($U(0.75, 1.1)$), the Total Annual Meals Yield Is Expected to Improve by 27 Percent on Average

	Improvement in total annual meals yield (%) (Dollars/food pounds) (%)			
Uniform distribution	Mean	Standard deviation	Minimum	Maximum
$U(0.9, 1.1)$	38 (42/13)	7 (8/7)	24 (27/2)	51 (56/24)
$U(0.75, 1.1)$	27 (31/4)	13 (14/11)	4 (6/−15)	50 (56/24)

Implementation and Acceptance

HHFB incorporated the model's recommendations for revising its mix of promotional initiatives for 2016. After seeing the critical impact of the bottleneck resource, marketing manager, on the optimal mix and effectiveness of promotional initiatives, it took steps to make its marketing efforts more effective and time efficient; for example, it hired an additional marketing manager whose responsibilities include achieving the recommended mix. The administrative manager is using the model as a framework to conduct orientations of paid staff and volunteers. The CEO and operations director have shared the framework and model results with the HHFB board, and they have been working with corporate sponsors on the amount of external resources required to execute the new mix of initiatives. HHFB managers have also been reviewing the set of initiatives that our parametric analysis recommends for cancellation as they plan the mix of future initiatives.

With our project, we made three major contributions to HHFB management's capabilities. First, the data-collection phase helped reveal the capacity requirements for each type of promotional initiative, as well as the consumption versus benefit trade-offs inherent in executing these initiatives. Although this phase took the longest time in our project, involvement of all stakeholders and the championship of HHFB's CEO ensured that we collected accurate data. None of HHFB's managers has a formal OR background; therefore, the time we took to co-develop and reflect on the capacity bills (in conjunction with benefits) for each promotional initiative allowed the management team to formally recognize for the first time the counterbalancing forces within its promotional efforts. Second, the optimization model answered the question of which initiatives and how many events per initiative should be executed within the existing resource limits. It is not just the meals yield per event but the interactions between meals yield and resource usage across various events that determines the optimal mix of initiatives. Thus, it is difficult to estimate how the optimal mix would change in response to changes in input data without the use of optimization modeling. Since food banks (and in general, most humanitarian organizations) typically do not use OR techniques, it was enlightening for HHFB to understand the benefits of a formalized analytical framework. Finally, the comprehensive parametric analysis we conducted was also valuable to HHFB management. Although the insights of our model are intuitive, HHFB could not easily see model dynamics, such as which events provided the least value, which events could or should be cancelled, or which resources were contributing to which events and by how much. Per HHFB's CEO, the ability to evaluate decisions in an integrated manner under various scenarios was a significant contribution of our work.

In our view, HHFB embraced and trusted the optimization approach and outcomes because we did not deliver them as a black box but in the form of a simple but practical framework that we developed collaboratively with HHFB managers. These managers have also seen the benefits of the framework, model, and recommendations to further the efficiency and effectiveness of their promotional efforts to raise donations. Hence, HHFB managers, and particularly the CEO, have started to informally share their insights as a part of the FA benchmarking initiative with peer food banks in the system. Knowledge transfer of this scientific approach to other food banks in the network can potentially lead to improvements in promotional efforts across the network.

Concluding Remarks

HHFB of South Carolina faces challenges in utilizing its operational resources and budget to maximize the food and dollar donations raised to enable it to serve meals to the most vulnerable segment of the population facing food insecurity. Unfortunately, these specific challenges, which are typical of most food banks, have received little attention in the OM literature.

We developed an optimization framework to help HHFB optimize the mix of its promotional initiatives to raise food and dollar donations. Our recommended mix of initiatives can raise food and dollar donations to serve 1.72 million additional meals (a 41 percent improvement) over current levels within the existing resource limits, which represents a substantial contribution to HHFB's mission. Even more importantly, HHFB has embraced the model outcomes and started using the integrative framework to fine-tune its promotional strategy, resource planning, and long-term operations and marketing strategies. The project framework and model have applicability to food banks and other nonprofit organizations who must raise funds and resources to meet their social service and community-service missions. HHFB is already disseminating the value of this framework to other food banks under the national FA umbrella.

Per HHFB's guidance, the recommended increase in the donations (including both food and money) can be reasonably used to close the meal gap and cover the distribution and operational costs of serving the food. We note that our results, which are based on an aggregate planning model with a one-year horizon rather than a multiperiod model, assume that HHFB will plan its events in such a way that all resources will be utilized in a balanced way throughout the year. Clearly, this is challenging to achieve, especially because some resources are almost fully utilized. Although this is a limitation of our framework, our parametric analysis results provide insights under various scenarios and indicate that significant benefits may be achieved even if the key assumptions of our model, such as the expected donations raised per event or the number of events that can be held per year, do not hold. As a continuation of this project, we have been collaborating with HHFB in the design and implementation of various new initiatives, such as Kids Cafe and BackPack Program (Feeding America 2017), to help with the distribution of the additional food supplies raised with the optimized mix of initiatives. We hope that our work inspires more academic and practical research for applications of OR techniques in a sector that urgently needs help.

Acknowledgments

The authors thank Denise Holland, CEO of Harvest Hope Food Bank (HHFB), for her vision and willingness to explore a scientific approach to optimizing the yield from HHFB's resource allocation across its outreach initiatives. Her commitment to improving HHFB's operations and her practical insights helped the authors to ensure the practical relevance of their optimization model and recommendations. They also thank project analysts—Luke Bolembach, Megan Worthington, Kelton Lynch, Samantha Young, and Patrick Kiley—for their perseverance and focus in numerous meetings over three months with HHFB for developing and validating the optimization model. Finally, the authors thank members of the review team for their valuable comments in revising the paper.

Appendix A. Promotional Resource Allocation Integer Programming Model

In this appendix, we provide the mathematical formulation of the linear IP model. There are 34 decision variables, and 13 knapsack (resource-capacity) constraints, 34 lower-bound, and 35 upper-bound constraints, as well as integrality constraints for all decision variables. We use $|\cdot|$ to denote the cardinality of a set.

Sets:
I = Set of promotional initiatives ($i = 1, \ldots, |I|$).
J = Set of resource pools ($j = 1, \ldots, |J|$).

Parameters:
m_i = Number of meals yield per event of promotional initiative i (given in Table 1).
l_i = Lower bound on the number of events of promotional initiative i (= 1 for all i).
u_i = Upper bound on the number of events of promotional initiative i (given in Table 1).
r_{ij} = Number of units of resource pool j required per event of promotional initiative i (given in Table 2 for examples of two initiatives).
R_j = Annual availability of units of resource for resource pool j (given in Table 2).

Decision variables:
X_i = Number of events of promotional initiative i held per year.

Objective: Maximize the total meals yield acquired in a year through promotional initiatives

$$\max \sum_{i \in I} m_i X_i$$

subject to:

Resource constraints:

$$\sum_{i \in I} r_{ij} X_i \le R_j, \quad \forall\, j \in J,$$

Lower and upper bounds:

$$l_i \le X_i \le u_i, \quad \forall\, i \in I,$$

Nonnegativity and integrality of variables:

all $X_i \ge 0$ and integer.

Note that if HHFB wanted to incorporate a budget constraint to ensure that the dollar donations raised through promotional initiatives could cover the distribution cost of the collected food donations, we could add the following constraint to the model, where f_i is the food pounds raised per event of promotional initiative i and d_i is the dollars yield per event of promotional initiative i ($m_i = f_i/1.3 + d_i/0.2$):

$$\frac{\$0.2/meal}{1.3\ pounds/meal} \sum_{i \in I} f_i X_i \le \sum_{i \in I} d_i X_i.$$

On the left side of this equation, we convert the total food pounds raised to meals using the "one meal = 1.3 pounds of food" conversion ratio, and multiply by 20 cents, which is the estimated distribution and operational cost (per meal) incurred to serve the food. On the right side of the equation, we show the total dollars raised through promotional initiatives.

Applying this equation to the optimal mix of initiatives recommended in Table 3, we see that the total expected 862,267 pounds of food corresponds to 862,267/1.3 = 663,282 meals, which corresponds to about \$132,656 in distribution costs (at 20 cents per meal), while the total dollar donations raised is about \$1 million. Therefore, the operational mix that we recommend already satisfies that there will be enough monetary funds, coming directly from these promotional initiatives, to pay for the distribution of the food donations. HHFB could use the remaining funds to purchase additional food and cover the distribution and operational expenses of other food supplies.

We could alternatively incorporate a high-level budget constraint into the model using the operating budget that HHFB allocates to the distribution and operational expenses of the total meals yield from promotional initiatives. Let B denote this budget. The constraint then would be as follows:

$$\frac{\$0.2}{meal} \cdot \sum_{i \in I} m_i X_i \le B.$$

Appendix B. Modeling Variations

In this appendix, we provide modeling variations to support the parametric analysis results.

I. *Limiting the total number of events held in a year.*

Let N be the maximum total number of events that can be held in a year across all initiatives. We add the following constraint to the optimization model:

$$\sum_{i \in I} X_i \le N.$$

II. *Limiting the total number of cancelled initiatives.*

Let C be the maximum number of cancelled initiatives in a year. We define a binary decision variable to denote whether at least one event of an initiative is held (i.e., the initiative is not cancelled):

$Y_i = 1$ if at least one event of promotional initiative i is held per year; 0 otherwise.

We first add a constraint to limit the total number of cancelled initiatives in a year. Let S be the total number of unique initiatives (except food drives, $S = |I| - 1$):

$$\sum_{i \in I} Y_i \geq S - C.$$

We then add another set of constraints to ensure that if no events of an initiative are held, the initiative is cancelled, and if an initiative is cancelled, the number of events of that initiative cannot be positive:

$$Y_i \leq X_i, \quad \forall\, i \in I;$$
$$X_i \leq u_i Y_i, \quad \forall\, i \in I.$$

Note that the latter constraints replace the upper-bound constraints in the base model. We finally add binary constraints for the Y_i variables:

$$\text{All} \quad Y_i \in \{0, 1\}.$$

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Verification Letter

Denise Holland, CEO, Harvest Hope Food Bank; Chairperson, South Carolina Food Bank Association, writes:

"I am delighted to write my testimonial for the project that Professor Ahire executed with me and my management team recently in order to help us revamp our promotion strategy.

"I am the Chief Executive Officer of Harvest Hope Food Bank and Chairperson of the South Carolina Food Bank Association. As partners of Feeding America®, the nation's largest domestic hunger initiative, we work to provide food to hungry people through a variety of programs. Harvest Hope Food Bank distributed over 28 million pounds of food in 2014–15 across 20 counties in South Carolina. We still could fulfill only 40% of the overall needs. We are always looking for ways to streamline our operations to stretch our reach.

Our operating budget must be utilized effectively and efficiently to maximize our resources to feed hungry people.

"Professor Ahire has participated in and helped us on many strategic initiatives and projects over the last several years in the areas of supply logistics and receipts, distribution logistics planning, inventory management and warehouse operations. The promotion strategy revamping project was technically and organizationally quite complex for us. While we receive a large part of our food supply as donations from USDA, retailers, and wholesalers, we still have to pay for the transportation and storage of the food for pickup by distribution agencies. Thus, we need to use our operating budget effectively and efficiently, and any efforts to enhance the operating budget are critical to our ability to provide more food from these sources to ultimate customers (hungry people in our service area). We have started implementing a deliberate promotions strategy to raise food donations as well as monetary donations from corporations and individuals toward this end. It was this part of donation efforts that was the focus of Dr. Ahire's project.

"Dr. Ahire managed the project really well in terms of eliciting the detailed information to help us connect the dots systematically without overwhelming us. In addition to the significant benefits that his final recommendations demonstrated, it was his approach to conducting the project and making everyone from my various functions understand their part in the overall donations and promotion process that made this project a clear success with my organization.

"The ultimate goal of Harvest Hope is to ensure the right amount and types of food are available to the hungry population of South Carolina. Whether we accomplish this by using food donations from individuals or by using funds raised through our dollar donation promotion efforts, the goal is to maximize the amount of food that can be made available to people in need. The challenge of managing the balance between food donations versus dollar donations is that they are intertwined in more than one way.

"For example, dollar donations make it possible for us to properly plan and procure the foods that are important and we can do so in the desired amounts at various times. We can also buy food from institutional donors such as Walmart and Kroger at a steep discount. Food donations do not afford us that luxury. However, food donations cannot be ignored as they actually ignite the donating passion in individual donors as well as provide ways for institutional donors to be in the donation loop. Moreover, all different types of promotion efforts must be organized within the diverse resources that they demand; from marketing and administrative staff times, to advertising budget, to transportation and material handling equipment.

"Dr. Ahire brought to bear his expertise in operations management to help us put all these seemingly competing considerations into an integrative framework. The optimization methodology used by him was completely new to most of us but it made logical sense because he developed it in close coordination with our team. And our folks were able to understand how their own function/role was connected both in terms of resources and activities related to the various promotional efforts.

"For instance, warehouse operations staff, who have an informal understanding of their workload in response to various levels of food drives, were able to develop a more deliberate and clear understanding of how different types of promotion events, with their varying levels of food donation potential, would lead to consumption of warehouse resources including staff, materials handling equipment and holding costs.

"When Dr. Ahire completed the comprehensive optimization model, he presented the analyses to us in two phases:

"First, he presented to us the initial model, with a view to validate the objective, constraints, data that we initially provided and to complete the gaps. In that session, we were able to refine our own understanding of managerial preferences we wanted to incorporate in the model.

"Dr. Ahire, then, presented the final version of the model in a three-hour session to our entire management team; comprised of myself, operations director, warehouse manager, marketing manager, donations manager, and staffing/volunteer administrator.

"The presentation not only showed us the extent to which we were operating sub-optimally in our promotion efforts and focus but also showed us a clear roadmap of how we can improve the mix of our promotion efforts while maintaining pragmatic balance between food donation generation and dollar donation generation.

"The most important finding of the recommended promotion strategy was the feasibility of us accomplishing 1.72 million additional meals (41% increase over current levels) using the same resource levels in key areas. Additionally, based on the optimization model, Dr. Ahire presented to us a plan to reach our 10-year goals for meal distribution through a rebalanced promotion strategy and associated resource plans.

"We have incorporated the findings and recommendations from this project to refine our promotions strategy for the current year and our medium-term (five-year) operations plan. We are already seeing the evidence of better donation yields and are confident that we will realize the capability to serve the 1.72 million additional meals per year (41% increase) over the next couple of years. It will take that time for us to complete realigning of our resources and initiatives. We have also used the long-term recommendations to plan our resources to help us achieve the long-term goals. We have embedded the optimization model and its associated framework in how we think about linkages between various resources and activities as a part of our donation generation and food distribution strategies. We have also started informally sharing this integrative approach with our peer food banks in the national consortium of food banks coordinated by the national Feeding America® Initiative as a part of benchmarking. We are sure the work will have an even wider impact as it gets disseminated across our network of food banks.

"I have read Dr. Ahire's submission to *Interfaces* and I fully endorse it. We respect and sincerely thank Dr. Ahire for his passion to contribute to our social mission, his enthusiasm to go the extra mile to make our operations more effective and efficient and to help us sharpen our integrative thinking. Please feel free to contact me for any additional details and feedback about this project and about Dr. Ahire's work with us."

Sanjay L. Ahire is a professor of global supply chain and operations management at the Darla Moore School of Business, University of South Carolina (USC). He also serves as the co-director of the USC-Global Supply Chain and Process Management Center, and leads the Sonoco-USC Lean Six Sigma Green Belt Initiative. He holds a PhD in management science from the University of Alabama and a master's degree in management studies and bachelor's degree in chemical engineering from the University of Bombay (India). Dr. Ahire has published extensively in operations strategy and process improvement in leading journals. His 1996 scholarly article on Quality has accrued more than 2,300 citations. In 2012, Dr. Ahire became the first tenured university professor to receive the Six Sigma Master Black Belt certification from the American Society for Quality. He received the prestigious Wickham Skinner Teaching Innovation Achievements Award from the Production and Operations Management Society in 2002, the University of Dayton Alumni Teaching Award in 2005, the Southwest Ohio Council on Higher Education Excellence Award in 2005, the Alfred Smith Teaching Excellence Award from Darla Moore School of Business (USC) in 2015, and the USC Michael Mungo Undergraduate Teaching Excellence Award in 2015. He was the USC nominee to the national U.S. Professor of the Year Award from Carnegie Foundation in 2015. Dr. Ahire has executed more than 100 operations and operations improvement consulting projects in major organizations, including Colonial Life, Cummins, Eaton, GE, GM, Johnson & Johnson, PwC, Siemens, Sonoco, Walmart, and Westinghouse. He has also executed more than 40 projects in nonprofits including hospitals, food banks, homeless shelters, blood banks, charities, and HIV-AIDS testing/treatment organizations.

Pelin Pekgün is an associate professor of management science in the Darla Moore School of Business at the University of South Carolina. She was a visiting assistant professor in the Stewart School of Industrial and Systems Engineering at Georgia Institute of Technology. Prior to joining academia, she led the operations research team at JDA Software's Pricing and Revenue Management Group, where her work with the Carlson Rezidor Hotel Group on stay night price optimization became a finalist for the 2012 INFORMS Franz Edelman Award and the 2013 INFORMS Revenue Management and Pricing Section Practice Award. She was awarded an Honorable Mention for the INFORMS George B. Dantzig Dissertation Award in 2008 and won the IIE Transactions Best Paper Award in Scheduling and Logistics in 2009. Dr. Pekgün received BS and MS degrees in industrial engineering from Boğaziçi University, and MS and PhD degrees in industrial and systems engineering from Georgia Institute of Technology. Her research interests include applications of management science and operations research in pricing and revenue management, supply chain management, marketing/operations interface, and humanitarian logistics.