ADDITIONAL CASES

CASE 3.2 CUTTING CAFETERIA COSTS

A cafeteria at All-State University has one special dish it serves like clockwork every Thursday at noon. This supposedly tasty dish is a casserole that contains sautéed onions, boiled sliced potatoes, green beans, and cream of mushroom soup. Unfortunately, students fail to see the special quality of this dish, and they loathingly refer to it as the Killer Casserole. The students reluctantly eat the casserole, however, because the cafeteria provides only a limited selection of dishes for Thursday's lunch (namely, the casserole).

Maria Gonzalez, the cafeteria manager, is looking to cut costs for the coming year, and she believes that one sure way to cut costs is to buy less expensive and perhaps lower-quality ingredients. Because the casserole is a weekly staple of the cafeteria menu, she concludes that if she can cut costs on the ingredients purchased for the casserole, she can significantly reduce overall cafeteria operating costs. She therefore decides to invest time in determining how to minimize the costs of the casserole while maintaining nutritional and taste requirements.

Maria focuses on reducing the costs of the two main ingredients in the casserole, the potatoes and green beans. These two ingredients are responsible for the greatest costs, nutritional content, and taste of the dish.

Maria buys the potatoes and green beans from a wholesaler each week. Potatoes cost $0.40 per pound, and green beans cost $1.00 per pound.

All-State University has established nutritional requirements that each main dish of the cafeteria must meet. Specifically, the total amount of the dish prepared for all the students for one meal must contain 180 grams (g) of protein, 80 milligrams (mg) of iron, and 1,050 mg of vitamin C. (There are 453.6 g in 1 lb and 1,000 mg in 1 g.) For simplicity when planning, Maria assumes that only the potatoes and green beans contribute to the nutritional content of the casserole.

Because Maria works at a cutting-edge technological university, she has been exposed to the numerous resources on the Internet. She decides to conduct a search to find the nutritional content of potatoes and green beans. Her research yields the following nutritional information about the two ingredients:

	Potatoes	Green Beans
Protein	1.5 g per 100 g	5.67 g per 10 ounces
Iron	0.3 mg per 100 g	3.402 mg per 10 ounces
Vitamin C	12 mg per 100 g	28.35 mg per 10 ounces

(There are 28.35 g in 1 ounce.)

Edson Branner, the cafeteria cook who is surprisingly concerned about taste, informs Maria that an edible casserole must contain at least a six to five ratio in the weight of potatoes to green beans.

Given the number of students who eat in the cafeteria, Maria knows that she must purchase enough potatoes and green beans to prepare a minimum of 10 kilograms (kg) of casserole each week. (There are 1,000 g in 1 kg.) Again for simplicity in planning, she assumes that only the potatoes and green beans determine the amount of casserole that can be prepared. Maria does not establish an upper limit on the amount of casserole to prepare, since she knows all leftovers can be served for many days thereafter or can be used creatively in preparing other dishes.

(a) Determine the amount of potatoes and green beans Maria should purchase each week for the casserole to minimize the ingredient costs while meeting nutritional, taste, and demand requirements.

Before she makes her final decision, Maria plans to explore the following questions independently except where otherwise indicated.

(b) Maria is not very concerned about the taste of the casserole; she is only concerned about meeting nutritional requirements

and cutting costs. She therefore forces Edson to change the recipe to allow for only at least a one to two ratio in the weight of potatoes to green beans. Given the new recipe, determine the amount of potatoes and green beans Maria should purchase each week.

(c) Maria decides to lower the iron requirement to 65 mg since she determines that the other ingredients, such as the onions and cream of mushroom soup, also provide iron. Determine the amount of potatoes and green beans Maria should purchase each week given this new iron requirement.

(d) Maria learns that the wholesaler has a surplus of green beans and is therefore selling the green beans for a lower price of $0.50 per lb. Using the same iron requirement from part (*c*) and the new price of green beans, determine the amount of potatoes and green beans Maria should purchase each week.

(e) Maria decides that she wants to purchase lima beans instead of green beans since lima beans are less expensive and provide a greater amount of protein and iron than green beans. Maria again wields her absolute power and forces Edson to change the recipe to include lima beans instead of green beans. Maria knows she can purchase lima beans for $0.60 per lb from the wholesaler. She also knows that lima beans contain 22.68 g of protein per 10 ounces of lima beans, 6.804 mg of iron per 10 ounces of lima beans, and no vitamin C. Using the new cost and nutritional content of lima beans, determine the amount of potatoes and lima beans Maria should purchase each week to minimize the ingredient costs while meeting nutritional, taste, and demand requirements. The nutritional requirements include the reduced iron requirement from part (*c*).

(f) Will Edson be happy with the solution in part (*e*)? Why or why not?

(g) An All-State student task force meets during Body Awareness Week and determines that All-State University's nutritional requirements for iron are too lax and that those for vitamin C are too stringent. The task force urges the university to adopt a policy that requires each serving of an entrée to contain at least 120 mg of iron and at least 500 mg of vitamin C. Using potatoes and lima beans as the ingredients for the dish and using the new nutritional requirements, determine the amount of potatoes and lima beans Maria should purchase each week.

CASE 3.3 STAFFING A CALL CENTER[1]

California Children's Hospital has been receiving numerous customer complaints because of its confusing, decentralized appointment and registration process. When customers want to make appointments or register child patients, they must contact the clinic or department they plan to visit. Several problems exist with this current strategy. Parents do not always know the most appropriate clinic or department they must visit to address their children's ailments. They therefore spend a significant amount of time on the phone being transferred from clinic to clinic until they reach the most appropriate clinic for their needs. The hospital also does not publish the phone numbers of all clinic and departments, and parents must therefore invest a large amount of time in detective work to track down the correct phone number. Finally, the various clinics and departments do not communicate with each other. For example, when a doctor schedules a referral with a colleague located in another department or clinic, that department or clinic almost never receives word of the referral. The parent must contact the correct department or clinic and provide the needed referral information.

In efforts to reengineer and improve its appointment and registration process, the children's hospital has decided to centralize the process by establishing one call center devoted exclusively to appointments and registration. The hospital is currently in the middle of the planning stages for the call center. Lenny Davis, the hospital manager, plans to operate the call center from 7 A.M. to 9 P.M. during the weekdays.

Several months ago, the hospital hired an ambitious management consulting firm, Creative Chaos Consultants, to forecast the number of calls the call center would receive each hour of the day. Since all appointment and registration-related calls would be received by the call center, the consultants decided that they could forecast the calls at the call center by totaling the number of appointment and registration-related calls received by all clinics and departments. The team members visited all the clinics and departments, where they diligently recorded every call relating to appointments and registration. They then totaled these calls and altered the totals to account for calls missed during data collection. They also altered totals to account for repeat calls that occurred when the same parent called the hospital many times because of the confusion surrounding the decentralized process. Creative Chaos Consultants determined the average number of calls the call center should expect during each hour of a weekday. The following table provides the forecasts.

[1]This case is based on an actual project completed by a team of master's students in the Department of Engineering-Economic Systems and Operations Research at Stanford University. (Following a later merger, this department now is the Department of Management Science and Engineering.)

Work Shift	Average Number of Calls
7 A.M.–9 A.M.	40 calls per hour
9 A.M.–11 A.M.	85 calls per hour
11 A.M.–1 P.M.	70 calls per hour
1 P.M.–3 P.M.	95 calls per hour
3 P.M.–5 P.M.	80 calls per hour
5 P.M.–7 P.M.	35 calls per hour
7 P.M.–9 P.M.	10 calls per hour

After the consultants submitted these forecasts, Lenny became interested in the percentage of calls from Spanish speakers since the hospital services many Spanish patients. Lenny knows that he has to hire some operators who speak Spanish to handle these calls. The consultants performed further data collection and determined that on average, 20 percent of the calls were from Spanish speakers.

Given these call forecasts, Lenny must now decide how to staff the call center during each 2 hour shift of a weekday. During the forecasting project, Creative Chaos Consultants closely observed the operators working at the individual clinics and departments and determined the number of calls operators process per hour. The consultants informed Lenny that an operator is able to process an average of six calls per hour. Lenny also knows that he has both full-time and part-time workers available to staff the call center. A full-time employee works 8 hours per day, but because of paperwork that must also be completed, the employee spends only 4 hours per day on the phone. To balance the schedule, the employee alternates the 2-hour shifts between answering phones and completing paperwork. Full-time employees can start their day either by answering phones or by completing paperwork on the first shift. The full-time employees speak either Spanish or English, but none of them are bilingual. Both Spanish-speaking and English-speaking employees are paid $10 per hour for work before 5 P.M. and $12 per hour for work after 5 P.M. The full-time employees can begin work at the beginning of the 7 A.M. to 9 A.M. shift, 9 A.M. to 11 A.M. shift, 11 A.M. to 1 P.M. shift, or 1 P.M. to 3 P.M. shift. The part-time employees work for 4 hours, only answer calls, and only speak English. They can start work at the beginning of the 3 P.M. to 5 P.M. shift or the 5 P.M. to 7 P.M. shift, and like the full-time employees, they are paid $10 per hour for work before 5 P.M. and $12 per hour for work after 5 P.M.

For the following analysis consider only the labor cost for the time employees spend answering phones. The cost for paperwork time is charged to other cost centers.

(a) How many Spanish-speaking operators and how many English-speaking operators does the hospital need to staff the call center during each 2-hour shift of the day in order to answer all calls? Please provide an integer number since half a human operator makes no sense.

(b) Lenny needs to determine how many full-time employees who speak Spanish, full-time employees who speak English, and part-time employees he should hire to begin on each shift. Creative Chaos Consultants advise him that linear programming can be used to do this in such a way as to minimize operating costs while answering all calls. Formulate a linear programming model of this problem.

(c) Obtain an optimal solution for the linear programming model formulated in part (*b*) to guide Lenny's decision.

(d) Because many full-time workers do not want to work late into the evening, Lenny can find only one qualified English-speaking operator willing to begin work at 1 P.M. Given this new constraint, how many full-time English-speaking operators, full-time Spanish-speaking operators, and part-time operators should Lenny hire for each shift to minimize operating costs while answering all calls?

(e) Lenny now has decided to investigate the option of hiring bilingual operators instead of monolingual operators. If all the operators are bilingual, how many operators should be working during each 2-hour shift to answer all phone calls? As in part (*a*), please provide an integer answer.

(f) If all employees are bilingual, how many full-time and part-time employees should Lenny hire to begin on each shift to minimize operating costs while answering all calls? As in part (*b*), formulate a linear programming model to guide Lenny's decision.

(g) What is the maximum percentage increase in the hourly wage rate that Lenny can pay bilingual employees over monolingual employees without increasing the total operating costs?

(h) What other features of the call center should Lenny explore to improve service or minimize operating costs?

CASE 3.4 PROMOTING A BREAKFAST CEREAL

Claire Syverson, vice president for marketing of the Super Grain Corporation, is facing a daunting challenge. She needs to develop a promotional campaign that will enable the company's new breakfast cereal—Crunchy Start—to successfully enter a crowded breakfast cereal market. Fortunately, Crunchy Start has a lot going for it. Great taste.

Nutritious. Crunchy from start to finish. She can recite the litany in her sleep. It has the makings of a winning promotional campaign.

However, Claire knows that she has to avoid the mistakes she made in her last campaign for a breakfast cereal (her first big assignment since she won this promotion). She thought she had developed a really good campaign, but somehow it had failed to connect with the most crucial segments of the market—young children and parents of young children. She also has concluded that it was a mistake not to include cents-off coupons (coupons that provide rebates) in the magazine and newspaper advertising.

She had better get it right this time, especially after the big stumble last time. The company's president, David Sloan, already has impressed on her how important the success of Crunchy Start is to the future of the company. She remembers exactly how David concluded the conversation. "The company's shareholders are not happy. We need to get those earnings headed in the right direction again."

Claire already has employed a leading advertising firm, Giacomi & Jackowitz, to help design a nationwide promotional campaign that will achieve the largest possible exposure for Crunchy Start. Super Grain will pay this firm a fee based on services performed (not to exceed $1 million), and has allocated an additional $4 million for advertising expenses.

Giacomi & Jackowitz has identified the three most effective advertising media for this product:

Medium 1: Television commercials on Saturday morning programs for children.
Medium 2: Advertisements in food and family-oriented magazines.
Medium 3: Advertisements in Sunday supplements of major newspapers.

The problem now is to determine which *levels* should be chosen for these *advertising activities* to obtain the most effective *advertising mix*.

To determine the *best mix of activity levels* for this particular advertising problem, it is necessary (as always) to identify the *overall measure of performance* for the problem and then the contribution of each activity toward this measure. An ultimate goal for Super Grain is to maximize its profits, but it is difficult to make a direct connection between advertising exposure and profits. Therefore, as a surrogate for profit, Claire decides to use *expected number of exposures* as the overall measure of performance, where each viewing of an advertisement by some individual counts as one exposure.

Giacomi & Jackowitz has made preliminary plans for advertisements in the three media. The firm also has estimated the expected number of exposures for each advertisement in each medium, as given in the bottom row of Table 1.

TABLE 1 Cost and exposure data

	Costs		
Cost Category	**Each TV Commercial**	**Each Magazine Ad**	**Each Sunday Ad**
Advertising costs	$300,000	$150,000	$100,000
Planning costs	$ 90,000	$ 30,000	$ 40,000
Expected number of exposures	1,300,000	600,000	500,000

The number of advertisements that can be run in the different media are restricted by both the advertising budget (a limit of $4 million) and the planning budget (a limit of $1 million for the fee to Giacomi & Jackowitz). Another restriction is that there are only five commercial spots available for running different commercials on children's television programs on Saturday morning (medium 1). The other two media have an ample number of spots available.

Consequently, the three *limited resources* for this problem are

Resource 1: Advertising budget ($4 million),
Resource 2: Planning budget ($1 million),
Resource 3: Commercial spots available (5).

Table 1 shows how much of the advertising budget and the planning budget would be used by each advertisement in the respective media.

- The first row gives the cost per advertisement in each medium. (The cost of using only a fraction of an advertising spot is assumed to be that fraction of the cost given in the table.)
- The second row shows Giacomi & Jackowitz's estimates of its total cost (including overhead and profit) for designing and developing each advertisement for the respective media.[1] (This cost represents the billable fee from Super Grain.)
- The last row then gives the expected number of exposures per advertisement.

Since the promotional campaign is for a breakfast cereal that should have special appeal to young children, Claire feels that two audiences should be especially targeted—*young children* and *parents of young children.* (This is why one of the three advertising media recommended by Giacomi & Jackowitz is commercials on children's television programs Saturday morning.) Consequently, Claire has established two requirements for the campaign.

Requirement 1: The advertising of one type or another should be seen by at least 5 million young children.

Requirement 2: The advertising of one type or another should be seen by at least 5 million parents of young children.

In effect, these two requirements are *minimum acceptable levels* for two special *benefits* to be achieved by the advertising activities.

Benefit 1: Promoting the new breakfast cereal to young children.

Benefit 2: Promoting the new breakfast cereal to parents of young children.

Because of the way the requirements have been articulated, the *level* of each of these benefits is measured by the *number of people* in the specified category that are reached by the advertising.

To enable the construction of the corresponding *benefit constraints,* Claire asks Giacomi & Jackowitz to estimate how much each advertisement in each of the media will contribute to each benefit, as measured by the number of people reached in the specified category. These estimates are given in Table 2.

TABLE 2 Benefit data

	Number Reached in Target Category			
Target Category	**Each TV Commercial**	**Each Magazine Ad**	**Each Sunday Ad**	**Minimum Acceptable Level**
Young children	1.2 million	0.1 million	0	5 million
Parents of young children	0.5 million	0.2 million	0.2 million	5 million

Claire has one more consideration she wants to incorporate into the model. She is a strong believer in the promotional value of *cents-off coupons* (coupons that shoppers can clip from printed advertisements to obtain a refund of a designated amount when purchasing the advertised item). Consequently, she always earmarks a major portion of her annual marketing budget for the redemption of these coupons. She still has $1,490,000 left from this year's allotment for coupon redemptions. Because of the importance of Crunchy Start to the company, she has decided to use this *entire* remaining allotment in the campaign promoting this cereal. Both medium 2 (advertisements in food and family-oriented magazines) and medium 3 (advertisements in Sunday supplements of major newspapers) will feature cents-off coupons. The estimates of the amount of coupon redemption per advertisement in each of these media is given in Table 3.

[1]When presenting its estimates in this form, the firm is making two simplifying assumptions. One is that its cost for designing and developing each additional advertisement in a medium is roughly the same as for the first advertisement in that medium. The second is that its cost when working with one medium is unaffected by how much work it is doing (if any) with the other media.

TABLE 3 Coupon redemption data

	Contribution Toward Required Amount			
Requirement	**Each TV Commercial**	**Each Magazine Ad**	**Each Sunday Ad**	**Required Amount**
Coupon Redemption	0	$40,000	$120,000	$1,490,000

(a) You now are in Claire's shoes. Formulate and solve a linear programming model to determine the number of advertisements to run in each of the media in order to maximize the expected number of exposures while satisfying all the constraints.

(b) For each of the four assumptions of linear programming presented in Sec. 3.3, discuss how well you feel it is satisfied for this problem.

(c) In light of your conclusions in part (*b*), do you feel that the linear programming model used in part (*a*) adequately captures the complexities of this problem for Claire's purposes? Explain.

Note: This case will be continued in Case 13.3, so we suggest that you save your results.