ADDITIONAL CASES

CASE 8.2 CONTINUATION OF THE TEXAGO CASE STUDY

Reconsider the case study presented in the supplement to Chap. 8 (on the CD-ROM) involving the Texago Corp. site selection problem.

Texago management has tentatively chosen St. Louis as the site of the new refinery. However, management now is addressing the question of whether the capacity of the new refinery should be made somewhat larger than originally planned.

While analyzing the site selection problem, the task force had been told to assume that the new refinery would have the capacity to process 120 million barrels of crude oil per year. As indicated in Table 3, this then would increase the total capacity of all the corporation's refineries from 240 million barrels to 360 million barrels. According to marketing forecasts, Texago would be able to sell all its finished product once this new capacity becomes available, but no more. Therefore, the choice of 120 million barrels as the capacity of the new refinery would enable all the corporation's refineries to operate at full capacity while also fully meeting the forecasted demand for Texago's products.

However, to prepare for possible future increases in demand beyond the current forecasts, management now wants to also consider the option of enlarging the plans for the new refinery so that it would have the capacity to process 150 million barrels of crude oil annually. Although this would force the corporation's refineries collectively to operate below full capacity by 30 million barrels for awhile, the extra capacity then would be available later if Texago continues to increase its market share. This might well be worthwhile since the capital and operating costs incurred by enlarging the plans for the new refinery would be far less (perhaps 40 percent less) than constructing and operating another refinery later to process only 30 million barrels of crude oil per year. Furthermore, management feels that this extra capacity might be needed within a few years.

The extra capital needed to increase the capacity of the new refinery by 30 million barrels is estimated to be $1.2 billion. The cost of carrying this extra capital would be $100 million per year, although this figure could change depending on future interest rates. If some of this extra capacity is used at the new refinery, the total operating cost for the refinery would be somewhat larger than the amount shown in Table 6, but decreasing the production rate by the same amount at another refinery would decrease its total operating cost by a comparable amount. Since the operating cost per million barrels of crude oil processed is roughly the same at all the refineries, including the new one, the total operating cost for processing 360 million barrels should not be substantially affected by the allocation of this work to the refineries. However, management feels that having some flexibility for where to allocate this work might enable substantially reducing the cost of shipping crude oil and finished product. Since Table 7 indicates that the total annual shipping cost for crude oil and finished product would be $2.92 billion with St. Louis as the site for the refinery, management hopes that substantial reductions can be achieved in this way.

Figures 4 and 8 show the optimal shipping plans for crude oil and finished product, respectively, when the new refinery is in St. Louis and has a capacity of processing 120 million barrels of crude oil per year. Management now is asking the task force to analyze the situation under the option of increasing this capacity to 150 million barrels. In particular, management wants the following questions addressed. Under the new option, how should the shipping plan for crude oil in Fig. 4 change, and how much reduction in the total shipping cost would be achieved? How should the shipping plan for finished product in Fig. 8 change, and how much reduction in the total shipping cost would be achieved? Finally, assuming that the differences in operating costs shown in Table 6 would continue to apply under the new option, would the financial comparison of the three sites given in Table 7 be altered substantially if this option were to be adopted?

As the head of the task force, you have decided to lead the way by executing the following steps with the new option. Thus, each of the following parts assumes that the capacity of the new refinery will be 150 million barrels instead of the 120 million barrels assumed in the original Texago case study.

(a) Formulate and solve a model to find an optimal plan for shipping 360 million barrels of crude oil per year from the oil fields to the refineries, including the new one in St. Louis, where the amount of crude oil each refinery will receive (up to its capacity) is based on minimizing the total annual cost for these shipments. (*Hint:* If you are using a spreadsheet model, you can save some time in this and subsequent parts by using the live spreadsheets for the Texago case study in this chapter's Excel files as a starting point and then making the adjustments needed to reflect the increased capacity of the new refinery.) Compare the resulting total annual cost for these shipments with the results obtained in Fig. 4 under the original assumption of a smaller refinery in St. Louis.

(b) Assume that the plan found in part (*a*) will be used. Since this plan specifies how much crude oil each refinery will receive, it also dictates how much final product each refinery will supply. On this basis, formulate and solve a model to find an optimal plan for shipping finished product from the refineries to the distribution centers. Compare the resulting total annual cost for these shipments with the results obtained in Fig. 8. Also calculate the total annual cost of shipping both crude oil and finished product under this plan and compare it with the corresponding total of $2.92 billion obtained from Table 7.

(c) You realize that the cost of shipping final product tends to be somewhat larger than the cost of shipping crude oil. Therefore, rather than having the decisions on the amount of crude oil each refinery will receive and process be dictated by minimizing the total annual cost of shipping *crude oil* [as in parts (*a*) and (*b*)], you decide to check on what would happen if these decisions are based on minimizing the total annual cost of shipping *final product* instead. Formulate and solve a model to find an optimal plan for shipping final product from the refineries (including the new one in St. Louis) to the distribution centers, where the allocation of the 360 million barrels of crude oil per year to the refineries is based on minimizing the total annual cost for these shipments. Compare the resulting total annual cost for these shipments with the results obtained in part (*b*) and in Fig. 8.

(d) Assume that the plan found in part (*c*) will be used. Since this plan specifies how much final product each refinery will ship, it also dictates how much crude oil each refinery will receive. On this basis, formulate and solve a model to find an optimal plan for shipping crude oil from the oil fields to the refineries. Compare the resulting total annual cost for these shipments with the results obtained in part (*a*) and in Fig. 4. Also calculate the total annual cost of shipping both crude oil and finished product under this plan, and compare it with the corresponding total obtained in part (*b*) and in Table 7.

(e) You realize that, so far, you have been only *suboptimizing* the overall problem by optimizing only one part of the problem at a time, so now it is time to get down to serious business. Formulate a single linear programming model that simultaneously considers the shipping of 360 million barrels of crude oil per year from the oil fields to the refineries (including the new one in St. Louis) and the shipping of final product from the refineries to the distribution centers. Use the objective of minimizing the grand total of all these shipping costs. (This kind of linear programming problem is referred to as a *transshipment problem*.) Since the refineries collectively have a capacity of processing 390 million barrels of crude oil per year, the decisions on the amount of crude oil each refinery will receive and process (up to its capacity) also is to be based on this same objective. Solve the model and compare the resulting total of all the shipping costs with the corresponding total calculated in parts (*b*) and (*d*) and from Table 7.

(f) Repeat part (*e*) if the new refinery (with a capacity of processing 150 million barrels of crude oil per year) were to be placed in Los Angeles instead of St. Louis. Then repeat it again if Galveston were to be selected as the site instead. Using the operating costs given in Table 6 for the three sites, construct a table like Table 7 to show the new financial comparison between the sites. (Although the operating costs will be larger than given in Table 6 if the new refinery processes more than 120 million barrels of crude oil per year, management has instructed the task force to assume that the differences in operating costs shown in Table 6 would continue to apply, so the differences in the total variable costs in the table being constructed would still be valid.)

(g) You now are ready to submit all your results to management. Write an accompanying memorandum that summarizes your results and recommendations in the language of management.

CASE 8.3 PROJECT PICKINGS

Tazer, a pharmaceutical manufacturing company, entered the pharmaceutical market 12 years ago with the introduction of six new drugs. Five of the six drugs were simply permutations of existing drugs and therefore did not sell very heavily. The sixth drug, however, addressed hypertension and was a huge success. Since Tazer had a patent on the hypertension drug, it experienced no competition, and profits from the hypertension drug alone kept Tazer in business.

During the past 12 years, Tazer continued a moderate amount of research and development, but it never stumbled upon a drug as successful as the hypertension drug. One reason is that the company never had the motivation to invest heavily in innovative research and development. The company was riding the profit wave generated by its hypertension drug and did not feel the need to commit significant resources to finding new drug breakthroughs.

Now Tazer is beginning to fear the pressure of competition. The patent for the hypertension drug expires in 5 years,[1] and Tazer knows that once the patent expires, generic drug manufacturing companies will swarm into the market like

[1]In general, patents protect inventions for 17 years. In 1995, GATT legislation extending the protection given by new pharmaceutical patents to 20 years became effective. The patent for Tazer's hypertension drug was issued prior to the GATT legislation, however. Thus, the patent only protects the drug for 17 years.

vultures. Historical trends show that generic drugs decreased sales of branded drugs by 75 percent.

Tazer is therefore looking to invest significant amounts of money in research and development this year to begin the search for a new breakthrough drug that will offer the company the same success as the hypertension drug. Tazer believes that if the company begins extensive research and development now, the probability of finding a successful drug shortly after the expiration of the hypertension patent will be high.

As head of research and development at Tazer, you are responsible for choosing potential projects and assigning project directors to lead each of the projects. After researching the needs of the market, analyzing the shortcomings of current drugs, and interviewing numerous scientists concerning the promising areas of medical research, you have decided that your department will pursue five separate projects, which are listed below:

Project Up	Develop an antidepressant that does not cause serious mood swings.
Project Stable	Develop a drug that addresses manic-depression.
Project Choice	Develop a less intrusive birth control method for women.
Project Hope	Develop a vaccine to prevent HIV infection.
Project Release	Develop a more effective drug to lower blood pressure.

For each of the five projects, you are only able to specify the medical ailment the research should address, since you do not know what compounds will exist and be effective without research.

You also have five senior scientists to lead the five projects. You know that scientists are very temperamental people and will work well only if they are challenged and motivated by the project. To ensure that the senior scientists are assigned to projects they find motivating, you have established a bidding system for the projects. You have given each of the five scientists 1000 bid points. They assign bids to each project, giving a higher number of bid points to projects they most prefer to lead. The following table provides the bids from the five individual senior scientists for the five individual projects:

Project	Dr. Kvaal	Dr. Zuner	Dr. Tsai	Dr. Mickey	Dr. Rollins
Project Up	100	0	100	267	100
Project Stable	400	200	100	153	33
Project Choice	200	800	100	99	33
Project Hope	200	0	100	451	34
Project Release	100	0	600	30	800

You decide to evaluate a variety of scenarios you think are likely.

(a) Given the bids, you need to assign one senior scientist to each of the five projects to maximize the preferences of the scientists. What are the assignments?

(b) Dr. Rollins is being courted by Harvard Medical School to accept a teaching position. You are fighting desperately to keep her at Tazer, but the prestige of Harvard may lure her away. If this were to happen, the company would give up the project with the least enthusiasm. Which project would not be done?

(c) You do not want to sacrifice any project, since researching only four projects decreases the probability of finding a breakthrough new drug. You decide that either Dr. Zuner or Dr. Mickey could lead two projects. Under these new conditions with just four senior scientists, which scientists will lead which projects to maximize preferences?

(d) After Dr. Zuner was informed that she and Dr. Mickey are being considered for two projects, she decided to change her bids. The following table shows Dr. Zuner's new bids for each of the projects:

Project Up	20
Project Stable	450
Project Choice	451
Project Hope	39
Project Release	40

Under these new conditions with just four scientists, which scientists will lead which projects to maximize preferences?

(e) Do you support the assignment found in part (*d*)? Why or why not?

(f) Now you again consider all five scientists. You decide, however, that several scientists cannot lead certain projects. In particular, Dr. Mickey does not have experience with research on the immune system, so he cannot lead Project Hope. His family also has a history of manic-depression, and you feel that he would be too personally involved in Project Stable to serve as an effective project leader. Dr. Mickey therefore cannot lead Project Stable. Dr. Kvaal also does not have experience with research on the immune systems and cannot lead Project Hope. In addition, Dr. Kvaal cannot lead Project Release because he does not have experience with research on the cardiovascular system. Finally, Dr. Rollins cannot lead Project Up because her family has a history of depression and you feel she would be too personally involved in the project to serve as an effective leader. Because Dr. Mickey and Dr. Kvaal cannot lead two of the five projects, they each have only 600 bid points. Dr. Rollins has only 800 bid points because she cannot lead one of the five projects. The following table provides the new bids of Dr. Mickey, Dr. Kvaal, and Dr. Rollins:

Project	**Dr. Mickey**	**Dr. Kvaal**	**Dr. Rollins.**
Project Up	300	86	Can't lead
Project Stable	Can't lead	343	50
Project Choice	125	171	50
Project Hope	Can't lead	Can't lead	100
Project Release	175	Can't lead	600

Which scientists should lead which projects to maximize preferences?

(g) You decide that Project Hope and Project Release are too complex to be led by only one scientist. Therefore, each of these projects will be assigned two scientists as project leaders. You decide to hire two more scientists in order to staff all projects: Dr. Arriaga and Dr. Santos. Because of religious reasons, the two doctors both do not want to lead Project Choice. The following table lists all projects, scientists, and their bids.

	Kvaal	**Zuner**	**Tsai**	**Mickey**	**Rollins**	**Arriaga**	**Santos**
Up	86	0	100	300	Can't lead	250	111
Stable	343	200	100	Can't lead	50	250	1
Choice	171	800	100	125	50	Can't lead	Can't lead
Hope	Can't lead	0	100	Can't lead	100	250	333
Release	Can't lead	0	600	175	600	250	555

Which scientists should lead which projects to maximize preferences?

(h) Do you think it is wise to base your decision in part (*g*) only on an optimal solution for an assignment problem?

Note: A data file for this case is provided on the CD-ROM for your convenience.