

## THE ORANGE PEEL SOCIAL AID AND PLEASURE CLUB

Dennis Patenotte, Western Carolina University  
George W. Mechling, Western Carolina University

### CASE DESCRIPTION

*This case primarily targets students enrolled in management science/quantitative business methods courses. Its intent is two-fold: 1) provide students the opportunity to decide how a real-world entertainment club should assign its bartenders to work stations at its wet bar in order to realize the bar's revenue potential and 2) require students to construct a business context in which to make such a decision.*

*The bar has six work stations and the expected revenue each of the club's eight bartenders generates varies from work station to work station. Doubling up bartenders at selected work stations does occur. The complexity of this case's assignment requirements and restrictions go beyond what the "assignment" algorithms found in most student software packages can accommodate. Linear programming is not so limited and thus, is this case's methodology of choice.*

*This case is valuable to students for several reasons. Constructing the business context in which they are to make their decisions, students add a transcendent layer of analysis to their task that can give them valuable first-hand practice at defining problems and developing an appreciation for the relevance of the methods they can employ solving such problems. Furthermore, this case's assignment restrictions and requirements reflect the club's operational reality and are therefore, quite realistic, practical, and worth knowing how to program. Programming many of these assignment restrictions and requirements will also challenge students well beyond what they customarily encounter in most linear programming problems. It will also require them to use their intuition in at least one assignment situation the club faces that should lead them to conclude that the application of a decision-support methodology such as linear programming is not particularly necessary. Finally, students can transfer lessons learned from this case to real-world business settings they will eventually face.*

*The authors designed this case for use by MBA and upper class undergraduate students to be taught in 2 class hours, with 3-4 hours of student preparation time. The instructor can modify this case for more complexity per suggestions found in the "Instructor's Note."*

## CASE SYNOPSIS

*The Orange Peel Social Aid and Pleasure Club is located in downtown Asheville, NC and is the premiere music venue in Western North Carolina. It books music groups from all over the United States and the world and has the reputation of having the best beer selection in town. Patrons travel to the Orange Peel from all over the southeast region of the United States to enjoy their favorite musicians live. The club opened in fall 2002 and has become the most popular night spot in Asheville since that time. The Orange Peel's goal is to provide its customers the best convivial social atmosphere and "pop" music in a 100 mile radius of Asheville.*

*The club's wet bar is an important revenue center. Opportunities occur for the bar to generate the most revenue on nights when the club has sold-out shows. The club manager has eight bartenders (six of whom are part-time) she can assign to six work stations for such occasions. The revenue performances of each bartender vary from one work station to the next and vary among bartenders for a given work station. Therefore, making assignments that will realize the bar's revenue potential is somewhat complex and therefore, will require some thought by the club manager.*

## INSTRUCTORS' NOTE

### Recommendations for Teaching Approaches

This case requires students to identify, address and organize a range of operations management issues the club manager would most likely put into her report that she intends to submit to the club's owners. Based on her assessment, a logical and useful way to organize these issues might be first to provide the club's owners her critique of the bar's operations (Part 1). Then, she could make remedial recommendations for improving the bar's performance (Part 2). Finally, she would need to present to the club's owners rigorously "worked out" examples that implement these recommendations (Part 3). The authors suggest organizing the content of her report in this way to provide students a conceptual framework to guide and assist them in solving this case.

This case is primarily about applications of quantitative methods to a particular kind of management problem (Part 3). This case, however, is more than an elaborated management science problem. Identifying and devising recommendations to resolve the management issues associated with the Parts 1 and 2 should establish a business context for students in which applying quantitative methods to solve a particular management problem is logically appropriate. The instructor should, therefore, challenge the students' imaginations to establish this context. One might expect to find the following list of "points" and their associated commentaries in the club manager's report. Nevertheless, the framework of this teaching note is rather open and the instructor has substantial latitude deciding how students shall deal with this case, to what depth and complexity they are to

go, and in what format they are to put their solutions. It also includes suggested focus questions and commentary that may prove helpful to the instructor.

### **Part 1—Critique of the Club's Bar Operations**

- 1. Given the data the club manager has developed assigning bartenders to different work stations, what should she conclude?**

Following her exercise assigning bartenders to different work stations, the club manager finds that bartender work station assignments do matter when it comes to putting the club in a position to realize the bar's revenue potential.

- 2. Given that bar assignments are important, why is the bar's revenue often less than anticipated?**

The club manager discovers to her dismay that the bartenders have been participating in an informal work station assignment rotation system of their own devising in lieu of management directly designating such assignments. The two bar managers, Andrew and Lori, for the most part trade off working at WS1 and WS2 and the remaining bartenders rotate through the six work stations each in turn doubling up with Andrew and Lori at WS1 and WS2.

- 3. Is this a problem for the club? If yes, why?**

The club's management has failed to adequately plan, monitor, and control the bartenders' work station assignments. Consequently, the bartenders have exercised a great deal of discretion in devising their own system for making these assignments. Several factors taken together could explain why such a system came into being. First of all, the bartenders work together in close quarters, having to accommodate and get along with each other. To the extent this is true they could well come to see that looking out for each other's interests is looking out for one's own as well. So they have probably developed a sense of being a "team" that is fine but without supervision it can lead to a perverse end. Second, they no doubt know that some work stations generate more revenue than others and along with that *more* tips. Thus, rotating the six part-time bartenders thru the six work stations provides each of them the opportunity to work some stations at which the higher volume of beverage sales should provide each of them more tips than at other work stations regardless of their relative job skills. While this may be a nice accommodation for the bartenders it does not bode well for the club.

4. **How might this practice explain a number of the performance issues the new club manager has observed?**

First, the rotation system may only periodically yield an optimal set of bartender work station assignments. Second, the rotation system insures that a female bartender will be at WS5 from time to time who, on her own, is generally unable to change out empty beer kegs on tap for full heavy ones and must recruit additional help from other work stations thus, disrupting bar operations.

## **Part 2—Remedial Recommendations**

5. **Given the critique Part 1 provides, the club manager should make what sort of recommendations?**

The club manager can argue that since bartender work station assignments do matter and management has failed to plan, monitor, and control this important part of the bar's operations, club management needs to take charge of making those assignments to put the club in position to realize the bar's revenue potential. This will abolish the informal rotation system the bartenders devised for themselves. She could explain that she is content for the moment to see if she can improve the effectiveness of the bar's management through making informed work station assignments without resorting to any physical modifications in the bar itself.

6. **Why might she be able to get away saying this?**

First, making informed work station assignments is cheaper and less disruptive than resorting to physical modifications. It is therefore, prudent to determine if making such assignments leads to satisfactory results before embarking on something more drastic. Second, the case provides little specific information on bar redesign, beverage inventory space and placement, and specific bartender travel. So students are limited to determining the set of optimal work station assignments alone as the basis for improving the bar's operation.

7. **Are there provisions the club manager might wish to consider as she takes control of the bar's work station assignments?**

First, Andrew and Lori are the bar managers and the club's most experienced bartenders. Therefore, the club manager would probably want to assign them exclusively to WS1 and WS2. These work stations are where the greatest flow of customer traffic occurs requiring

the most experienced bartenders and it is from these two vantage points that those in charge of coordinating the bar's operations can most likely best see what they need to do if they are to effectively manage it. However, the club manager would probably not want the two bar managers to be free to choose which of the two work stations (WS1 and WS2) each works nor to work the same work station together.

Second, it stands to reason that when only a female bartender is at WS5, one of the male bartenders at another work station usually must assist her in changing out empty kegs on tap for full ones because the full kegs are heavy, weighing up to 80 lbs. Doing this, most likely, impairs bar service at two work stations for a time and could be what disrupts the bar's operation, partially stalling its activity.

**8. How could she solve this dilemma?**

The club manager would probably think it wise to assign Sterling, Chad or Mike (at least one of the three) permanently to WS5 in the hope of improving the bar's operations.

(NOTE: If the club manager compiled Table One with Sterling, Chad, or Mike already at WS5 permanently, then there exists within the table a set of work station assignments that will yield an estimate of the bar's revenue potential. Presumably, however, the club manager compiled Table One before having yet assigned Sterling, Chad, or Mike to WS5 permanently. There would exist then a set of work station assignments within the table that should yield a lower estimate of the bar's revenue potential. This suggests that if the club manager should use that set of assignments as the basis for her assignment decisions, the bar's performance will regularly exceed that estimate. Thus, it would be prudent for the club manager to validate her policy with respect to WS5 after she implements it by recompiling the table with new data and re-computing assignments.)

Third, doubling up at work stations occurs. Based on diminishing marginal returns to scale, it has been an established part of the bar's operations policy that there can be no more than two bartenders assigned to any one work station and cash register. The club manager would probably see no reason to change that policy.

Fourth, Sterling, Gavra, Chad, Mike, Jessica, and Leslie are part time.

**9. What recommendations would one expect the club manager to make to the club's owners about how she would employ them?**

The club manager will probably recommend that she staff the bar with all her bartenders with sold-out shows and staff the bar only with the club's most efficient bartenders as needed for less-than sold-out shows.

Fifth, the club manager needs to devise an efficient and rigorous method for determining the appropriate set of work station assignments for a given show night that she can present to the club's owners. This means that she should have such a method in place for dealing with both sold-out and less than sold-out shows. She should be able to apply this method frequently with convenience and ease since it would be useful to the club if she periodically, or as she deems necessary, recompiles Table One and updates her decisions about work station assignments. This would of course oblige her to continually experiment with sets of assignments and not let the one her method initially identifies be "set in stone" and do all the thinking for her. This also means that the set of assignments she initially settles on she could use as a benchmark by which she can evaluate later decisions.

### **Part 3—Implementation**

Students need to effectively answer several questions that arise if they are to determine what the club manager should present to the club's owners as her method for implementing some of the recommendations she has made regarding work station assignments.

**10. Should she try to realize the revenue potential of each employee or try to realize the revenue potential of the group?**

The answer to this question is a somewhat elementary one. However, concepts and principles can "slip through the cracks" for us all, so to speak. So it is well to insure that every student clearly understands what the club manager must do. An inspection of Table One readily discloses that the revenue potential of each employee cannot be realized given the club manager's assignment policy. Otherwise three of the eight bartenders would be at WS1 and the remaining five would be at WS2 which is clearly at odds with assigning no more than two bartenders to a work station at one time. Consequently, the club manager should seek to realize the group's potential revenue taken as a whole. This means that the club manager may assign a bartender to a work station and cash register where the realization of his or her expected revenue is less than at another work station. However, the gain achieved for the entire group of bartenders as a result of their collective assignments can more than offset such a difference. So the club manager may make some suboptimal decisions for some of her bartenders individually while making the optimal assignment

decision for the group. This is an important decision-making principle which some students sometimes forget.

11. **What is the point of the case scrupulously referring to realizing the revenue potential of the bar and not maximizing its revenue?**

It is important to note that the work station revenues reported in Table One each bartender generates are technically, expected values. They are estimates and merely suggest in a rough way, how well each bartender performs relative to the others. In a world that is uncertain and in so many ways quite non-linear, the bar's revenue potential amounts to something that one does not know in the same way one does not know a population regression function. Nevertheless, by using the revenue figures reported in Table One, the club manager can attempt to position the club to realize its bar revenue potential whatever it might be even if based only on the comparative performances of its bartenders.

12. **What quantitative method should the club manager select to solve the assignment problems confronting her?**

Most management science student-grade software packages will contain solution methods that appear quite capable of calculating a solution for this problem. One such solution method that may come to mind is the "assignment" algorithm. This algorithm efficiently optimizes the assignment of personnel to various work stations where one and only one assignee is given one and only one assignment. Can one appropriately apply such an algorithm in order to support the club manager's assignment decision? Searching for the answer to such a question should prompt discussion from students that leads them to practical and critical insights both on the use of various quantitative methods and implementing the club manager's recommendations.

Consider the following two applications of the assignment algorithm. Both are the sort of possible applications one would expect to see although the second is the more imaginative of the two. Given that there are more assignees (eight) than assignments (six), the assignment model of the problem is unbalanced. Its solution therefore, must leave two bartenders unassigned. Andrew and Lori (the two bar managers) can be restricted to WS1 and WS2 by not entering into the model their revenues at the other work stations. Running the problem yields the following results:  $Z = 7,689$  (USD) with the following assignments, Leslie (WS1), Andrew (WS2), Sterling (WS3), Chad (WS4), Mike (WS5), Gavra (WS6). Lori (a bar manager who is supposed to be at WS1 or WS2 and Jessica are without an assignment.

The possibility of doubling up assignees at a work station and assigning all of them is possible if one doubles the work stations. Let WS1 become WS1a and WS1b and the same for the other work stations. Thus, if one assignee is at WS1a and another is at WS1b, WS1, in effect, has two assignees. However, the students may anticipate that the least productive work stations will have no assignees. Running the problem yields the following results:  $Z = 10,982$  (USD) with the following assignments, Leslie and Sterling (WS1), Andrew and Lori (WS2), Mike and Chad (WS3), Jessica and Gavra (WS4), and WS5 and WS6 are without assignees.

The results of these two applications of the assignment algorithm should give rise to a question of two from the students. *How appropriate is the assignment algorithm when it comes to modeling the club manager's assignment policy and how well-conceived is that policy? Should the club double up its bartenders on four work stations and leave WS5 and WS6 empty?* The first application should appear to students to be not the least bit satisfactory. The club manager would have to leave one bar manager (Lori) along with Jessica unassigned and the potential revenue that she and Jessica could have generated unrealized. Furthermore, she would assign only one bar manager to WS1 or WS2 (Andrew at WS2). Clearly the algorithm fails to capture this aspect of the club's established assignment policy. Finally, although she would assign Mike to WS5 which is consistent with the club's new assignment policy, there is no compelling reason why that should be the case save that he generates enough revenue at that work station to put him there. Had the expected revenue for either Lori or Jessica at that work station been greater than Mike's but not as great as Sterling's or Chad's, the club manager would assign Lori or Jessica to that work station. She would "bench" Mike and clearly the algorithm would have failed to capture this aspect of the club manager's assignment policy.

Students should conclude that this first (unbalanced) application of the assignment algorithm cannot model the club manager's assignment policy adequately nor can it realize the bar's revenue potential given that policy.

The second model is more imaginative than the first and should illicit questions from the students. These questions should also provide the basis for critiquing the club manager's assignment policy as well as drawing conclusions about the adequacy of further attempts to effectively implement that policy with assignment algorithm models. The results this assignment algorithm model generates, indicates that both bar managers are assigned to WS2 and no one is assigned to WS5 or to WS6. These results clearly do not conform to the club manager's assignment policy. So in that regard, this application of the algorithm is inadequate. Also, it does not appear that further reformulation and elaboration of the

assignment algorithm will yield a model that is capable of generating results consistent with the club manager's assignment policy.

The results this second model generates do however, raise an interesting question that the instructor may want students to not ignore or overlook. Given the fact that the club manager must assign Andrew and Lori *only* to WS1 and/or WS2, the work station assignments this application identifies is no doubt optimal since the eight bartender assignments double up on four of the work stations leaving the remaining two work stations without assignees. *If Andrew's and Lori's assignments were less restricted would it be possible for the bar to generate more revenue by assigning them to other work stations?* Any restrictions one puts in place as part of an assignment policy risk being sub-optimizing. The club manager should, therefore, have compelling reasons supporting staffing requirements or restrictions she recommends or otherwise. It may be necessary to have Andrew and Lori at WS1 and WS2 or vice versa but the justification for doing so should be convincing—something along the line suggested earlier in this note.

The club manager intended to have Sterling, Chad, or Mike change out the empty beer kegs on tap for full ones when working WS5 in order for the bar to operate more efficiently. Their absence from this work station with the second (more imaginative) assignment model could degrade the efficiency of the bar's operations. Thus, it is possible that the revenue doubling up all eight bartenders at the first four work stations realizes might be disappointing without at least Sterling, Mike, or Chad at WS5. Whatever may be the case, it should be apparent to the students that even imaginatively designing models that employ the assignment algorithm cannot adequately capture the complexities of staffing the club's bar.

### 13. How should the club manager go about modeling the selected method?

The club manager's staffing assignment restrictions and requirements add sophistication and complexity beyond what textbook assignment algorithms can capture. However, this added sophistication and complexity more realistically depicts the assignment issues real world decision makers must sometimes face. Linear programming is not as limited as the assignment algorithm is in this regard. Therefore, the algorithm available in most student-grade software best suited to handle such complexities is linear programming.

The linear program that will provide an optimal solution for this assignment problem has 40 decision variables and 24 constraints. The constraint system consists of three sub-systems. The first subsystem consists of eight bartender constraints that insure that each bartender is

assigned to one and only one work station and cash register. The second subsystem consists of twelve work station/cash register constraints that make sure that each work station and cash register has at least one bartender assigned, but no more than two. The third subsystem consists of six inclusionary/exclusionary constraints. Two of these (inclusionary) constraints make sure that Sterling, Chad or Mike is at the work station at CR5. The remaining four (exclusionary) constraints insure that Andrew and Lori are at WS1 and WS2 but not to the same work station. This constraint subsystem makes this particular problem more interesting than the typical assignment problems textbooks provide. Constraining the assignments of selected assignees (bartenders and bar managers) as this case stipulates is a feature one does not find in typical case/textbook problems. Finally, this constraint subsystem reflects the kinds of accommodations a manager must often make in the real world of work. Thus, challenging students to correctly program such constraints should be productive.

The decision variables are as follows:

A1=Andrew on WS1, A2=Andrew on WS2, LO1=Lori on WS1, LO2=Lori on WS2, S1= Sterling on WS1, S2= Sterling on WS2, S3= Sterling on WS3, S4= Sterling on WS4, S5= Sterling on WS5, S6= Sterling on WS6, G1=Gavra on WS1, G2=Gavra on WS2, G3=Gavra on WS3, G4=Gavra on WS4, G5=Gavra on WS5, G6=Gavra on WS6, C1=Chad on WS1, C2=Chad on WS2, C3=Chad on WS3, C4=Chad on WS4, C5=Chad on WS5, C6=Chad on WS6, M1=Mike on WS1, M2=Mike on WS2, M3=Mike on WS3, M4=Mike on WS4, M5=Mike on WS5, M6=Mike on WS6, J1=Jessica on WS1, J2=Jessica on WS2, J3=Jessica on WS3, J4=Jessica on WS4, J5=Jessica on WS5, J6=Jessica on WS6, LE1=Leslie on WS1, LE2=Leslie on WS2, LE3=Leslie on WS3, LE4=Leslie on WS4, LE5=Leslie on WS5, LE6=Leslie on WS6

The *objective function* is:

$$\begin{aligned} Z_{\max} = & 1527(A1) + 1589(A2) + 1350(LO1) + 1387(LO2) + 1685(S1) + 1654(S2) + 1592(S3) + \\ & 1473(S4) + 1365(S5) + 542(S6) + 1106(G1) + 1068(G2) + 1058(G3) + 965(G4) + 952(G5) + \\ & 628(G6) + 1298(C1) + 1368(C2) + 1365(C3) + 1254(C4) + 1123(C5) + 485(C6) + 1459(M1) + \\ & 1387(M2) + 1369(M3) + 1152(M4) + 1158(M5) + 486(M6) + 1268(J1) + 1158(J2) + 1087(J3) + \\ & 1154(J4) + 1041(J5) + 368(J6) + 1468(LE1) + 1475(LE2) + 1368(LE3) + 1198(LE4) + \\ & 1024(LE5) + 472(LE6) \end{aligned}$$

The following *bartender* constraints make sure that each bartender is at one and only one cash register (two of these constraints, Andrew and Lori on CR1 and CR2, respectively are with the exclusionary constraints to facilitate one's grasp of the programming logic):

$$\begin{aligned} S1 + S2 + S3 + S4 + S5 + S6 &= 1 \\ G1 + G2 + G3 + G4 + G5 + G6 &= 1 \\ C1 + C2 + C3 + C4 + C5 + C6 &= 1 \\ M1 + M2 + M3 + M4 + M5 + M6 &= 1 \\ J1 + J2 + J3 + J4 + J5 + J6 &= 1 \\ LE1 + LE2 + LE3 + LE4 + LE5 + LE6 &= 1 \end{aligned}$$

The following *work station* constraints make sure that each work station has at least one bartender assigned to it but no more than 2:

$$\begin{aligned} A1 + LO1 + S1 + G1 + C1 + M1 + J1 + LE1 &\leq 2 \\ A2 + LO2 + S2 + G2 + C2 + M2 + J2 + LE2 &\leq 2 \\ S3 + G3 + C3 + M3 + J3 + LE3 &\leq 2 \\ S4 + G4 + C4 + M4 + J4 + LE4 &\leq 2 \\ S5 + G5 + C5 + M5 + J5 + LE5 &\leq 2 \\ S6 + G6 + C6 + M6 + J6 + LE6 &\leq 2 \\ A1 + LO1 + S1 + G1 + C1 + M1 + J1 + LE1 &\geq 1 \\ A2 + LO2 + S2 + G2 + C2 + M2 + J2 + LE2 &\geq 1 \\ S3 + G3 + C3 + M3 + J3 + LE3 &\geq 1 \\ S4 + G4 + C4 + M4 + J4 + LE4 &\geq 1 \\ S5 + G5 + C5 + M5 + J5 + LE5 &\geq 1 \\ S6 + G6 + C6 + M6 + J6 + LE6 &\geq 1 \end{aligned}$$

The following *inclusion/exclusion* constraints make sure that at least Sterling, Chad or Mike is at WS5 to the exclusion of any two other employees at that work station:

$$\begin{aligned} S5 + C5 + M5 &\leq 2 \\ S5 + C5 + M5 &\geq 1 \end{aligned}$$

Lastly, the following *inclusion/exclusion* constraints make sure that Andrew and Lori are only at WS1 and WS2 but not to the same work station:

$$\begin{aligned} A1 + A2 &= 1 \\ LO1 + LO2 &= 1 \\ A1 + LO1 &= 1 \\ A2 + LO2 &= 1 \end{aligned}$$

Running the problem in QM for Windows 2.1 yields the following assignments:

Andrew on WS2  
 Lori on WS1  
 Sterling on WS1  
 Gavra on WS6  
 Chad on WS3  
 Mike on WS5  
 Jessica on WS4  
 Leslie on WS2

Based on the expected revenues from Table One, these assignments position the club to realize sales of 10,404 (USD).

The instructor should make sure that students also review the sensitivity analysis that is a part of the program's output, specifically the coefficients in the objective function. These coefficients are of course, *expected values*. Thus, there are probability distributions associated with these coefficients despite the fact that linear programming assumes a world of certainty. Sensitivity analysis can weaken that assumption which is desirable. The club manager anticipates that the revenue her bartenders generate will vary from the revenue figures upon which she relies to make her assignments. However, as long as they vary individually within a range the sensitivity analysis reports, the assignments she makes will remain optimal even though the bar's revenue will vary from what she would otherwise expect. The sensitivity analysis of the objective function's coefficients follows where the values to the left are the lower bound values, the center values are the coefficients in the objective function, and the values to the right are the upper bound values:

|                   |                            |
|-------------------|----------------------------|
| Andrew on WS2 :   | $1564 \leq 1589 \leq M$    |
| Lori on WS1 :     | $1325 \leq 1350 \leq 1527$ |
| Sterling on WS1 : | $1666 \leq 1685 \leq 1692$ |
| Gavra on WS6 :    | $296 \leq 628 \leq 1269$   |
| Chad on WS3 :     | $1350 \leq 1365 \leq 1368$ |
| Mike on WS5 :     | $1142 \leq 1158 \leq M$    |
| Jessica on WS4 :  | $1064 \leq 1154 \leq 1157$ |
| Leslie on WS2 :   | $1468 \leq 1475 \leq M$    |

While the distributional properties of the bartender's respective revenues are not readily available, the students should be able make a number of reasonable conjectures. The probability of having to reassign bartenders in order to optimize bar revenue because of Gavra's revenue at WS6 falling outside the range reported is most likely very low since the

range is quite wide, relatively speaking. The probability of having to reassign bartenders in order to optimize bar revenue because Andrew's, Mike's, and Leslie's revenues at WS2, WS5, and WS2, respectively exceed what is expected is zero (0) since there is no upper bound on their respective ranges. For Lori at WS1, her revenue would have to exceed expectation by more than 13% before some change in the basic solution would apparently be in order. However, if the revenue she generates exceeds her upper bound, decision variable A1 which happens to have been in the basis with a value of zero<sup>1</sup> leaves the basis and is replaced by the artificial variable with a zero (0) value that is associated with constraint A1\_A2 and now, the upper bound for Lori's revenue at WS1 has no limit. Thus, no change in the assignments is necessary. When Sterling's earning at WS1 (S1) exceed the upper bound, decision variables LE1 (with a value of zero) and the slack for the constraint WS1\_2 leave the basis. LE3 (also with a value of zero) and the slack for constraint WS2\_2 enter the basis with no change to the assignments. The upper bound for S1 now has no limit. Exceeding the upper bounds on both Chad and Jessica yields the same kinds of changes in the basis with no changes in the assignments. So the assignments made are particularly robust even if revenue appreciably exceeds expectations for any one bartender.

Should revenue for any one bartender fall appreciably short of expectations, however, reassignments will be necessary. Should either Andrew's or Lori's revenue fall below their lower bounds, 1564 (USD) or 1325 (USD), respectively, they should switch work stations. Should Sterling's revenue at WS1 fall below 1666 (USD), he should switch places with Mike who is at WS5. Should Chad's revenue at WS3 falls below 1350 (USD), no change in assignment occurs with changes in the basis being similar to the changes that occurred when the earnings of Lori, Sterling, Chad, and Jessica exceed their upper bounds. Should Jessica's revenue at WS4 falls below 1064 (USD) (a 90 (USD) short-fall in expectations), she should switch to WS1, Sterling should switch to WS3, and Chad should switch to WS4—"musical work stations" with bartenders, so to speak. Leslie's revenue at WS2 must actually fall below 1437 (USD) to result in any assignment changes (her lower bound is 1468 (USD)). Should that happen, Leslie and Sterling switch work stations. Thus, the initial set assignments is not so robust should revenue fall below expectations for any one bartender. Nevertheless, switching Andrew and Lori is not particularly drastic since they must be at WS1 and WS2 anyway and both Jessica's and Leslie's revenues must fall below expectations by roughly 100 (USD) before reassignments would be optimizing. Thus, a sensitivity analysis of the expected revenues for the assignments made, specifically the *lower* bounds for those expected revenues in this case, serve to alert the club manager and students that the set of work station assignments the program initially identifies may not always be optimal.

14. **How might the club manager go about making bar assignments for less-than sold-out shows?**

It is certainly a matter of concern to position the club to realize its bar revenue potential for a sold-out show. Closely related to this issue is the issue as to what the club manager should do if she already has reason to expect a less-than sold-out show. *Should she decide to staff the bar with fewer bartenders and possibly fewer work stations, what kind of assumptions must she make if she is to make well-informed and efficacious decisions?* Without additional information except for a reason to believe that the total revenue for the evening will be less, the club manager may assume that each bartender's expected revenue performance at every work station (reported in Table One) would be the same if with fewer bartenders the patrons congregate at fewer work stations. Furthermore, the club manager certainly should have some idea on such occasions as to what the "crowd size" should be based on summing the number of reservations once multiplied by their respective party size and the history on walk-ins. Assume for example, a show that is expected to draw 550 patrons. Assume further, that each patron will have a bar tab of 11 (USD).<sup>2</sup> With these assumptions, how should the club's manager proceed to make the optimal staffing decision?

Students might tempt themselves to try and modify the original linear programming model to capture the reality of a less-than sold-out show. The original model was necessary because the club manager had to combine her resources (the bartenders) in such a way as to put the club in a position to realize its potential bar revenue which means maximizing the estimate whatever that might be. Modifying this model for a lesser amount of anticipated revenue is, for the most part, not necessary. Other than the fact that at least one of the bar managers should be working the night of a less-than sold-out show and WS5 should be staffed with either Sterling, Chad, or Mike, the club manager merely needs to insure that she has enough work stations staffed to more than cover the anticipated bar revenue for that night (6050 (USD)— $550 \times 11$ ). She could, for example, using the figures from Table One, put Lori at WS1 (1350 (USD)), Mike at WS2 (1459 (USD)), Leslie at WS3 (1368 (USD)), Jessica at WS4 (1154 (USD)), and Sterling at WS5 (1365 (USD)) for 6050 (USD). Another configuration might be Leslie at WS1 (1468 (USD)), Andrew at WS2 (1589 (USD)), Gavra at WS3 (1058 (USD)), Chad at WS4 (1254 (USD)), and Mike at WS5 (1158 (USD)) for 6427 (USD). Thus, the club manager has some flexibility in how she staffs the bar on such occasions and discretion as to whom she distributes work—something programming would not capture or for which be necessary.

15. How might the club's compensation of its bartenders figure into these decisions?

The compensation the bartenders receive from the club for their work may or may not complicate the assignment problem the club manager must solve. The solution procedures advanced above for both sold-out and less-than sold-out shows assume that compensation is some percentage of the revenue each bartender generates whether this is approximated by an hourly rate or a commission. Thus, compensation is not a factor for the club manager in deciding these assignments. However, if the revenue generated does not mechanically drive compensation (e.g., Andrew and Lori might be paid more because they are bar managers even though someone like Sterling appears to outperform them), one must factor compensation into the calculations informing the assignment decisions. With respect to sold-out shows, all the club manager needs to do is subtract the wage bill for the night (and other prorated personnel costs as well) for each bartender from the revenues one expects each to generate at each work station. These differences then replace the revenue figures in the objective function as the club's margins for the evening and the program is ready to be run. The club manager would then make her assignments on the basis of the expected profits each bartender generates at each work station.

A less-than sold-out show in which the revenue it generates does not mechanically driving compensation, presents a different and bit more complex issue. Certainly, the club manager must insure that the anticipated bar revenue is more than covered by the bartenders she has selected and the work stations she has selected to staff. Each set of bartender and work station assignments will however, yield different profits. Allow a wage bill for Andrew and Lori of 150 (USD)/night each. Sterling, Mike, Leslie receive 100 (USD)/night each, Chad and Jessica 85 (USD)/night each, and Gavra receives 75 (USD)/night. The club manager could again select and assign bartenders so as to be sure to cover anticipated bar revenue for that evening's show and further, she could compute the expected profit. This would not however, necessarily position the club to realize the bar's profit potential. Some sets of assignments would understandably do better than others. Such a situation suggests that a modification of the programming might be in order to determine the optimal set of work station assignments. Thus, assume a less-than sold-out show of 550 patrons, work stations have only one bartender, WS6 is closed, Sterling, Chad, or Mike are at WS5, and Andrew or Lori are at WS1 or WS2 but not at both stations meaning if Andrew works Lori does not and vice versa.

Modifying the program, replace the four *exclusion* constraints for Andrew and Lori with respect to WS1 and WS2 with one constraint in which their respective variables for both work stations sum to one (1). The *inclusion* constraints that assign at least Sterling, Chad,

or Mike to WS5 remain unchanged. The programming for the *bartender* constraints for the "sold-out" problem had each bartender adding up to "1" (one). Obviously a bartender could not be at more than one work station simultaneously and all eight of them are subject to assignment. However, in the present case, change those equalities from " $= 1$ " to " $\leq 1$ " since one of the decisions to be made is precisely which bartender or bartenders the club manager will leave unassigned. Drop the *work station* constraints pertaining to having at least one bartender assigned to a work station since one or more work stations may have no assignees. Furthermore, one can easily shut down the satellite bar (WS6) with less-than sold-out shows below a certain number of patrons by changing the RHS of its remaining constraint from  $\leq 2$  to  $= 0$ . Change the RHSs of the rest of the work station constraints from  $\leq 2$  to  $\leq 1$ . Add, however, another constraint to the constraint system limiting the bar revenue to  $\leq 6050$  (USD). This added "*capping*" constraint insures the selection of an optimal subset of the available bartenders for assignment to some or all of the bar's work stations and captures the reality of the club manager's expectations for a less-than sold-out show. Such a constraint is not at all inappropriate. The budgeting of resources should always be based on the calculation of what is minimally sufficient to achieve the expectation for which they are being put to use. Finally, reduce the coefficients in the objective function to their profit margins.

One should run this problem as an integer linear program. Capping bar revenue with a constraint and maximizing an objective function virtually insures the exact satisfaction of the constraint while guaranteeing that less than one bartender (e.g., 4.333, 4 and  $\frac{1}{3}$  bartenders) could easily be part of the solution. Integer programming insures that this will not be the case. The number of bartender assignments made will all be integers although the value of the "capping constraint" will more than likely be less than what exactly satisfies it. The program follows.

The objective function is:

$$\begin{aligned} Z_{\max} = & 1377(A1) + 1439(A2) + 1200(LO1) + 1237(LO2) + 1585(S1) + 1554(S2) + 1492(S3) + \\ & 1373(S4) + 1265(S5) + 442(S6) + 1031(G1) + 993(G2) + 983(G3) + 890(G4) + 877(G5) + \\ & 553(G6) + 1213(C1) + 1283(C2) + 1280(C3) + 1169(C4) + 1038(C5) + 400(C6) + 1359(M1) + \\ & 1287(M2) + 1269(M3) + 1052(M4) + 1038(M5) + 386(M6) + 1183(J1) + 1073(J2) + 1002(J3) + \\ & 1069(J4) + 956(J5) + 283(J6) + 1368(LE1) + 1375(LE2) + 1268(LE3) + 1098(LE4) + \\ & 924(LE5) + 372(LE6) \end{aligned}$$

The following **bartender** constraints make sure that the club manager assigns each bartender to one and only one cash register but also allows for the fact that she may not assign a bartender to any work station:

$$S1 + S2 + S3 + S4 + S5 + S6 \leq 1$$

$$G1 + G2 + G3 + G4 + G5 + G6 \leq 1$$

$$C1 + C2 + C3 + C4 + C5 + C6 \leq 1$$

$$M1 + M2 + M3 + M4 + M5 + M6 \leq 1$$

$$J1 + J2 + J3 + J4 + J5 + J6 \leq 1$$

$$LE1 + LE2 + LE3 + LE4 + LE5 + LE6 \leq 1$$

The following **work stations** constraints make sure that the club manager assigns each work station at least one bartender to it or not but no more than 1:

$$A1 + LO1 + S1 + G1 + C1 + M1 + J1 + LE1 \leq 1$$

$$A2 + LO2 + S2 + G2 + C2 + M2 + J2 + LE2 \leq 1$$

$$S3 + G3 + C3 + M3 + J3 + LE3 \leq 1$$

$$S4 + G4 + C4 + M4 + J4 + LE4 \leq 1$$

$$S5 + G5 + C5 + M5 + J5 + LE5 \leq 1$$

$$S6 + G6 + C6 + M6 + J6 + LE6 = 0$$

The following **inclusion/exclusion** constraints make sure that the club manager assigns at least Sterling, Chad or Mike to WS5 and Andrew or Lori to WS1 or WS2:

$$S5 + C5 + M5 = 1$$

$$A1 + A2 + LO1 + LO2 = 1$$

Finally, add the “**capping**” constraint to the system.

$$1527(A1) + 1589(A2) + 1350(LO1) + 1387(LO2) + 1685(S1) + 1654(S2) + 1592(S3) + 1473(S4) + 1365(S5) + 542(S6) + 1106(G1) + 1068(G2) + 1058(G3) + 965(G4) + 952(G5) + 628(G6) + 1298(C1) + 1368(C2) + 1365(C3) + 1254(C4) + 1123(C5) + 485(C6) + 1459(M1) + 1387(M2) + 1369(M3) + 1152(M4) + 1158(M5) + 486(M6) + 1268(J1) + 1158(J2) + 1087(J3) + 1154(J4) + 1041(J5) + 368(J6) + 1468(LE1) + 1475(LE2) + 1368(LE3) + 1198(LE4) + 1024(LE5) + 472(LE6) \leq 6050$$

The assignments of this problem's solution are:

Lori on WS2  
Gavra on WS3  
Chad on WS 5  
Jessica on WS1  
Leslie on WS4

These assignments are capable of realizing anticipated revenue of 6,034 (USD) and a profit of 5,539 (USD). While revenue is below 6050 (USD), it is by only 16 (USD), the bar tab of close to one person. Thus, this set of work station assignments is probably good enough since the result indicates that the club has positioned itself close to realizing its anticipated revenue. If the club manager was to make assignments such as suggested in the last paragraph of section 5 of Part 3 of this teaching note, she would have more than adequately positioned the club to realize the revenue anticipated. *Given that she did, what would be the "bottom" line consequence of so over-positioning?* Assuming the revenue realized is 6050 (USD) as anticipated, the cost with Lori in charge would have been 535 (USD) and with Andrew, 510 (USD) compared to 495 (USD) for the computer solved configuration. The greater of the two increased costs against the computer solution entails less than a 1% reduction in profit ( $40 \div (6050 - 495)$ ). One can try other configurations but for the most part the results will be similar. The club manager can of course always try to avoid over-positioning the bar business but even if she fails, the cost penalty is not great. Thus, it would seem that the club manager merely needs to insure that she has enough work stations staffed to more than cover the anticipated bar revenue even when she takes the respective wage bills of the bartenders into account. She can of course always run the expected revenue figure associated with the set of work station assignments she has selected and see by how much the computer solution with a different set improves on her expected profit. The club manager may choose to go with *her* selection in the interest of maintaining balance in scheduling bartender assignments at the bar within a time horizon sufficiently distant to be reliable should the difference be acceptable.

The program for a less-than sold-out show discussed above, has only five work stations open and permits no doubling of assignments at work stations. This means that it has revenue limits. This limit is reached at 641 patrons when no configuration of bartenders and their assigned work stations can position the club to realize more revenue regardless as to how much one increases the RHS of the "capping" constraint. Either WS6 needs to be opened or doubling up on work stations needs to take place (with the additional consideration of assigning both bar managers) when the anticipated number of patrons for a show exceeds 641. The club manager can easily determine what staffing change to make by merely insuring that it is sufficient to cover the expected bar revenue. If she needs to verify the optimality of the selection she contemplates she can do so with the less-than sold-out

program by modifying it with selected work station constraints from the sold-out program that she had previously dropped. No doubt she will determine that doubling up on a work station is more productive than opening WS6 at all and raises a question about an assignment policy that assumes WS6 has any utility whatsoever.

16. **How might the club manager's termination of the informal work station assignment rotation system the bartenders practiced impact her effort to come up with a combination of assignments to optimize the bar's performance?**

Studies of organizational performance several decades ago assumed significant correlations between organizational structure and outcomes. Thus, if one could manage to structure an organization in just the "right" sort of way according to rigorously preconceived "sound" theoretical guidelines, one would then maximize the organization's performance. No doubt, this is to some extent true. One could certainly do just the opposite and design an organization to languish or fail. Any redesign of it that could be significantly associated with improved organizational performance would then seem to support that assumption. Reliance on such an assumption as a primary answer to remedially addressing an organization's ills persists to the present. Certainly, this assumption is somewhat in play with the club manager's intention to identify various sets of work station assignments for different situations that would optimize the bar's performance. More recent studies are quick to point out, however, that participants in an organization can debilitate it regardless of how apparently efficacious and well informed is its design. Thus, what would seem to be the appropriate managerial thing to do in terminating the informal work station assignment rotation system the bartenders had practiced could lead to a loss of morale, sense of being a cohesive team that looks out (cares) for its members, increased rate of bartender turnover and attendant recruiting/training costs, etc. Such consequences of terminating the rotation system could "derail" revenue and profit generation and disappoint expectations. (Positive responses to the termination of this system could also occur but focus will be on the negative since that is not what the club manager or the club wants.)

What does the possibility of such factors coming into play imply with respect to the club manager's effort to model her decision-making in the way she has done? Those hostile to the use of such modeling methods could simply raise these issues in the attempt to make a case that as support systems to decision making, these methodologies are irrelevant. If factors such as, loss of morale, turnover, teamwork disruption, etc. can derail the pursuit of the possibilities these methodologies reveal, then what good are they? Why then employ them? Such questions are legitimate. However, to dismiss such methodologies because some factors might contaminate the results that issue from their employment evidences a

superficial and unsophisticated understanding of the value of these methodologies and what they can accomplish.

First, reality is far too rich for any model to completely comprehend it in its totality. Even for a segment of reality this is so. Therefore, models of reality are but abstractions. And being abstractions, they are, as G. E. P. Box has said, all “wrong” because being incomplete they cannot avoid distorting what they represent. The issue then is not that they are wrong but rather, are they “too wrong” to be useful. The previously discussed sensitivity analyses of the club manager’s models serves the purpose of attempting to establish just how useful her models could be. Even though there is no reason to believe that what will occur will even closely reflect the model to which it is paired in terms of objective function values, it could still confirm the optimality of the work station assignments the solution determined.

Second, even if quantitative modeling fails to produce the results anticipated due to “derailing” factors like those identified above, such modeling has informative value. The solutions quantitative modeling provides are like benchmarks against which the club manager can evaluate the adequacy of her grasp of the problem she is addressing. So what if something derails the club manager’s effort? Such modeling then proves valuable because it alerts the decision makers that aberrations have occurred that were not before present. Modeling can then serve a diagnostic function analogous to the use of control charts in statistical quality control. Rather than trying to incorporate various “derailing” factors into the model for the sake of improved accuracy which could be very difficult let alone ill-advised, the model merely points the decision maker to where “fixes” are needed. It becomes then incumbent upon the decision maker or someone competent to do so to develop an explainable cause for the aberration so that some remedial action can be taken to eliminate it.

## Software

Howard Weiss’ management science software package, POM/QM for Windows v. 2.2, (ISBN 0131450662) computed the solutions for these problems. The package is user friendly and can be purchased from Prentice-Hall for \$16 + s/h. WinQSB, v. 2.0 by Chang ((ISBN 0471406724) is another fine package that is near commercial grade that students can order from Wiley for just shy of \$60. One could also use Excel employing Solver (Tools>Add-ins>Solver—this is usually necessary to access Solver). Once a student has invoked Solver, he or she can program problems by referencing the cells on the spreadsheet where they have entered the appropriate cell formulas and constants. The simple example that follows should suffice.

$$\begin{aligned}
 &Z_{\max} = 30X_1 + 45X_2 \\
 \text{s.t.} \quad &2X_1 + 2X_2 \leq 240 \\
 &X_1 + 2X_2 \leq 160
 \end{aligned}$$

Maximize the target cell which is:  $30X_1 + 45X_2$ . The changing cells are simply the two cells the target cell references for variables  $X_1$  and  $X_2$ . The constraints are simply two cells,  $2X_1 + 2X_2$  and  $X_1 + 2X_2$  which the two changing cells reference for variables  $X_1$  and  $X_2$ . The RHS values are constants that are part of the constraint system. See Table Two and Figure Two below.

| Table Two |                |     |
|-----------|----------------|-----|
|           | A              | B   |
| 1         | 80             | 40  |
| 2         | $=30*A1+45*B1$ |     |
| 3         | $=2*A1+2*B1$   | 240 |
| 4         | $=1*A1+2*B1$   | 160 |

Figure Two

**Solver Parameters**

Set Target Cell:

Equal To: ☒ Max ☐ Min ☐ Value of:

By Changing Cells:

Subject to the Constraints:

If it is necessary to make the variables integers as opposed to continuous, additional constraints are needed for each of the changing cells values specifying them as integers (e.g.,  $\$A\$1=\text{int}$ ,  $\$B\$1=\text{int}$ ).

### SUMMARY

The case description notes that the instructor can, upon completion of the case, modify it with discussion questions to the class that explore its application to more complex and other realistic settings. The authors suggest two such scenarios the instructor can present. The first scenario (Section 5 of Part 3) involves a less-than sold-out show where bartender compensation is not a factor. The second scenario (Section 6 of Part 3) involves shows that sell out and do not sell out where bartender compensation is a factor. The programming of this scenario for the "sold-out" program is not complex. However, the programming for the less-than sold-out show is and the utility of this model is that it permits the club manager to insure that the assignments she makes cover the expected

### ENDNOTES

- 1 In any simplex solution, especially for more complex problems, it is not uncommon to find decision variables and artificial values with values of zero in the basis along with slacks and surpluses which of course, is not unusual, especially when the problem is over-identified as is this problem.
- 2 10,404 (USD)/950 patrons taken from the linear programming solution could be used in lieu of historical data, not the least of which would be bar receipts and number of patrons. Historical data, if available, would probably be more useful and a better indicator of expected bar revenue inasmuch as the relationship between bar revenue and number of patrons as well as type of show could be considered and may have some other functional form than linear.