

**Assignment # 2**  
**Linear Programming Formulation and Sensitivity Analysis**

ADM2302 students are reminded that submitted assignments must be neat, readable, and well-organized. Assignment marks will be adjusted for sloppiness, poor grammar and spelling, as well as for technical errors. This assignment can be done in a group of one, two, three or four students. Plagiarism on assignments will not be accepted, *each student must sign the statement of integrity*. Solutions to the Case Study are to be prepared using the **Report to Management format provided in the ADM2302 Course Outline**.

This assignment can NOT be hand written.

*Please note: Solutions to the case study below must include clear “managerial statements” that communicate the results of the analyses and the recommended decisions to be made.*

**Problem 1 - LP Problem**

The J. Mehta Company’s production manager is planning a series of one-month production periods for stainless steel sinks. The forecasted demand for the next four months is as follows:

Month	Demand for Stainless Steel Sinks
1	120
2	160
3	240
4	100

The Mehta firm can normally produce 100 stainless steel sinks in a month. This is done during regular production hours at a cost of \$100 per sink. If demand in any one month cannot be satisfied by regular production, the production manager has three other choices:

- (1) he can produce up to 50 more sinks per month in overtime but at a cost of \$130 per sink;
- (2) he can purchase a limited number of sinks from a friendly competitor for resale (the maximum number of outside purchases over the four-month period is 450 sinks, at a cost of \$150 each);
- (3) Or, he can fill the demand from his on-hand inventory (i.e. beginning inventory). The ending inventory holding cost is \$10 per sink per month.

A constant workforce level is expected. Back orders are NOT permitted (e.g. order taken in period 3 to satisfy demand in later period 2 is not permitted). Inventory on-hand at the beginning of month 1 is 40 sinks.

- a. Formulate algebraically the Linear Programming (LP) model for the above “production scheduling” problem.

- b. Formulate this same linear programming problem on a spreadsheet and SOLVE using Excel solver (Provide a printout of the corresponding “Excel Spreadsheet”, “Answer Report” and “Sensitivity Report”).
- c. Describe clearly and completely the optimal production schedule using a managerial statement.
- d. Are there any alternative ways of production that would achieve the same optimal production cost? Justify.

### Problem 2 - STUDY CASE: The PB Lumber Company

The PB Lumber Company, a small player in the lumber industry, has carved out a market niche by focusing on only a few products for which it has been able to establish a loyal clientele over the years. PB produces pine and fir saw lumber and two types of plywood. The production processes for their small product line is relatively simple, and careful attention to maintenance of machinery and training of personnel has proved to be an effective combination for long-term profit. In fact, for many years PB has been able to sell all of the wood products it makes, partially due to high product quality.

As a result of its steady sales, PB has been able to avoid fluctuations in the amount of labour it keeps on staff. The effect of this is that labour is in effect a fixed cost. Since labour and wood are the major costs incurred by PB, this results in a planning problem in which maximization of contribution to fixed costs amounts to maximization of revenue minus cost of wood.

The relevant revenues and costs are shown below:

Product	Revenue/board-meter
pine saw lumber	\$0.34
fir saw lumber	0.46
	Revenue/board
type I plywood	9.20
type II plywood	9.90

Type of Wood	Cost/board-meter
Pine	\$0.30
Fir	0.40

For example, the contribution per **bm (board-meter)** for pine saw lumber is  $\$0.34 - \$0.30 = \$0.04$ .

For the month of December, the company has **2,580 thousand bm (2,580 mbm)** of pine available for either saw lumber or plywood. Similarly, 2,040 mbm of fir are available. One panel of type 1 plywood requires 16 bm of pine and 8 bm of fir. One panel of type 2 plywood requires 12 bm of each species.

Saw lumber is restricted only by the capacity of the headrig saw. The saw can handle 400 mbm per month of either species.

The plywood mill can be restricted by either the peeler or the dryer. During a month no more than 250 thousand panels of plywood may be peeled, and there are 920 thousand minutes of dryer time available. Each type 1 panel requires 4 minutes of dryer time and each type 2 panel requires 6 minutes of dryer time.

Market conditions limit the number of type 1 panels sold to no more than 120 thousand and the number of type 2 panels to no more than 100 thousand. Any amounts of saw lumber can be sold. Commitments have been made to produce at least 90 mbm of type I plywood.

The company formulated a linear programming model for their operations. Note that the variables have not been defined.

Maximize  $.04P + .06F + 1.20T1 + 1.50T2$

Subject to :

$$\begin{array}{rcll}
 P & + & 16T1 & + & 12T2 & \leq & 2580 \\
 & & F & + & 8T1 & + & 12T2 & \leq & 2040 \\
 P & + & F & & & \leq & 400 \\
 & & & & T1 & + & T2 & \leq & 250 \\
 & & & & 4T1 & + & 6T2 & \leq & 920 \\
 & & & & T1 & & & \leq & 120 \\
 & & & & T1 & & & \geq & 90 \\
 & & & & & & T2 & \leq & 100
 \end{array}$$

$$P, F, T1 \text{ and } T2 \geq 0$$

- a. As the primary analyst for this problem, you should make sure to include the formulation above in your report, including the definitions of variables, labeling or description of the constraints, and derivation of the objective function.

PB's CEO, Tammy Henrich, has a number of concerns on her mind which she feels should be dealt with before she finalizes her plans for the month. She has asked you to provide appropriate recommendations.

- b. If nothing changes in the problem described above, she would like to know how much to produce of each product, and what the total contribution to profit will be.
- c. Additional sawmill, peeler and dryer capacity is available, and costs of \$0.02/bm, \$0.06 per panel and \$0.04 per minute, respectively. Ms. Henrich would like advice on how to deal with this unexpected capacity.
- d. A nearby business (not in competition with PB) would like to buy 50,000 minutes of dryer capacity from PB for \$0.06 per minute. Ms. Henrich finds the offer interesting, but doesn't know what to do about it.
- e. PB's marketing manager has suggested advertising its plywood products. PB figures that each dollar spent on type I (type II) advertising will increase demand by 4 panels for type I and 5 panels for type II plywood. Is there an interesting opportunity here?
- f. The supplier of Fir Wood has decreased the cost/board-meter by one cent (i.e. decreased cost/board-meter to \$0.39). Ms. Henrich would like to know if this would change her production plan.

**Incidentally, the last four questions above (part c to part f) arose just before production decisions had to be finalized, so the only information available for answering these questions is the linear programming output (i.e. sensitivity report) which was produced for part b. There is no time to run additional linear programming models.**

**Source:**

LP Problem: Render, B., and R.M. Stair, Jr., N. Balakrishnan 2003. *Managerial Decision Modeling*. Prentice-Hall, Inc.: Upper Saddle River, New Jersey. 616p.