**Assignment 4**

Use the **Excel** Solver tool to perform the analyses specified below and answer the given questions using the data set provided. Save your analysis results in the Excel file, but also answer any additional questions in this Word document clearly and completely as requested. Upload this completed worksheet, along with your modified Excel file, by the deadline specified in Canvas.

Scoring for this assignment will be based not only on the accuracy of your data analysis, but also on the organization, clarity, and quality of your written answers, Excel worksheets, and this completed summary as a whole. Refer to the posted slide set and problems that we did in class if you need a refresher on linear programming concepts.

**Case: Minimizing shipping costs from regional warehouses to retail stores.** Many companies use regional warehouses to reduce the time and cost required to restock their retail outlets. (Companies such as Amazon use similar strategies to ship merchandise directly to their customers). The Excel file “Warehouse\_to\_Store\_Costs” contains a worksheet with four tables. A company has six retail store locations, and three regional warehouses from which they can obtain boxes of materials needed to operate the stores for an upcoming week. The first table shows the cost of shipping one box of materials from a given warehouse to a given retail location (boxes of materials at the three warehouses are identical). The second table shows how many boxes will be shipped from each warehouse to each store, the total shipped to each store, and how many boxes of materials are needed at each store for the upcoming week. The third table shows the total number of boxes available to ship from each warehouse. The fourth table shows the total cost to ship boxes from all three warehouse to the six stores.

We wish to **minimize** the cost of shipping boxes of materials from the warehouses to all of the stores, and need to determine how many boxes we should ship from each warehouse to each store in order to achieve this objective. Each store **must** receive the number of boxes it needs for the week, which is the value in the last column of the second table. In addition, we cannot ship more boxes from a warehouse than they have available. Be sure that each amount shipped from a warehouse to a store is an **integer** and is **nonnegative**. (Do not worry about possible differences in shipping times – just minimize total costs.)

**A.** Use Solver to find the optimal values for the number shipped from each warehouse to each store based on the goal and constraints described above. There are 18 values that you need to determine (6 stores x 3 warehouses = 18 decision variables). Use the Simplex LP method to do this. Once you find the optimal solution, keep it and generate an Answer report. Be sure to save this solution and the report in your Excel file.

**B.** What is the minimum cost to ship the required number boxes of materials to the stores?

$67,050

**C.** The number of boxes available at each warehouse represent three constraints in this problem. When the problem is solved, are any of these three constraints binding? If so, which one(s)? Do any of these three constraints have slack or surplus? If so, which ones, and how much?

The inventory in St. Louis is binding since all of the boxes are used. On the other hand, the inventory in L.A. and Boston both have surpluses, with L.A. having 125 extra and Boston having 75 extra.

**D.** Now make a copy of the Shipping worksheet (In Windows, you can right-click on the tab, select Move or Copy, and then check Create a Copy). On this copied worksheet, change the Number Needed for Atlanta from 150 to 250. Run Solver again for this modified set of data (generate an Answer report). Save the new worksheet and the report as part of your Excel file.

**E.** What is the new minimum shipping cost? Also note any changes in the values of **each** decision variable and any changes in the **three** warehouse constraints (are they still the same as in Part C?).

$72,725

There was a change in the decision variables due to this change. Firstly, the shipping to Denver had 25 sent from L.A. and only 150 from St. Louis instead of all 175 coming from St. Louis. The shipping to Atlanta also changed to account for 250 boxes needing to be shipped to Atlanta. It still received all its boxes from Boston, however they received 250 from there instead of 150. Lastly, Miami received 25 of its boxes from St. Louis and only 200 from Boston instead of receiving all 225 from Boston.

There were also changes to the constraints mentioned in Part C. St. Louis is still a binding constraint, but now Boston is as well due to the extra boxes being sent to Atlanta. The inventory in L.A. is still in surplus, however, it only has 100 boxes in surplus as opposed to the 125 it had in Part C.

**F.** If you did have to integrate shipping time into this model in addition to cost, how might you do so? You do not have to go into depth here or provide a complete model – just some general ideas are fine.

To implement this, I would set up another table like the cost table, having each entry represent the shipping time to get from the specific warehouse to the given location (in consistent units like hours or days throughout). I would then include another table like “Available Warehouse Inventory” that provides the constraints that need to be met for each location (L.A., St. Louis, and Boston) in terms of the shipping time that needs to be met or whatever other constraints there are related to shipping time. I would then add the specific constraints to the existing model to account for the shipping time along with everything else.