Southern New Hampshire University

Module Seven: Transportation Management

Optimal transportation of goods in a supply chain is essential because it is important that:

- The total transportation cost is minimized
- The demand at warehouses is satisfied
- The capacity at production facilities is not exceeded

Read this article that describes in detail the role of transportation in a supply chain.

Consider the following example that demonstrates optimization of transportation.

There are production facilities in Battle Creek, Cherry Creek, and Dee Creek with annual capacities of 500 units, 400 units, and 600 units, respectively. The annual demands at warehouses in Worchester, Dorchester, and Rochester are 300 units, 700 units, and 400 units, respectively. The table below gives the *unit* transportation costs between the production facilities and the warehouses.

	Worchester	**Dorchester**	**Rochester**
Battle Creek	$20/unit	$30/unit	$13/unit
Cherry Creek	$10/unit	$5/unit	$17/unit
Dee Creek	$15/unit	$12/unit	$45/unit

How much of the demand at each of the warehouses must be met by each of the production facilities?

This problem can be modeled as a linear programming model as follows:

Decision Variables

Xbw = # of units to be transported from Battle Creek to Worchester
Xcw = # of units to be transported from Cherry Creek to Worchester
Xdw = # of units to be transported from Dee Creek to Worchester
Xbd = # of units to be transported from Battle Creek to Dorchester
Xcd = # of units to be transported from Cherry Creek to Dorchester
Xdd = # of units to be transported from Dee Creek to Dorchester

Xbr = # of units to be transported from Battle Creek to Rochester
Xcr = # of units to be transported from Cherry Creek to Rochester
Xdr = # of units to be transported from Dee Creek to Rochester

Objective Function

Minimize total annual transportation cost ($):

= 20*Xbw + 10*Xcw + 15*Xdw + 30*Xbd + 5*Xcd + 12*Xdd + 13*Xbr + 17*Xcr + 45*Xdr

Constraints

Demand Constraints

Xbw + Xcw + Xdw ≥ 300 (demand at Worchester)
Xbd + Xcd + Xdd ≥ 700 (demand at Dorchester)
Xbr + Xcr + Xdr ≥ 400 (demand at Rochester)

Capacity Constraints

Xbw + Xbd + Xbr ≤ 500 (capacity at Battle Creek)
Xcw + Xcd + Xcr ≤ 400 (capacity at Cherry Creek)
Xdw + Xdd + Xdr ≤ 600 (capacity at Dee Creek)

Non-Negativity Constraints

Xbw, Xcw, Xdw, Xbd, Xcd, Xdd, Xbr, Xcr, and Xdr are ≥ 0

Integer Constraints

Xbw, Xcw, Xdw, Xbd, Xcd, Xdd, Xbr, Xcr, and Xdr are integers

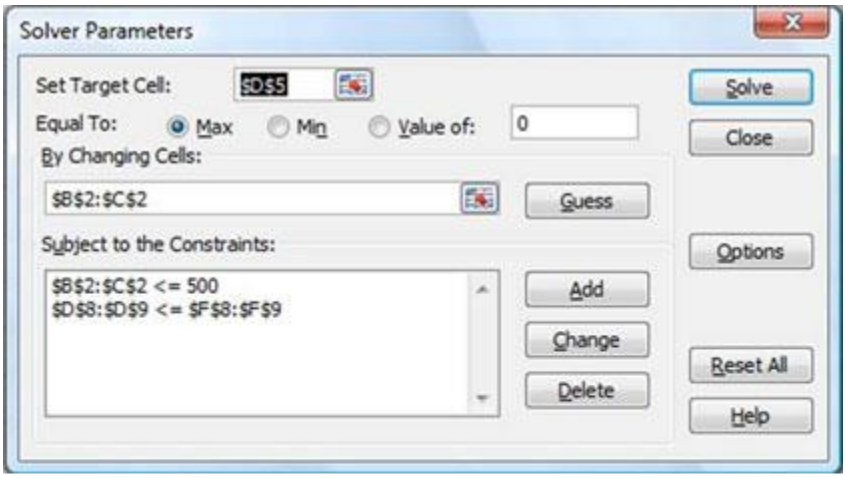
The above model can be solved using the Microsoft Excel Solver tool. Refer to the tutorial on how to use the Solver tool (click on each image for a better display).

Using Excel Solver

Microsoft Excel contains a tool called Solver that can be used to find the optimal solutions to linear programming problems. The Excel spreadsheet set up for the solver is given below. For an explanation of steps to set up the spreadsheet and use Solver to find the optimal solution, view the document Linear Programming with Excel Solver document found in the Resources folder.

	A	B	C	D	E	F
1	A	B	C	D	E	F
2	Variables	Baseballs	Softballs			
3	Number	10	10			
4						
5	Objective	Baseballs	Softballs	Total Profit		
6	Unit Profit	7	10	170		
7						
8	Constraints	Baseballs	Softballs	Total Required		Total Available
9	Cowhide	5	6	110	<=	3600
10	Mfg Time	1	2	30	<=	960

After setting up the spreadsheet, Excel Solver is used to find the optimal solution to the problem. The Excel Solver dialog box set up for the example problem is given below. The steps for installing and using the Excel Solver are given in the Linear Programming with Excel Solver document.



Excel Solver finds the optimal solution to the problem, which is displayed in the spreadsheet as well as presented through an Answer Report as shown below. For an explanation of the steps for producing the Answer Report for the example problem view the Linear Programming with Excel Solver document.

Microsoft Excel 11.0 Answer Report
Worksheet: [Book2]Sheet1
Report Created: 5/17/2006 9:00:27 PM

Target Cell (Max)

Cell	Name	Original Value	Final Value
$D$5	Unit Profit Total Profit	170	5520

Adjustable Cells

Cell	Name	Original Value	Final Value
$B$2	Number Baseballs	10	360
$C$2	Number Softballs	10	300

Constraints

Cell	Name	Cell Value	Formula	Status	Slack
$D$8	Cowhide Total Required	3600	$D$8<=$F$8	Binding	0
$D$9	Mfg Time Total Required	960	$D$9<=$F$9	Binding	0
$B$2	Number Baseballs	360	$B$2<=500	Not Binding	140
$C$2	Number Softballs	300	$C$2<=500	Not Binding	200

The answer report above provides the same optimal solution as was obtained through the graphical method. It gives the slack for each constraint. Slack is the unutilized resource. Slacks for cowhide and production time constraints are zero, implying that all of the cowhide and production time available are being utilized. It can also be seen that of the production capacity of 500 for baseballs, 360 is being utilized and 140 is the unutilized capacity. Similarly, for soft balls there is an unutilized production capacity of 200.

Note: In some cases, you may receive the following error message when generating the Answer Report, “Solver: an unexpected internal error occurred or the available memory was exhausted”. If that happens, you can view the optimal solution in the spreadsheet. After solving the problem by Excel Solver, the spreadsheet numbers change to the optimal solution.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