■ RICK HESSE, Feature Editor, Pepperdine University

Transportation Model Reports for Excel

Rick Hesse, Feature Editor

The standard transportation problem formulated as a spreadsheet model to be optimized by the Solver add-in has many advantages in terms of setup and solution for teaching. However, I have always been frustrated trying to get some form of report for the standard Transportation model that would be informative to a manager instead of a mathematician. The standard assignment model is a very simple model to have the report written automatically because there is only one assignment per row and the value of the assignments are 0s and 1s. But the transportation model will have more than one shipment for one or more rows and the values aren't 0 and 1.

Excel Transportation Model

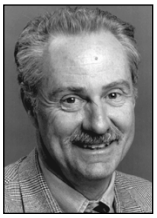
The data for the standard transportation model for three plants (Denver, Atlanta and New York) shipping to three warehouses (Tucson, Miami and San Diego) as well as the inventory (Storage) is given in rows 3-7 in Figure 1. It is a balanced problem (Supply = Demand) and a total of 300 units must be left at one or more of the plants. The optimal solution, using the Solver included with Excel from Frontline Systems is also shown.

A surprise is that the extra production is stored in New York, even though the cost ($0.80) is over twice as much as keeping the extra production in Denver ($0.30) or Atlanta ($0.20). But because the cost of shipping out of New York to all the other locations is so high, it is better to keep the extra production in New York than the other two plants.

The key cell formulas and range names are given below.

Cell Formulas:
F10: =**SUM**(B10:E10) copy to F11:F12
B13: =**SUM**(B10:B12) copy to C13:E13
F13: =**SUMPRODUCT**(***COST***,***SHIP***)
Range Names:
FROM: A4:A6; TO: B3:E3
COST: B4:E6; SHIP: B10:E12

Figure 2 gives the Solver setup showing that all seven constraints are equalities, with 12 variables and the total cost to be minimized.



Rick Hesse
is professor of quantitative methods at Pepperdine University in the Graziadia Graduate School of Business. He received his BS, MS, and DSc at Washington University School of Engineering in applied math and computer science. Dr. Hesse is the author of Managerial Spreadsheet Modeling & Analysis *and* Applied Management Science: A Quick & Dirty Approach *(with Gene Woolsey), articles in numerous journals, and software for personal computers. Rick was the first professor to be awarded the Outstanding Civilian Service Medal by the Department of the Army at West Point in 1982, and was the winner of the Decision Sciences Institute's Innovative Instructional Award in 1981.*

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	A	B	C	D	E	F	G
1	TRANSPORTATION PROBLEM						
2	Shipping			$/UNIT			
3		Tucson	Miami	San Diego	Storage	Supply	
4	Denver	$0.80	$3.10	$1.00	$0.30	1,800	
5	Atlanta	$1.60	$0.50	$2.80	$0.20	1,900	
6	New York	$2.30	$1.20	$4.20	$0.80	1,300	
7	Demand	2,000	1,500	1,200	300	5,000	
8				Shipping Allocations			
9		Tucson	Miami	San Diego	Storage	Used	Supply
10	Denver	600		1,200		1,800	1,800
11	Atlanta	1,400	500			1,900	1,900
12	New York		1,000		300	1,300	1,300
13	Used	2,000	1,500	1,200	300	$5,610.00	<== Min Cost
14	Demand	2,000	1,500	1,200	300		

Figure 1: Transportation spreadsheet model.

Transportation Report

For those of us who are used to matrices, it is a fairly simple matter to read off the solution—but it is not very user-friendly. What is more desirable is a report like the one shown in Figure 3. Such a report can certainly be created "manually"—that is, each entry needs to either be typed in or just "point and click" to the labels and values. The last column is a simple formula multiplying the number of cases times the cost per case. The Total formulas are also simple sums.

But the challenge has always been to find a way to at least set up a semi-automatic report. To do this, I have used the **INDEX** and **MATCH** functions in Excel in conjunction with the defined range names.

C18: =INDEX(*SHIP*,MATCH(A18, *FROM*,0),MATCH(B18,*TO*,0)) copy to **C19:C23**

D18: =INDEX(*COST*,MATCH(A18, FROM,0),MATCH(B18,*TO*,0)) copy to **D19:D23**

E18: =C18*D18 copy to **E19:E23**

The **INDEX(*range,row,column*)** function returns the value in ***range*** found in the specified ***row*** and ***column***. Thus **INDEX(*SHIP,1,1*)** returns the value 600. To determine which row and column is desired, the **MATCH(*value,range,0*)** function searches the specified ***range*** for an exact (the ***0*** is the code for that) match of the specified ***value***. In this case, the value is the name of the plant or wholesaler. The use of the ***0*** code in the **MATCH** function allows the list in the range not to have be ordered alphabetically. By using these two functions, then for any size model the report can be written fairly quickly and painlessly. All that is needed is to "point and click" to the names for the supply and demand to put into columns A and B of the report. Incidentally, to show what range names have been defined in your current workbook, click on the arrow on the box with the cell reference (upper left of the screen) and the drop-down list will show all the range names. Highlight any one of them and Excel will automatically highlight that range (taking you to another worksheet if necessary).

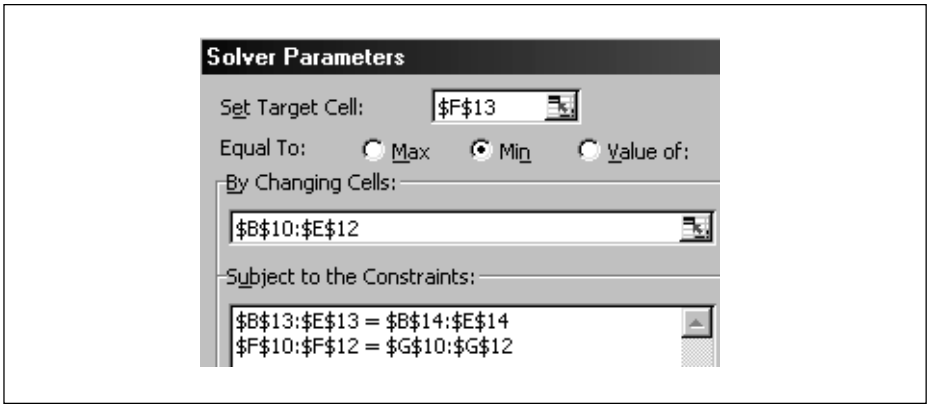
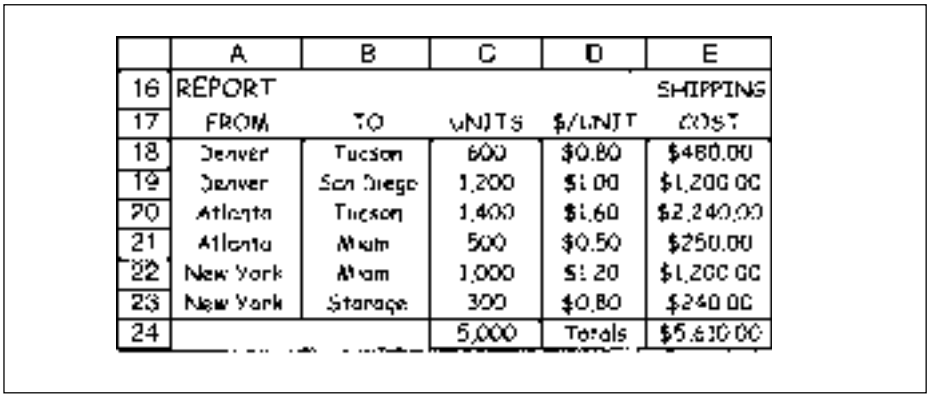


Figure 2: Solver setup for transportation model.



	A	B	C	D	E
16	REPORT				SHIPPING
17	FROM	TO	UNITS	$/UNIT	COST
18	Denver	Tucson	600	$0.80	$480.00
19	Denver	San Diego	1,200	$1.00	$1,200.00
20	Atlanta	Tucson	1,400	$1.60	$2,240.00
21	Atlanta	Miami	500	$0.50	$250.00
22	New York	Miami	1,000	$1.20	$1,200.00
23	New York	Storage	300	$0.80	$240.00
24			5,000	Totals	$5,410.00

Figure 3: Transportation model report.

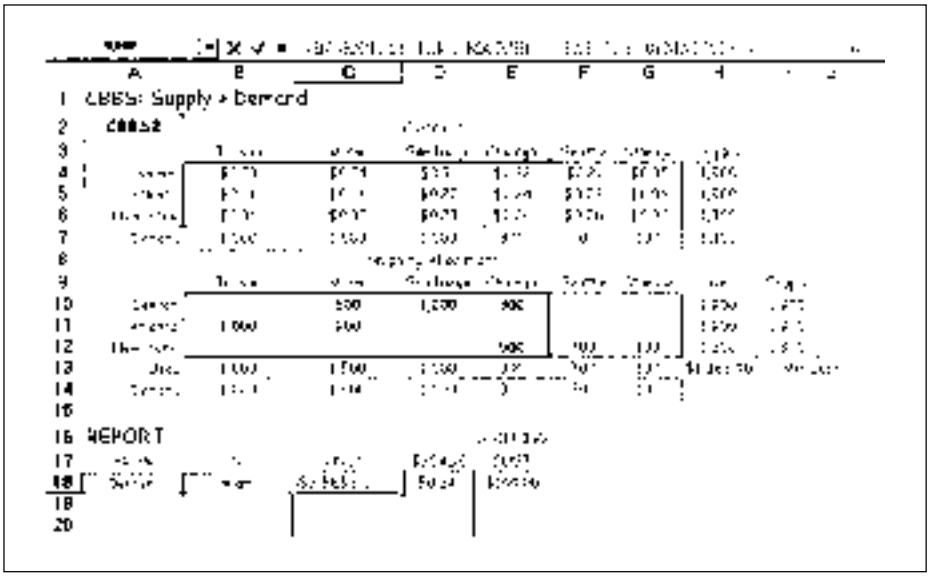


Figure 4: Edit function in Excel.

One of the problems with using range names is that the formulas will not redefine themselves for another model worksheet in the same workbook with a transportation model of different size (number of rows and/or columns). And if the ranges are redefined for one worksheet, they are redeifined for all the other worksheets in that workbook.

The cell formulas can be written using just the cell references (shown below):

C18: =INDEX($B$10:$E$12, MATCH(A18,$A$4:$A$6,0), MATCH(B18,$B$3:$E$3,0))

D18: =INDEX($B$4:$E$6, MATCH(A18,$A$4:$A$6,0), MATCH(B18,$B$3:$E$3,0))

Now when these formulas are copied over to another worksheet for a model with a different number of plants or warehouses, it is a simple matter to use the edit function in Excel for cell **C18** to resize the areas for the **INDEX** and **MATCH** functions, as shown in Figure 4. Just click on cell C18, then click inside the edit bar at the top of the screen and magically all the cell references in the formula are outlined.

Although you cannot see the colors in this article, Excel color codes each cell reference, so that the shipping range (B10:E12) is blue and the outline around that range is blue. Instead of retyping the cell reference, you can grab the lower right corner of the outline with the mouse and pull it up, down, left or right and resize the area that you want and then press **<Enter>**. If the rectangle is not in the proper upper left-hand corner, you can grab any side of the rectangle with the mouse and place the rectangle where desired and then resize it. This is an extremely useful way of editing formulas and a great time-saving device for spreadsheet users. In similar fashion we can resize the cell reference area in **B3:E3** and the reference to **A4:A6** needs no changing. The same process is repeated for the cost per case in cell **D18**. Once those two formulas are "resized" we can copy them down as needed for any new model. Armed with just one example template, students can quickly set up this semi-automatic report for any similar transportation model.

See **Classroom**, page 12

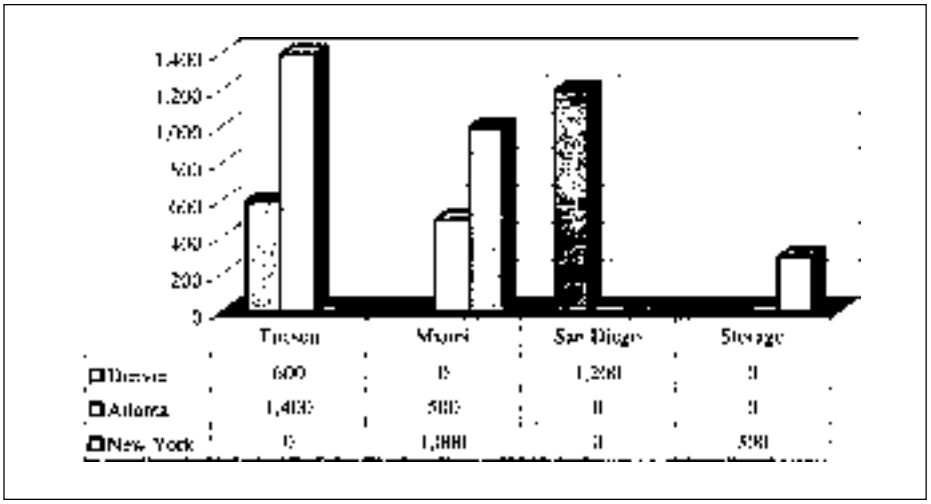


Figure 5: Column graph with data table.

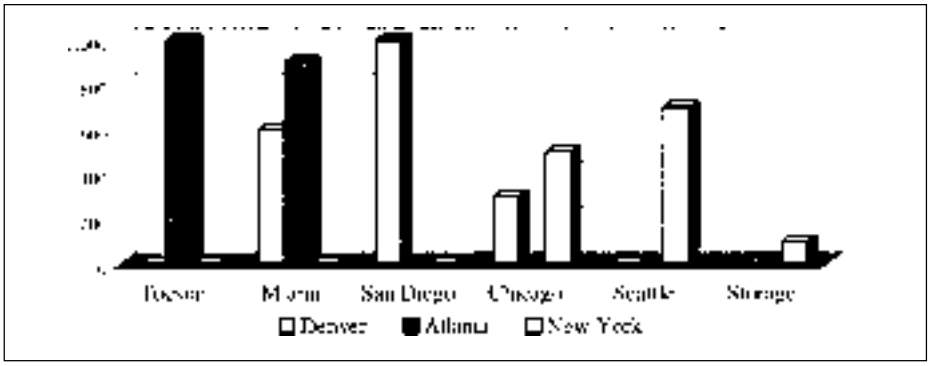


Figure 6: Black and white graph for larger transportation problem.

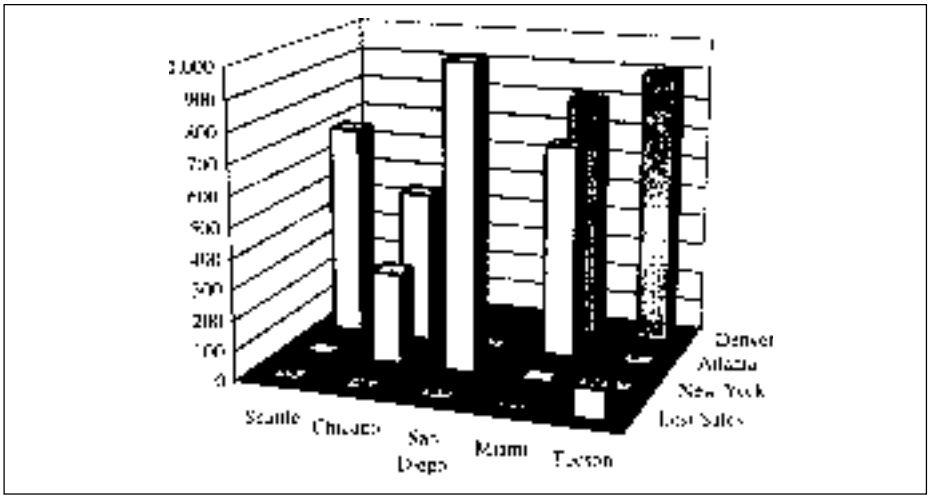


Figure 7: 3D graph of transportation model results.

To avoid misunderstandings, students should discuss co-authorship arrangements with their advisors well in advance of the completion of the dissertation. A well-chosen advisor should have little difficulty relating to the student's need to clarify ownership and responsibility for manuscripts emanating from the dissertation.

In general, how should the order of authorship in co-authored work be determined?

Put the project initiator and leader first.

This criterion acknowledges the importance of vision and direction on a project. On papers initiated by students (e.g., course papers or dissertations), I believe that first authorship should go to the student. However, there are several additional criteria to consider:

- Alternate the order of authorship on multiple papers. This criterion works for a team that will share work equally across multiple articles.
- Place the authors in alphabetical or random order. These criteria usually are selected when contributions are equal and where the authors cannot determine other criteria to apply.
- Put senior faculty first, followed by junior faculty and students. This criterion bestows first authorship on people who enjoy a higher social position, independent of their contributions to the work. I personally think that first authorship should be earned, not bestowed, so I do not favor this criterion.
- Give first authorship to the person who needs a publication the most. This criterion introduces a selfish motive and a logical flaw. We could all argue that we need first authorship because it does more for us to have our names first than to have a co-author's name first. First authorship should not be a charitable contribution by any author to another, so find another criterion that makes more sense.

What should my research priority be in the first year after getting my Ph.D.?

You should prepare two manuscripts from your dissertation for submission to top journals. At least one of these should be solo-authored.

The importance of "mining" your dissertation cannot be overemphasized. Although you may be tired of the dissertation after spending two to three years with it, you must shape it into the form of journal articles soon after your defense is completed. The dissertation is probably the most carefully supervised work you will ever do, and it would be a shame not to take advantage of the extensive feedback you have received.

Many students seek new projects with new colleagues when they take their first academic positions. I recommend against making binding commitments to new work before the old work is complete. You can discuss possible future work with your new faculty colleagues, but you need most of your research time in your first year in a new position to convert your dissertation into published articles.

Should my publication strategy in the years following my studies emphasize quality or quantity?

Quality.

You can fulfill all of your professional ambitions with a series of premier journal articles, and your colleagues will recognize you for it. A portfolio filled with large numbers of articles in obscure journals is valued less than a portfolio with three, four or five outstanding articles in recognized top-tier journals. Clearly, not everything you write will end up in premier journals. But premier journals should be your main target.

I am sure doctoral students have many more questions than the eight that I have posed on their behalf. My answers to these questions should not be taken as the only correct answers, and I do not assume that all doctoral students are the same and need the same advice. One's individual advisor may be able to provide deeper insights into a particular student's situation. Nonetheless, having pledged not to waffle on my advice, the answers given above are direct and reflect the collective concerns of many students in many different academic settings. ■

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Graphical Report

The shipping pattern and labels found in **A9:E12** in Figure 1 makes a good candidate for a graphical report, and there are several good options. The first works well when there are only a few rows and columns and includes a table of the shipments and is shown in Figure 5. This is a color column graph (option #4) with a data table.

The inclusion of a Data Table with the graph may not be as attractive when the names of the supply and demand cities are longer, or there are too many rows or columns (more than 5). When the model has a few rows and many columns, then the column graph without the data table is a good option. At that point, the colors may be a bit confusing, and so if black is chosen along with some patterns, it is not a bad choice. Figure 6 shows such a graph for a problem with 3 Plants by 6 Warehouses. This could be accompanied by the semi-automatic report instead of a data table.

A final option is to choose the 3D column graph (option #7) for problems with a moderate number of rows and columns, as shown in Figure 7 for a third Transportation model example. The only problem with this option is that some columns can get hidden behind taller ones in front. The 100 units of Lost Sales at Tucson are hidden in the back corner unless the series are reversed under the graph options. ■