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Solver and Backsolver
New additions to the manager's computerized tool kit

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ABSTRACT
This article describes and illustrates the use of two spreadsheet problem-solving tools—Solver and Backsolver. These tools are available in high-end software spreadsheet packages such as Lotus 1-2-3 for Windows and Excel for Windows. The illustrations and examples provided in this article use 1-2-3 for Windows and Windows 3.1 as the operating platform. Any business owner using a DOS based operating system and the Windows Graphical User Interface has access to the Solver and Backsolver.

Both tools utilize a form of what-if analysis. Traditional what-if analysis requires that the business owner manually alter the contents of a spreadsheet cell and observe the effects on other dependent cells. This is a trial and error approach, whereas Solver and Backsolver work from the other direction by asking the business owner to specify a goal. The Solver and Backsolver will automatically adjust one or more input cells in order to reach the goal.

HISTORY
Solver and Backsolver borrow from the academic fields of management science and operations research. Management science and operations research utilize mathematical techniques to help managers analyze decisions in a rational and scientific manner. Solver and Backsolver are not substitutes for the judgment and experience of management. The Solver and Backsolver techniques do not make decisions or solve problems by themselves. They can aid the business owner by providing automated analysis of certain types of business problems. Solver uses the mathematical techniques of linear and nonlinear programming. Linear or nonlinear programming uses optimization techniques to allocate scarce resources between competing products or projects in order to maximize profits or minimize costs.
The methodology behind mathematical optimization was developed in the late 1940s by the U. S. Military. Air Force strategists used mathematical optimization techniques to prepare cold-war planning models that would allocate America's remaining resources in the event of a nuclear exchange with the Soviet Union.

In the 1950s, mathematical optimization became widely popular in American industry, although even modest-size problems required the computing power of the mainframes of the time. The development of powerful desktop computers in the 1980s has greatly broadened the application of optimization techniques. Today optimization is used in everything from personnel planning to mass mailings. Many managers have begun to use mathematical optimization to help allocate their capital budgets to different projects. On Wall Street, investment bankers use it to create the best possible portfolios.

The types of problems Solver can address include:

*Production Planning with Limited Resources.* This problem is essentially a linear programming problem. The basic purpose of linear programming is to help the manager decide how to allocate scarce resources among competing products. The problem is this: How many units of products A and B (or more) should be made in order to maximize profits?

*Cash Flow Planning.* This problem involves optimally dividing cash among various projects or products in order to maximize income over a selected period of time.

*Maximizing Return on Investment.* This problem involves analysis of alternative investment strategies in order to obtain the highest possible return. Asset appreciation, risk, diversification, before-and-after tax yields, and maximum-minimum investment objectives per asset are variable common to this type of problem.

*Staff Allocation Problems.* This problem involves allocation of human resources in order to minimize the staffing needs. The objective is to minimize the number of staff employed while still meeting the needs of the business. Variables include staff needed, staff scheduled, consecutive days worked, and number of staff who start work on a given day.

*Warehouse Inventory and Shipping Cost Problems.* This type of problem involves distribution of inventory from warehouse locations to various retail outlets. The objective is to minimize the shipping costs and shipping distances while meeting the retail inventory needs and not exceeding available warehouse inventory.

*Mortgage and Loan Determination Problems.* This problem involves determining real estate purchase prices and bank loans. Constraints included in this type of problem include the amount of down payment required, debt to annual income, principal, insurance, taxes, and interest as a percentage of annual income, and down-payment as a percentage of purchase price.

Solver is a more sophisticated tool then Backsolver. Solver can determine values for multiple cells, optimize a particular cell, and allow the business owner to use multiple constraints.
The types of problems Backsolver can address are relatively simple. Provide Backsolver with the answer wanted and Backsolver will calculate what input values are needed in order to find the answer. For example, to find the loan amount that will result in a monthly mortgage payment of $1,000, provide Backsolver with the goal of $1,000. Backsolver will provide the loan amount that results in a monthly mortgage payment of $1,000. Remember that Backsolver solves for only a single value.

Solver Conceptual Model Formulation

Solver spreadsheet model formulation utilizes the concepts of adjustable cells, constraint cells, logical formulas, and optimal cells. Adjustable cells are values that Solver can change when it searches for answers. The Solver automatically changes the values in the adjustable cells in order to meet any constraints imposed by the business owner. Adjustable cells cannot be blank or contain formulas or labels. Adjustable cells should not be protected. Constraint cells are cells containing formulas that return (1) true or (2) false depending on whether the conditions were met. Examples of logical formulas include: -t-A1>=$5000.00,-HProfit>=$10,000, (Profit would be a given spreadsheet cell stipulated as a range name). The Solver will not allow the use of compound logical formulas such as #AND#, #NOT#, or #OR# placed in one cell. The compound formula -t-C1>=1000#AND#C1<=2000 should not be placed in a single cell. A compound formula must be entered as two separate formulas in separate cells. The formulas +C1>=1000 and +C1<=2000 are allowed provided they are entered in separate cells.

The optimal cell is the cell that returns the maximum or minimum answer. Solver uses maximum as the default setting. A click of the mouse button changes this setting to minimum. Lotus 1-2-3 for Windows provides a user dialog box accessed through the Lotus menu. Use the mouse to click Tools Solver and the dialog box appears as follows:

Worksheet: C:\123W\SOLVER\PROD.WK3
Adjustable Cells: A:C20..A:C21
Constraint Cells: A:E17..A:E19
Optimal Cell: A:D24 *Max 0 Min
Options... Solve Cancel

Enter the appropriate parameters for the adjustable, constraint, and optimal cells as stated in the above dialog box. Choose maximum for maximizing profits and Solver provides the answers in cells C20 and C21 along with the maximum optimal profit in cell C24. Solver should provide an answer of 20 units of coffee tables (A) and 30 units of end tables (B) at an optimal profit of $560.00
SUMMARY

Solver and Backsolver are problem solving tools utilizing management science techniques of linear and non-linear programming. The tools are available to the business owner using a DOS based personal computer with Windows as the graphical user interface. Solver and Backsolver are practical business tools that can be used to solve many different types of business problems.