DECISION MODELING WITH MICROSOFT EXCEL

Chapter 2

Spreadsheet Modeling

Part 2

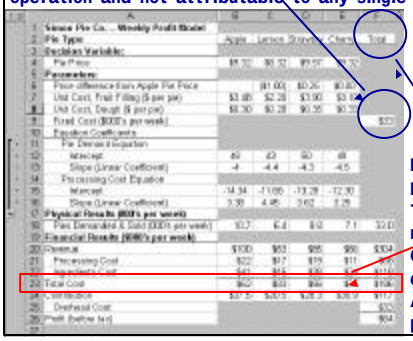
SPREADSHEET MODELING

Example 3: Simon Pies

- In addition to apple pies, Simon is considering expanding his business to begin producing and selling lemon, strawberry, and cherry pies.
- Since each pie product shares the same basic model form, each column in the spreadsheet model will be devoted to a different pie type.
- Start by copying the Apple Pie model to the new columns.
- Since no historic data exist, some parameter values for the new pie products are based on judgment.

Example 3: Simon Pies

Note that fixed overhead cost includes rent, interest expense, etc. and is now a fixed cost common to the entire operation and not attributable to any single pie type.

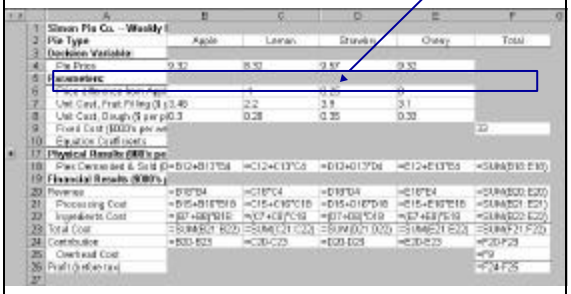


This cost was moved to the consolidated *Totals* column.

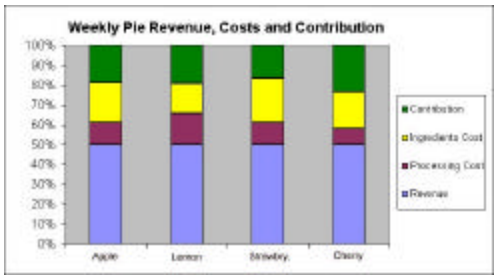
Because of this, Revenue minus Total Cost is now labeled *Contribution* to conform with Accounting practices.

Example 3: Simon Pies

Also note that pie *Price Difference* is given as a function of Apple pie price. This will facilitate sensitivity analysis of the multi-product model.



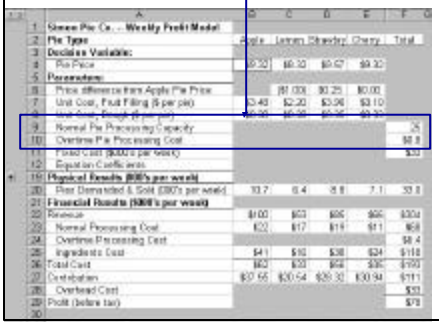
For easy comparison, use a Stacked Column chart in Excel to give the percentage breakdown of *Revenue*, *Costs* and *Contribution* of each pie type in the model.



SPREADSHEET MODELING

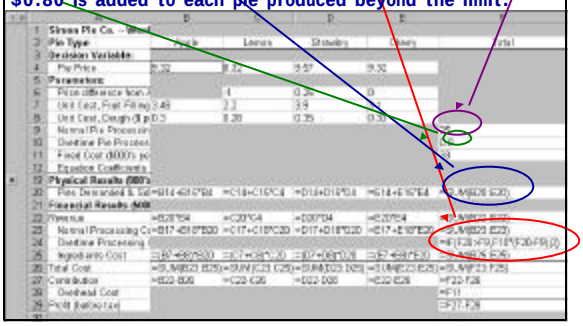
- After reviewing the model results, Simon decides that he will have to add a second shift in order to produce 33 thousand pies per week.
- However, adding a second shift will add overtime payments to his *Processing Cost*. Therefore, he must modify the model.
- After consulting his plant manager, he decides that if he introduces the new pie types, he will have capacity to produce a total of 25 thousand pies of any type per week.
- Production above that capacity limit will incur second shift overtime costs that will add $0.80 to the *Processing Cost* of any pies produced during a second shift.

Notice that there are 2 new parameters in this model: *Normal Pie Processing Capacity* (25 thousand pies) and *Overtime Processing Cost* ($.80 per pie).



Overtime Processing Cost uses an *IF* statement.

If total *Pies Demanded and Sold* is greater than the 25 thousand capacity limit, then an additional unit cost of $0.80 is added to each pie produced beyond the limit.



Sensitivity Analysis

After reviewing the previous results, Simon wonders:

- Can some of the overtime cost penalty be mitigated by raising pie prices, and thus reducing pie demand?
- What would the profit benefit be if Simon could find a way to raise *Normal Production Capacity* above the 25 thousand limit?

To do this sensitivity analysis, use Excel's *Data Table* command. This command allows you to systematically batch process whole collections of "What if?" projections at once and then tabulate their results into a rectangular array of cells.

Sensitivity Analysis

Simon is interested in the following:

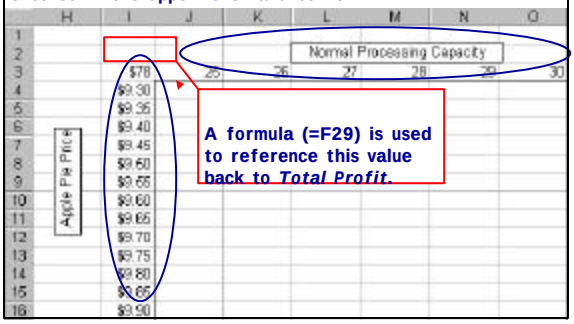
Performance Variable: *Total Profit* **
Decision Variable: *Apple Pie Price* **
Parameter: *Normal Processing Capacity* **

This lends itself well to the *Data Table 2* option which allows two ~~exogenous variables~~ to be varied over specified ranges but tabulates the results only for a single ~~endogenous variable.~~

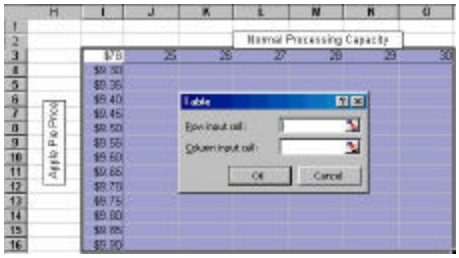
Remember, since all other pie prices are related to the Apple pie price, varying Apple pie price will affect the other pie prices according to their market price differences from the Apple Pie Price.

To begin, define the ranges of values for the two exogenous variables.

Note that a reference to a single performance measure is entered in the upper left hand corner.



Next, select all the cells in the rectangular range, I3:016, and choose the *Table* item from the *Data* pull down menu. This will result in a *Table* dialog.

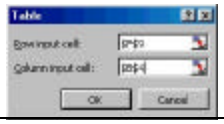


Now you must specify the Row and Column input cells.

For the Row Input, click on the button for the *Row input cell:* field. The *Table* dialog will collapse, allowing you to go to cell F9 and click on it.

This will automatically enter the absolute cell reference into the edit field. Click on the button to expand the dialog.

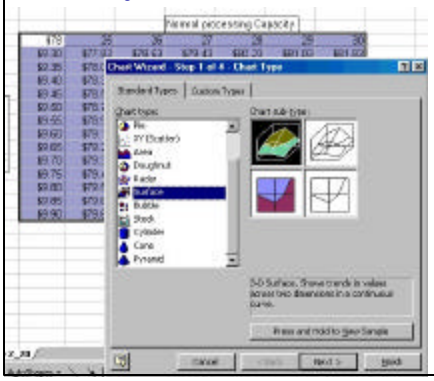
Now, move your curser to the *Column input cell:* edit field and repeat the above steps to specify cell B4 for this field.

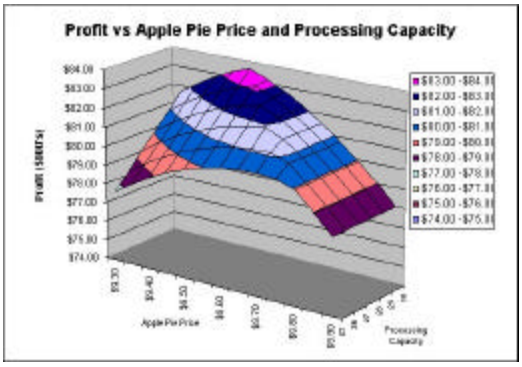


Now, click *OK* and Excel will use the input values in the Simon Pies model and re-calculate the worksheet, placing the resulting *Profit* value into the corresponding cell in the table.

	H	I	J	K	L	M	N	O
1								
2					Normal Processing Capacity			
3		$78	25	26	27	28	29	30
4		$9.30	$77.67	$78.47	$79.27	$80.07	$80.87	$81.67
5		$9.35	$78.31	$79.11	$79.91	$80.71	$81.51	$82.31
6		$9.40	$78.85	$79.65	$80.45	$81.25	$82.05	$82.85
7	Apple Pie Price	$9.45	$79.31	$80.11	$80.91	$81.71	$82.51	$83.31
8		$9.50	$79.69	$80.49	$81.29	$82.09	$82.89	$83.63
9		$9.55	$79.98	$80.78	$81.58	$82.38	$83.18	$83.23
10		$9.60	$80.18	$80.98	$81.78	$82.58	$82.74	$82.74
11		$9.65	$80.29	$81.09	$81.89	$82.17	$82.17	$82.17
12		$9.70	$80.32	$81.12	$81.51	$81.51	$81.51	$81.51
13		$9.75	$80.27	$80.77	$80.77	$80.77	$80.77	$80.77
14		$9.80	$79.94	$79.94	$79.94	$79.94	$79.94	$79.94
15		$9.85	$79.02	$79.02	$79.02	$79.02	$79.02	$79.02
16		$9.90	$78.02	$78.02	$78.02	$78.02	$78.02	$78.02

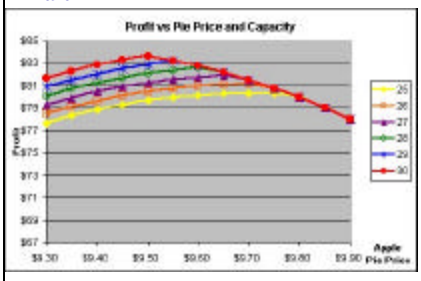
For graphical display, use Excel's Chart Wizard. Highlight the range of cells I3:016 and choose the *3-D Surface* chart type.





Interesting, but sensitivity analysis is difficult to see from the 3D chart contours.

An X-Y Scatter Chart is also created using the Chart Wizard.



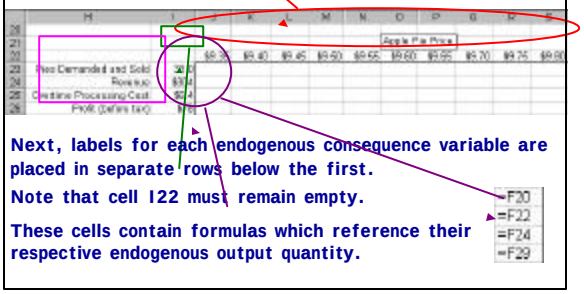
Simon should consider raising his *Apple Pie Price* from the previous value of $9.38 to at least $9.50 if *Normal Processing Capacity* is fixed at 25 thousand pies.

Also, for any given *Normal Processing Capacity* value above 27 thousand, *Profit* is relatively insensitive to *Apple Pie Price* for prices between $9.50 and $9.70.

Sensitivity Analysis

Now let's look at only one exogenous variable using the *Data Table 1* capability in Excel.

First, specify the values of the input variable in an empty row or column on a worksheet.

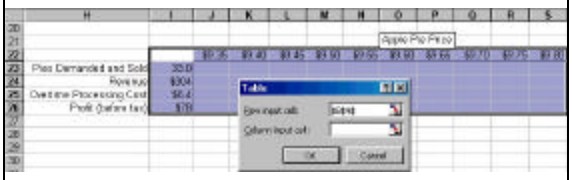


Next, labels for each endogenous consequence variable are placed in separate rows below the first.

Note that cell I22 must remain empty.

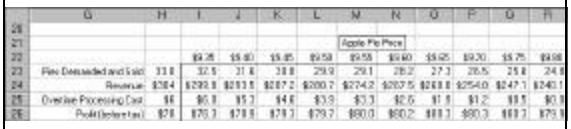
These cells contain formulas which reference their respective endogenous output quantity.

Select cells I22:S26 and then click on the ***Data*** pull down menu and select ***Table.*** In the resulting dialog, specify B4 as the ***Row Input cell:***



Click ***OK*** to tabulate each of the listed endogenous output variable values from the model.

The resulting table gives the ***Total Pies Demanded***, ***Total Revenue***, ***Overtime Processing Cost*** and ***Profit*** for various apple pie prices.



Simon can see that, unless he can raise ***Normal Processing Capacity*** (from 25 thousand), he must raise ***Apple Pie Price*** (and thus other pie prices) if he wishes to reduce his overtime processing costs.

SPREADSHEET MODELING

Example 4: XerTech Copy, Inc.

Emily and Bill Peterson want to start a company which will place heavy duty coin and smart card operated copiers (which they will lease) in libraries, universities, high schools, shopping malls, etc.

Costs for this business include:

- lease cost
- other expenses of the copier
- space rent fee
- incentive payments (optional)

SPREADSHEET MODELING

Emily and Bill have made the following assumptions:

# Copiers Leased	40
Copies/Month/Copier	30,000
Price Charged/Copy	$.05
Variable cost/Copy	$.03
Monthly Copier Space Rental Rate	$150
Other Monthly Expenses:	
Lease Cost of Each Copier	$250
Coin Collection Labor/Copier	$35
Misc. Fixed Costs/Copier	$50

SPREADSHEET MODELING

Using these assumptions, develop a spreadsheet model.

	A	B	C	D	E
1	**XerTech Copy Inc.**				
2	Average Monthly Expense/Copier		No. of Copiers Leased	40	
3	Monthly lease Cost	$250.00			
4	Copier Service Cost	$35.00	Price charged/Copy	$0.05	
5	Other Fixed Cost	$50.00	Variable Cost/Copy	$0.03	
6	Fixed Expense/Copier	$335.00	Contribution Margin	$0.02	
7	Space Rental Rate	$150.00			
8					
9	Copies/Month/Copier	30,000			
10	Monthly Income				
11	Revenue	$90,000			
12	Cost of Goods Sold	$35,000			
13	Contribution Margin	$24,000			
14	General & Admin. Costs	$19,400			
15	Net Income	$4,600			
16					

Here are the formulas associated with the spreadsheet model.

	A	B	C	D	E
1	**XerTech Copy Inc.**				
2	Average Monthly		No. of Copiers Leased	40	
3	Monthly lease Cost	250			
4	Copier Service Cost	35	Price charged/Copy	0.05	
5	Other Fixed Cost	50	Variable Cost/Copy	0.03	
6	Fixed Expense/Copier	=SUM(B3:B5)	Contribution Margin	=D4-D5	
7	Space Rental Rate	150			
8					
9	Copies/Month/Copier	30000			
10	Monthly Income				
11	Revenue	=$D$2*B9*$D$4			
12	Cost of Goods Sold	=$D$2*B9*$D$5			
13	Contribution Margin	=B11-B12			
14	General & Admin.	=$D$2*(B9$6+$B$7)			
15	Net Income	=B13-B14			
16					

SPREADSHEET MODELING

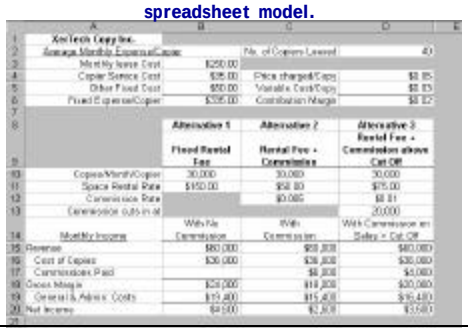
Now, the Peterson's are considering offering the following copier space rental payment options :

- fixed monthly space rent of $150/copier/month
- lower space rent plus a per copy commission payment for each copy made.
- fixed monthly rent plus a per copy commission payment, paid only for the portion of the monthly volume that exceeds a predetermined cutoff.

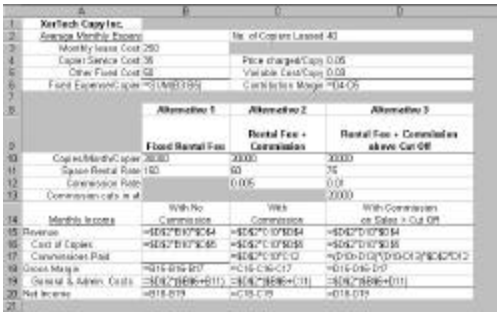
Let's examine how these alternative rental schemes will affect the break even volumes.

SPREADSHEET MODELING

To do this, present one alternative per column in the spreadsheet model.

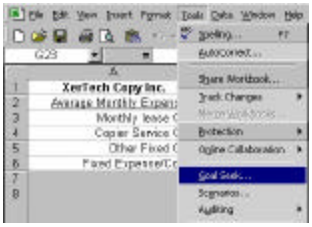


Formulas used for this spreadsheet model:



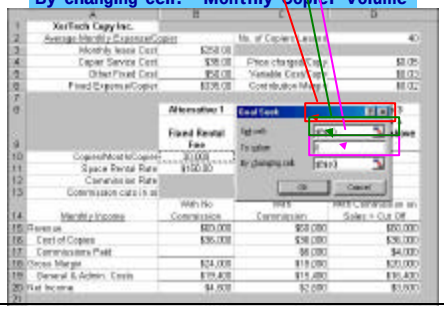
Use Excel's *Goal Seek* command to find the break-even value for *Copies per Month per Copier*.

Go to the *Tools* pull down menu and select *Goal Seek*

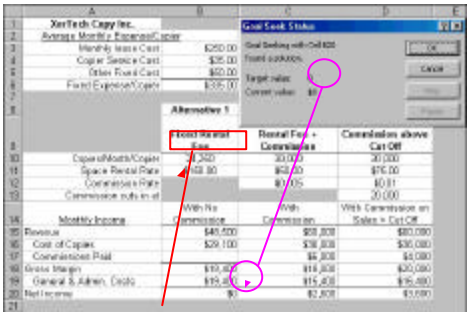


In the resulting dialog, specify the cell location for:

Edit Field	Value Represented by
Set cell:	Net Income
To Value:	break-even value of 0
By changing cell:	Monthly Copier Volume



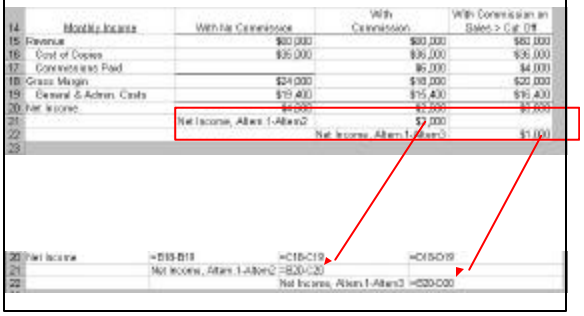
Click *OK* to perform a systematic iterative search of Alternative 1 for different values of *Monthly copier Volume* in order to achieve a break-even value of *0*.



The resulting break-even volume is 24,250 copies/month/copier.

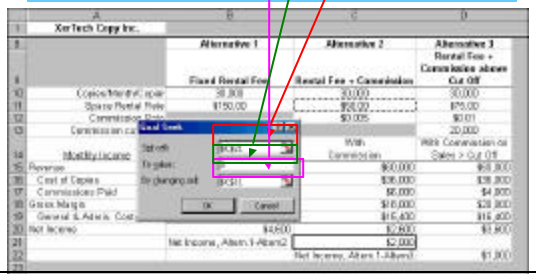
The same method of *Goal Seek* is applied to Alternative 2 and 3 for the following results:

Now, subtract the *Net Income* of Alternative 2 and the *Net Income* of Alternative 3 from that of Alternative 1 to examine the points of indifference in *Net Income* across the three alternatives (i.e., where the difference =0).

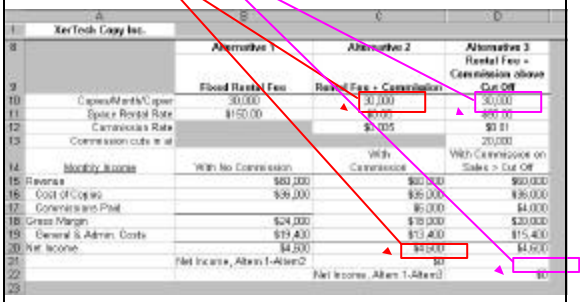


Goal Seek can again be used to find the point of indifference for Alternatives 2 and 3. Specify:

Edit Field	Value Represented by
Set cell:	Net Income, Altern. *i* – Altern. *j*
To Value:	Indifference value of 0
By changing cell:	Space Rental Rate



The results of *Goal Seek* for the points of indifference for Alternatives 2 and 3 are:



SPREADSHEET MODELING

The Art of Modeling

In setting up the model, you must anticipate the kinds of analyses you intend to do and pay attention to the layout of the model in order to produce a model that is:

- Logically Correct
- Presents major alternatives for comparisons
- Suitable for the manipulations necessary for analysis
- Easily understood by others
- Pleasing to the eye

SPREADSHEET MODELING

The Art of Modeling

Basic rules for creating good spreadsheet models:

1. Clearly define and label all variables
2. Clearly identify model inputs, decisions and parameters
3. Clearly identify model outputs, performance measure(s) and consequence variables
4. Do not "hard wire" parameter values into formulas; store in separate cells
5. Separate variables giving physical quantities from those that reflect them into accounting or financial consequences.
6. Use formatting option of Excel to improve appearance of model

SPREADSHEET MODELING

Example 5: Oak Products, Inc.

Oak Products, Inc. produces a line of high-quality solid oak chairs which use interchangeable component parts.

Product Line
Captain
Mate
American High
American Low
Spanish King
Spanish Queen

Interchangeable Parts
Long dowels
Sort dowels
Heavy seats
Light seats
Heavy rungs
Light rungs

In addition each type of chair has a distinguishing rail that caps the back.

SPREADSHEET MODELING

A production plan for the next week needs to be finalized.

Keep in mind that the finishing activity includes sanding, spraying and drying the component parts and takes one week.

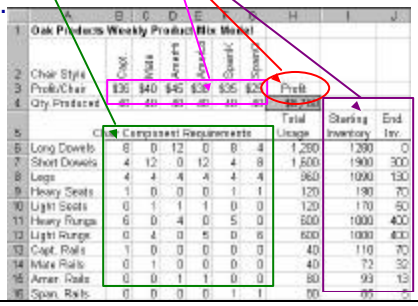
Therefore, only components that are already on hand and finished can be used in chairs that will be produced in the next week.

A spreadsheet for the production model was developed.

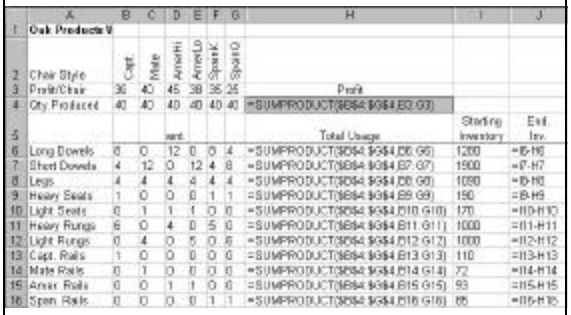
A spreadsheet for the production model was developed.

The plan is to produce 40 chairs of each type, yielding a total weekly profit of $8,760.

The number of component parts for each chair are give in the table as well as the starting and ending inventory of finished pieces.

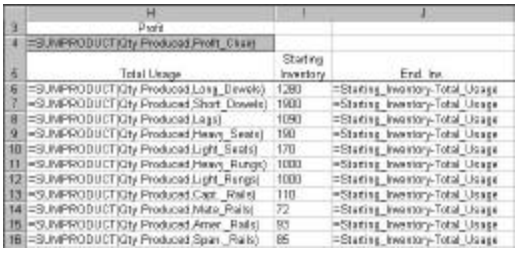


Here are the spreadsheet formulas:



Notice the use of the SUMPRODUCT function which multiplies each pair of corresponding cells in its argument and then adds up the resulting products.

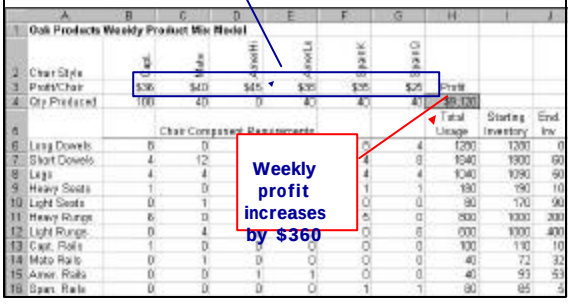
This spreadsheet illustrates Excel's *Naming* capability.



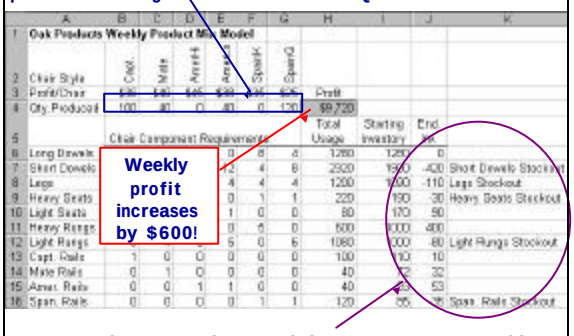
Naming a range (a group of adjacent cells) improves documentation and makes the named variable available to all worksheets within a workbook.

To name a range, highlight the adjacent cells, click on the *Insert* pull down menu and choose *Name – Define*. Specify the desired name for the range of cells or accept the default name.

Now, because of an increase in demand for solid wood chairs and a limited number of long dowels, what combination of chairs should be produced in order to maximize profit?

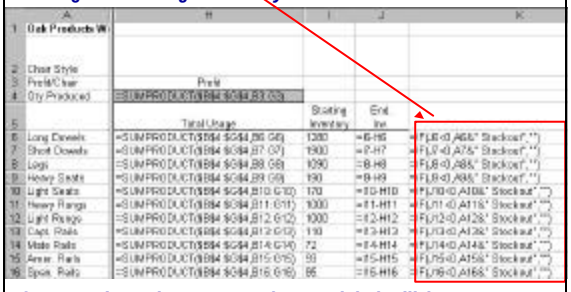


In addition to these changes, what would happen if we produced no Kings and a total of 120 Queens?



However, there won't be enough inventory to support this plan.

Notice that an IF statement is used to display a message if a negative *Ending Inventory* occurs.



If a negative value occurs, the row label will be concatenated (& symbol) with the word *Stockout* and the resulting text string displayed in the cell. Otherwise, the cell is left empty.

SPREADSHEET MODELING

Constraints and Constrained Optimization

To make the weekly profit as large as possible, the model becomes an optimization model.

In this case, it becomes a constrained optimization problem (a problem in which you want to maximize or minimize some performance measure subject to a set of constraints).

Constraint: a limitation on the range of allowable decisions

- Limited quantities of parts to produce chairs
- Time
- Import quotas
- Money (budget)
- Factory capacities
- Capital requirements
- Inventory costs
- Personnel
- Union work rules
- Delivery schedules
- Environmental regulations

Constraints and Constrained Optimization

The optimal solution to Oak Product's problem is given below.

	A	B	C	D	E	F	G	H	I	J
1	Oak Products Weekly Product Mix Model									
2	Chair Style	Capt.	Mate	Armet#1	Armet#2	Spank	Spank2			
3	Profit/Chair	$36	$40	$45	$38	$35	$25	Profit		
4	Qty Produced	100	72	40	53	0	0	$10,294		
5		Chair Component Requirements						Total Usage	Starting Inventory	End. Inv.
6	Long Dowels	8	0	12	0	6	8	1260	1380	0
7	Short Dowels	4	12	0	12	4	8	1900	1900	0
8	Legs	4	4	4	4	4	4	1060	1090	30
9	Heavy Seats	1	0	0	0	1	1	100	190	90
10	Light Seats	0	1	1	1	0	0	165	170	5
11	Heavy Rungs	6	0	4	0	5	0	750	1000	240
12	Light Rungs	0	4	0	5	0	6	553	1000	447
13	Capt. Rails	1	0	0	0	0	0	100	110	10
14	Mate Rails	0	1	0	0	0	0	72	72	0
15	Armet. Rails	0	0	1	1	0	0	93	93	0
16	Spank. Rails	0	0	0	0	1	1	0	65	65

This solution was found using a restricted version of Solver. This method will be covered at a later time.