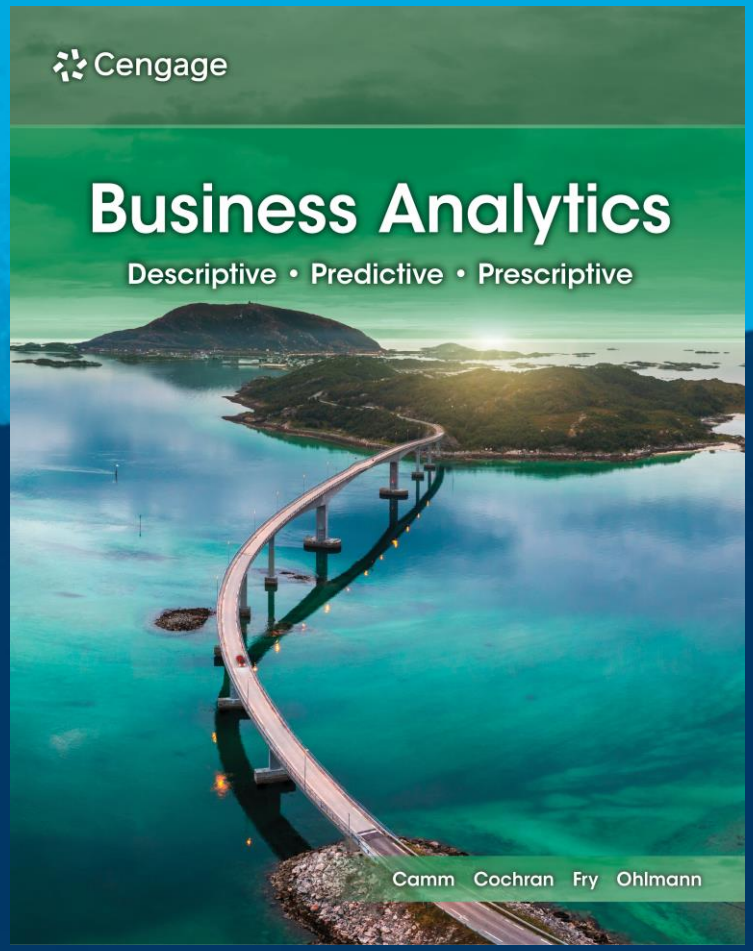

Business Analytics, 5e

Chapter 12 – Spreadsheet Models

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Chapter Contents

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Learning Objectives (1 of 2)

After completing this chapter, you will be able to:

LO 12-1 Construct an influence diagram of a problem and use it to construct a model.

LO 12-2 Build an Excel spreadsheet model of a business problem using formulas.

LO 12-3 Construct a one-way and two-way data table to quantify the impact of changing the value of one or two input variables on the value of an output variable.

LO 12-4 Conduct a break-even analysis in Excel.

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Learning Objectives (2 of 2)

LO 12-5 Use Goal Seek to solve for the value of an input variable that will result in a specified value of an output variable.

LO 12-6 Use Scenario Manager to quantify the impact of changing the values of multiple input variables on the value of one or more output variables.

LO 12-7 Use Excel functions such as SUM, SUMPRODUCT, IF, COUNTIF, and XLOOKUP and other Excel functions in a spreadsheet model.

LO 12-8 Use Excel's Formula Auditing Tools to audit a spreadsheet model and correct errors.

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Introduction

Spreadsheet models are mathematical, and logic-based models often referred to as **what-if models**.

Spreadsheet models are without question the most used business analytics tool because they

- provide easy-to-use, sophisticated mathematical and logical functions,
- allow for easy instantaneous recalculation of the output for a change in model inputs,
- are less expensive than specialized software packages,
- often come preloaded on computers, and
- are reasonably easy to use.

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12.1 Make-versus-Buy Decision

The total cost of manufacturing a product can be defined as the sum of two portions:

- The *fixed cost* does not depend on the production quantity and remains the same no matter how much is produced.
- The *variable cost* is the portion of the total cost dependent on and varies with the production quantity.

A **make-versus-buy decision** involves comparing the costs of manufacturing in-house to the costs of outsourcing production to another firm.

Let us consider a manufacturing problem Nowlin Plastics faces to illustrate how cost models can be developed.

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12.1 Nowlin Plastics

Nowlin Plastic, a producer of lines of cell phone covers, is considering outsourcing the production of the Viper, its best-selling cover.

- Total fixed cost of $234,000 includes management time, advertising, and other costs incurred regardless of the units eventually produced.
- Total variable cost of $2/unit produced includes labor and material costs.
- Nowlin has a bid from an outside firm to outsource production of the Viper for $3.50/unit with no associated fixed costs.
- The exact Viper demand for next year is not yet known.

Nowlin wants to compare the costs of manufacturing the Viper versus outsourcing its production to another firm for various production quantities.

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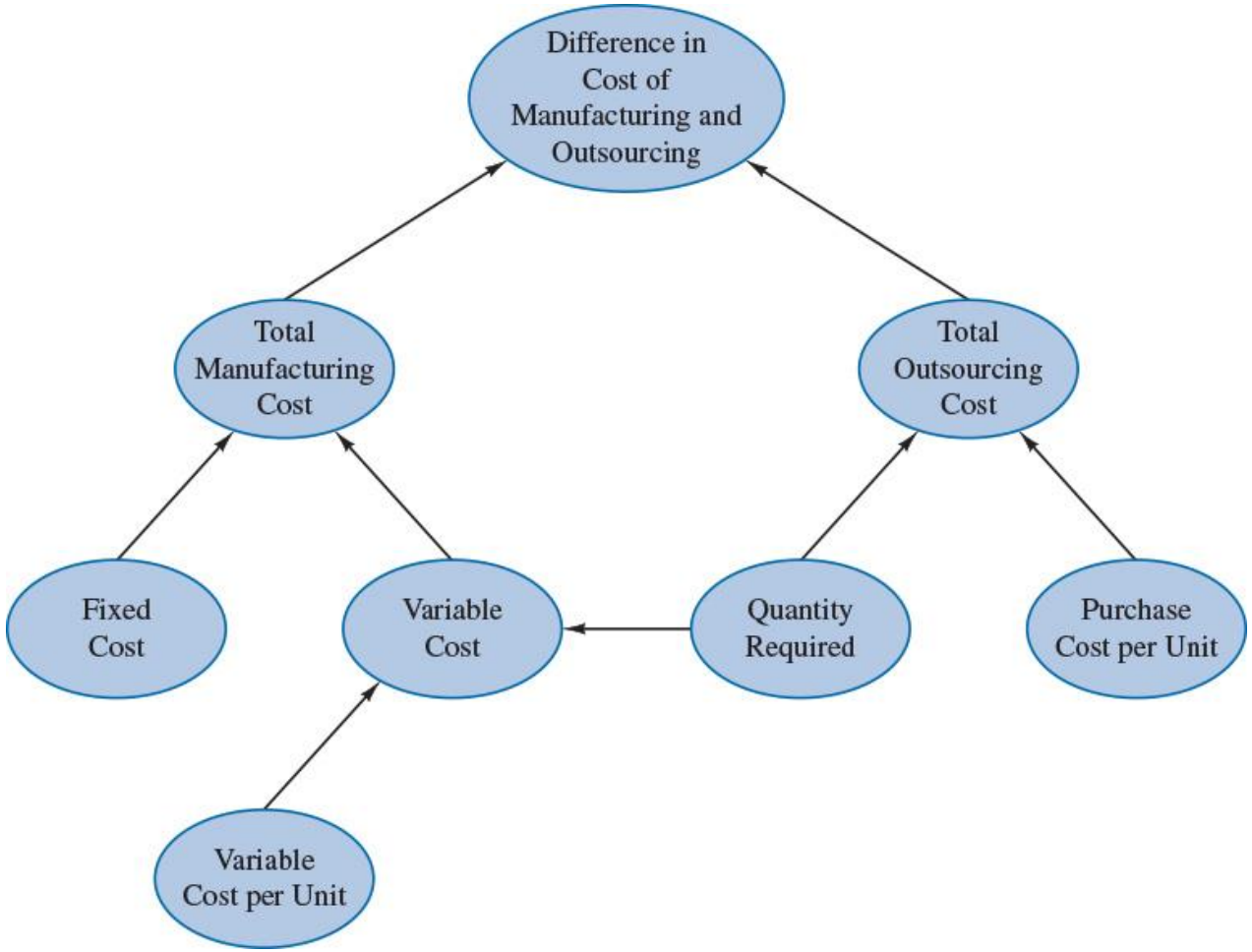
12.1 Influence Diagram for Nowlin Plastics

An **influence diagram** is a visual representation of which entities influence others in a model.

Influence in the model is depicted by the arrows connecting the *nodes* (oval symbols.)

The influence diagram to the right compares manufacturing versus outsourcing costs for Nowlin Plastics.

This modular approach simplifies the modeling process.



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12.1 Manufacturing Cost for Nowlin Plastics

As the influence diagram shows, the manufacturing cost is a function of the fixed cost, the variable cost per unit, and the quantity required. Thus, we have

q	quantity (number of units) required
$FC = \$234{,}000$	fixed cost of manufacturing
$VC = \$2/\text{unit}$	per-unit variable cost of manufacturing

The total cost to manufacture q units of the Viper can be written as

$$TMC(q) = FC + VC \times q = \$234{,}000 + \$2q$$

For example, a decision to manufacture 10,000 units results in a total cost of

$$TMC(10{,}000) = \$234{,}000 + \$2(10{,}000) = \$254{,}000$$

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12.1 Outsourcing Cost for Nowlin Plastics

Similarly, the outsourcing cost is a function of the production cost per unit and the ordered quantity. Thus, we have

q	quantity purchased
$P = \$3.50/\text{unit}$	per-unit purchasing (outsourcing) cost

The total cost to outsource q units of the Viper can be written as

$$TPC(q) = P \times q = \$3.5q$$

For example, the total cost to outsource 10,000 units is

$$TPC(10{,}000) = \$3.5(10{,}000) = \$35{,}000$$

We can now compare the two costs mathematically as a function of q.

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12.1 Savings for Nowlin Plastics

We can state mathematically the savings associated with outsourcing as the difference between $TMC(q)$, the total cost of manufacturing q units, and $TPC(q)$, the total cost of purchasing q units.

$$S(q) = TMC(q) - TPC(q)$$

Because management does not yet know the required demand, the key question becomes,

> "For what quantities is it more cost-effective to outsource than manufacture the Viper?"

Mathematically, this question can be stated as

> "For what values of q is $S(q) > 0$?"

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12.1 A Make-versus-Buy Spreadsheet Model

In the MODELfile: *nowlin*, we refer to the unknown quantity q as a **decision variable**, and the measurable factors FC, VC, and P as **parameters**.

We reserve column A for the title (cell A1) and the labels.

The spreadsheet's top portion includes the parameters (cells B4, B5, and B7.)

The model's bottom portion includes the decision variable (B11) and the various cost and savings formulas (B13, B15, and B17.)

	A	B	C
1	**Nowlin Plastics**		
2			
3	**Parameters**		
4	Manufacturing Fixed Cost	234000	
5	Manufacturing Variable Cost per Unit	2	
6			
7	Outsourcing Cost per Unit	3.5	
8			
9			
10	**Model**		
11	Quantity	10000	
12			
13	Total Cost to Produce	=B4+B11*B5	
14			
15	Total Cost to Outsource	=B7*B11	
16			
17	Savings due to Outsourcing	=B13-B15	
18			

	A	B
1	**Nowlin Plastics**	
2		
3	**Parameters**	
4	Manufacturing Fixed Cost	$234,000.00
5	Manufacturing Variable Cost per Unit	$2.00
6		
7	Outsourcing Cost per Unit	$3.50
8		
9		
10	**Model**	
11	Quantity	10,000
12		
13	Total Cost to Produce	$254,000.00
14		
15	Total Cost to Outsource	$35,000.00
16		
17	Savings due to Outsourcing	$219,000.00
18		

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12.1 General Principles of Spreadsheet Model Design and Construction

The following three general principles of spreadsheet model design and construction should always be followed:

- **Separate the parameters from the model**. We can update the model parameters without the risk of mistakenly creating an error in a formula.
- **Document the model and use proper formatting and color as needed**. A good spreadsheet model is well documented, has clear labels, and proper formatting and alignment facilitate navigation and understanding.
- **Use simple formulas**. We can reduce errors and make maintaining the spreadsheet easier by using clear and simple formulas. Long and complex calculations should always be divided into several cells.

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12.2 One-Way Data Table for Nowlin

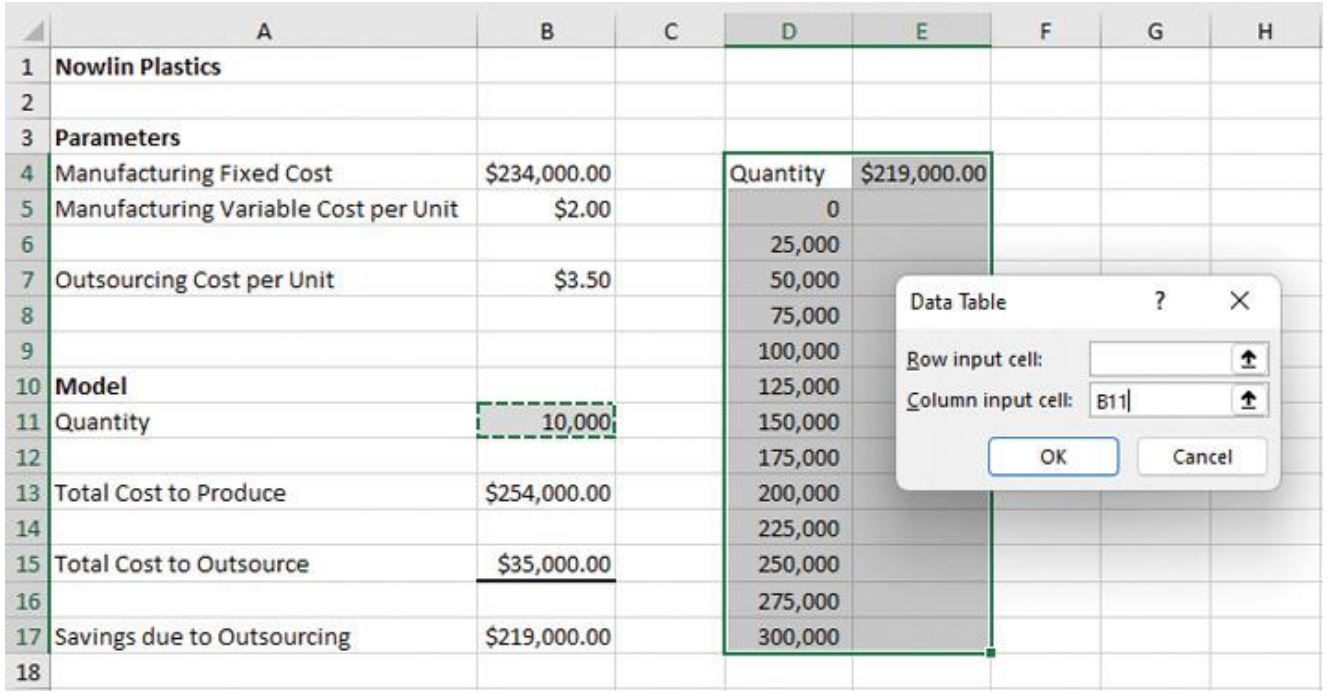
One-way data table is an Excel tool that quantifies the impact of changing the value of a *single* input on an output of interest.

In the example shown, we change the input quantity value from 0 to 300,000 units in 25,000 increments.

The output of interest is the savings due to outsourcing in cell B17.

MODELfile: *nowlin*

See the notes for instructions on building a one-way data table in Excel.



	A	B	C	D	E	F	G	H
1	**Nowlin Plastics**							
2								
3	**Parameters**							
4	Manufacturing Fixed Cost	$234,000.00		Quantity	$219,000.00			
5	Manufacturing Variable Cost per Unit	$2.00		0				
6				25,000				
7	Outsourcing Cost per Unit	$3.50		50,000				
8				75,000				
9				100,000				
10	**Model**			125,000				
11	Quantity	10,000		150,000				
12				175,000				
13	Total Cost to Produce	$254,000.00		200,000				
14				225,000				
15	Total Cost to Outsource	$35,000.00		250,000				
16				275,000				
17	Savings due to Outsourcing	$219,000.00		300,000				
18								

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12.2 Results of One-Way Data Table for Nowlin

A negative value for savings due to outsourcing means that manufacturing is cheaper than outsourcing for that quantity.

The results of the one-way data table show that

- at 150,000 units, the savings due to outsourcing is only $9,000,
- for quantities ≤ 150,000 units, outsourcing is cheaper than manufacturing, and
- for quantities ≥ 175,000 units, manufacturing is cheaper than outsourcing.

If the quality of the outsourcing firm is an issue, we consider this option only for quantities < 150,000 units.

Quantity	Savings
0	$234,000
25,000	$196,500
50,000	$159,000
75,000	$121,500
100,000	$84,000
125,000	$46,500
150,000	$9,000
175,000	−$28,500
200,000	−$66,000
225,000	−$103,500
250,000	−$141,000
275,000	−$178,500
300,000	−$216,000

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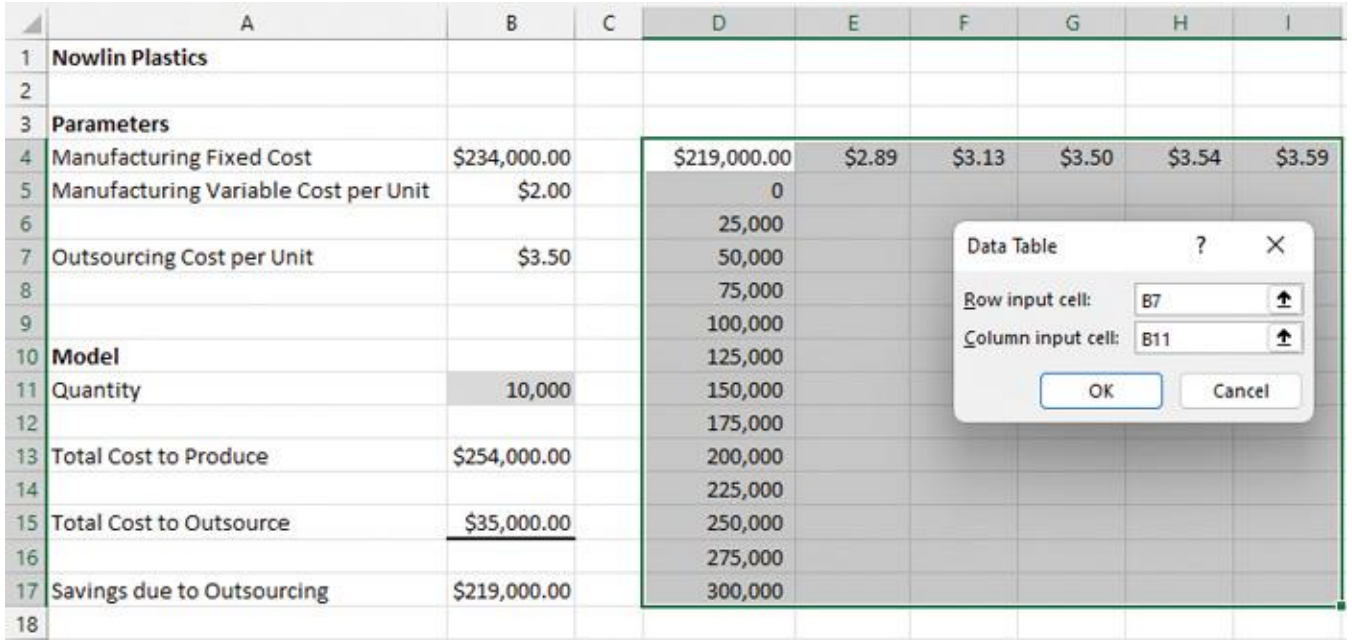
12.2 Two-Way Data Table for Nowlin

Two-way data table is an Excel tool that quantifies the impact of changing the value of *two* inputs on an output of interest.

Suppose that Nowlin has received five different bids on the per-unit cost for outsourcing the production of the Viper: $2.89, $3.13, $3.50, $3.54, and $3.59.

We can use the Excel Data Table to construct a two-way data table with quantity as a column and the five bids as a row.

See the notes for instructions on building a one-way data table in Excel.



	A	B	C	D	E	F	G	H	I
1	**Nowlin Plastics**								
2									
3	**Parameters**								
4	Manufacturing Fixed Cost	$234,000.00		$219,000.00	$2.89	$3.13	$3.50	$3.54	$3.59
5	Manufacturing Variable Cost per Unit	$2.00		0					
6				25,000					
7	Outsourcing Cost per Unit	$3.50		50,000					
8				75,000					
9				100,000					
10	**Model**			125,000					
11	Quantity	10,000		150,000					
12				175,000					
13	Total Cost to Produce	$254,000.00		200,000					
14				225,000					
15	Total Cost to Outsource	$35,000.00		250,000					
16				275,000					
17	Savings due to Outsourcing	$219,000.00		300,000					
18									

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12.2 Results of Two-Way Data Table for Nowlin

We now have a table that shows the savings due to outsourcing for each combination of quantity and bid price.

Manufacturing is better than outsourcing for the range of quantities and bid combinations that result in negative savings.

But what is the exact breakeven value?

Savings	Bids				
Quantity	$2.89	$3.13	$3.50	$3.54	$3.59
0	$234,000	$234,000	$234,000	$234,000	$234,000
25,000	$211,750	$205,750	$196,500	$195,500	$194,250
50,000	$189,500	$177,500	$159,000	$157,000	$154,500
75,000	$167,250	$149,250	$121,500	$118,500	$114,750
100,000	$145,000	$121,000	$84,000	$80,000	$75,000
125,000	$122,750	$92,750	$46,500	$41,500	$35,250
150,000	$100,500	$64,500	$9,000	$3,000	−$4,500
175,000	$78,250	$36,250	−$28,500	−$35,500	−$44,250
200,000	$56,000	$8,000	−$66,000	−$74,000	−$84,000
225,000	$33,750	−$20,250	−$103,500	−$112,500	−$123,750
250,000	$11,500	−$48,500	−$141,000	−$151,000	−$163,500
275,000	−$10,750	−$76,750	−$178,500	−$189,500	−$203,250
300,000	−$33,000	−$105,000	−$216,000	−$228,000	−$243,000

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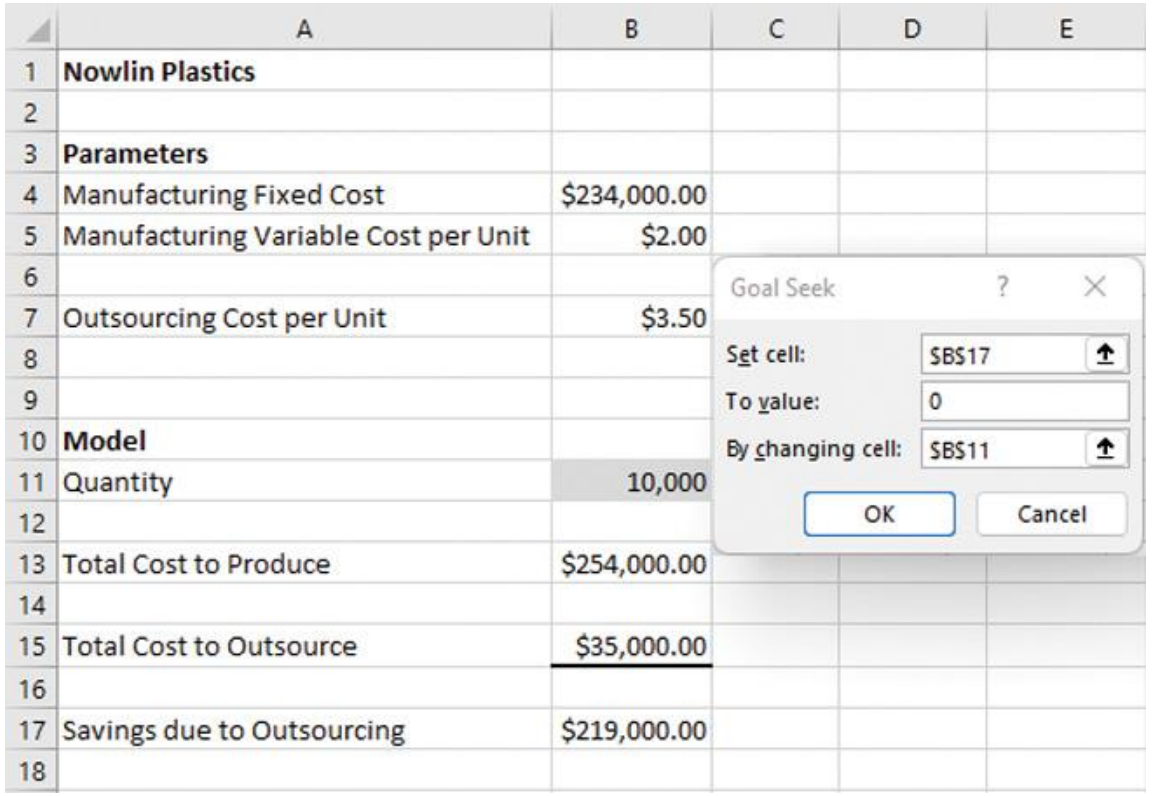
12.2 Breakeven Analysis for Nowlin

Goal Seek is an Excel tool that allows the user to determine the value of an input cell that will cause the value of a related output cell to equal some specified value (the goal).

We can conduct a **breakeven analysis** to learn that the value of the quantity of Vipers at which it becomes more cost-effective for Nowlin to manufacture rather than outsource is $q^* = 156{,}000$ units.

$$TMC(q^*) = TPC(q^*)$$

See the notes for instructions on using the Goal Seek tool in Excel.



	A	B	C	D	E
1	**Nowlin Plastics**				
2					
3	**Parameters**				
4	Manufacturing Fixed Cost	$234,000.00			
5	Manufacturing Variable Cost per Unit	$2.00			
6					
7	Outsourcing Cost per Unit	$3.50			
8					
9					
10	**Model**				
11	Quantity	10,000			
12					
13	Total Cost to Produce	$254,000.00			
14					
15	Total Cost to Outsource	$35,000.00			
16					
17	Savings due to Outsourcing	$219,000.00			
18					

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12.2 Middleton Amusement Park

John Miller, the manager at Middletown Amusement Park, has developed a simple spreadsheet model (shown in the next slide) of the park's daily profit.

- John's model expects profit = $81,500 with partly cloudy weather.

John created three separate scenarios to account for the weather's impact on

- season-pass holders,
- admissions,
- related expenditures,
- and cost of operations.

John is interesting in learning how rainy or sunny weather impacts the park's daily profit.

	Scenarios		
	Partly Cloudy	**Rain**	**Sunny**
Season-pass Holders	3,000	1,200	8,000
Admissions	1,600	250	2,400
Average Expenditure:			
Season-Pass Holders	$15	$10	$18
Admissions	$45	$20	$57
Cost of Operations	$33,000	$27,000	$37,000

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12.2 Middletown Amusement Park Daily Profit Model

MODELfile: *middletown*

We reserve column A for the model's title and labels.

The spreadsheet's top portion includes the parameters (cells B4:B12).

The model's bottom portion includes the various formulas computing the daily profit as total revenue minus total cost (cell B25).

	A	B
1	**Middletown Amusement Park**	
2		
3	**Parameters**	
4		
5	Admission Price	35
6	Number of Season-Pass Holders Admitted	3000
7	Admissions	1600
8	Average Expenditure - Season Pass Holders	15
9	Average Expenditure - Admissions	45
10		
11	Cost of Operations	33000
12	Cost of Goods %	0.5
13		
14	**Model**	
15		
16	Admissions Revenue	=B5*B7
17	Season Pass Holder Expenditures Revenue	=B6*B8
18	Admissions Expenditures Revenue	=B7*B9
19	Total Revenue	=B16+B17+B18
20		
21	Cost of Operations	=B11
22	Cost of Goods	=B12*(B17+B18)
23	Total Cost	=B21+B22
24		
25	Profit	=B19-B23
26		

	A	B
1	**Middletown Amusement Park**	
2		
3	**Parameters**	
4		
5	Admission Price	$35
6	Number of Season-Pass Holders Admitted	3000
7	Admissions	1600
8	Average Expenditure - Season Pass Holders	$15
9	Average Expenditure - Admissions	$45
10		
11	Cost of Operations	$33,000
12	Cost of Goods %	50%
13		
14	**Model**	
15		
16	Admissions Revenue	$56,000
17	Season Pass Holder Expenditures Revenue	$45,000
18	Admissions Expenditures Revenue	$72,000
19	Total Revenue	$173,000
20		
21	Cost of Operations	$33,000
22	Cost of Goods	$58,500
23	Total Cost	$91,500
24		
25	Profit	$81,500
26		

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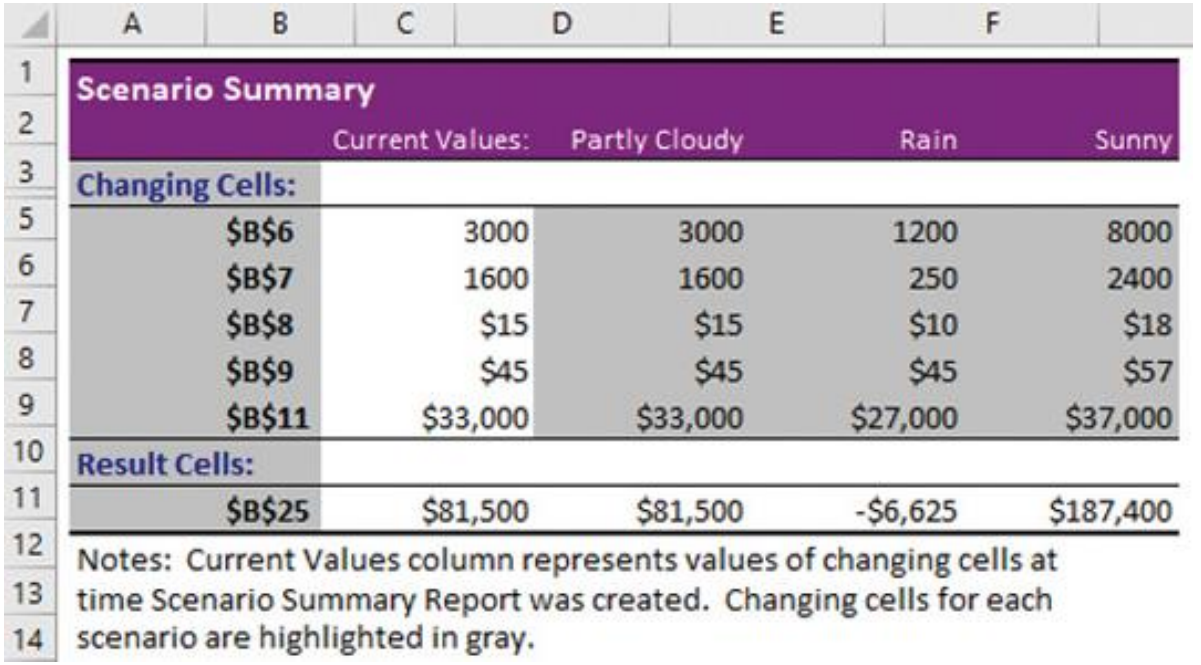
12.2 Scenario Manager for Middleton Amusement Park

Scenario Manager is an Excel tool that quantifies the impact of changing multiple inputs on one or more outputs of interest.

- A scenario is defined as a setting composed of multiple inputs.

Scenario manager is useful when the impact on the output variables of more than two input variables cannot be represented with the data table tool.

See next slide for instructions on running the scenario manager tool in Excel for the Middleton example.



Scenario Summary				
	Current Values:	Partly Cloudy	Rain	Sunny
Changing Cells:				
$B$6	3000	3000	1200	8000
$B$7	1600	1600	250	2400
$B$8	$15	$15	$10	$18
$B$9	$45	$45	$45	$57
$B$11	$33,000	$33,000	$27,000	$37,000
Result Cells:				
$B$25	$81,500	$81,500	-$6,625	$187,400

Notes: Current Values column represents values of changing cells at time Scenario Summary Report was created. Changing cells for each scenario are highlighted in gray.

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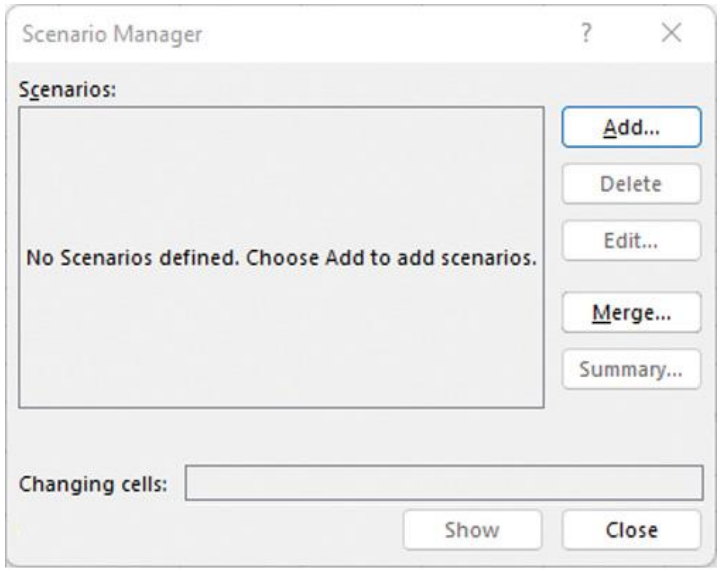
12.2 Scenario Manager Instructions (*see notes)

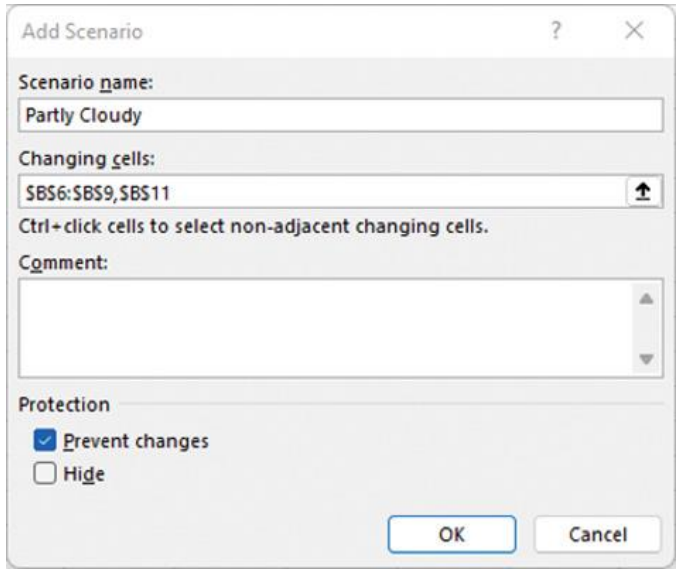
Steps 1-3:

Scenario Manager dialog box



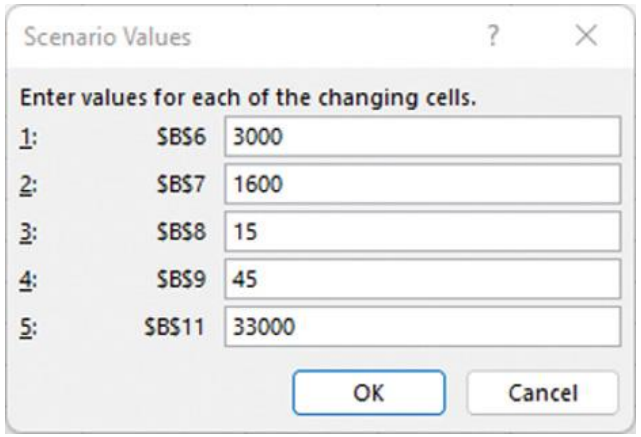
Step 4:

Add Scenario dialog box



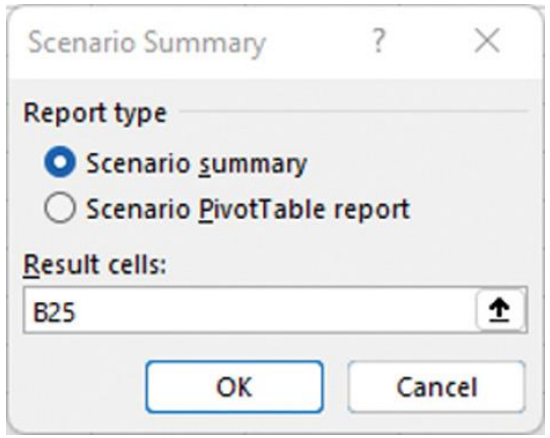
Step 5:

Scenario Values dialog box



Step 8:

Scenario Summary dialog box



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12.3 Useful Excel Functions: SUM and SUMPRODUCT

The SUM function adds all the numbers in a range of cells.

=SUM(*range*)

The SUMPRODUCT function returns the sum of the products of elements in a set of arrays.

=SUMPRODUCT(*array1*,*array2*)

The SUMPRODUCT function pairs each element of the first array with its counterpart in the second array, multiplies the elements of the pairs together, and adds the results.

The next slides show an application of these functions to a what-if model developed to address a transportation problem faced by Foster Generators.

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12.3 Foster Generators Transportation Problem

Foster Generators has developed a what-if spreadsheet model (shown in the next slide) to estimate the total transportation cost of a product from three plants (cells A5:A7) to four distribution centers (cells B4:E4).

- Production capacities for the three plants over the next three-month planning period are known (cells F5:F7).
- Foster has forecasted demand for the three-month period for each of the distribution centers (B8:E8).
- The per-unit shipping cost from each plant to each distribution center is also known (B5:E7).

Management wants to know how much product should be shipped from each plant to each distribution center (cells B17:E19) and the total cost (B13).

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12.3 What-If Model for Foster Generators

	A	B	C	D	E	F
1	**Foster Generators**					
2	**Parameters**					
3	Shipping Cost/Unit		Destination			
4	Origin	Boston	Chcago	St. Louis	Lexington	Supply
5	Cleveland	3	2	7	6	5000
6	Bedford	6	5	2	3	6000
7	York	2	5	4	5	2500
8	Demand	6000	4000	2000	1500	
9						
10						
11	**Model**					
12						
13	Total Cost	=SUMPRODUCT(B5:E7,B17:E19)				
14						
15			Destination			
16	Origin	Boston	Chcago	St. Louis	Lexington	**Total**
17	Cleveland	5000	0	0	0	=SUM(B17:E17)
18	Bedford	1000	4000	1000	0	=SUM(B18:E18)
19	York	0	0	1000	1500	=SUM(B19:E19)
20	Total	=SUM(B17:B19)	=SUM(C17:C19)	=SUM(D17:D19)	=SUM(E17:E19)	
21						

	A	B	C	D	E	F
1	**Foster Generators**					
2	**Parameters**					
3	Shipping Cost/Unit		Destination			
4	Origin	Boston	Chcago	St. Louis	exington	Supply
5	Cleveland	$3.00	$2.00	$7.00	$6.00	5000
6	Bedford	$6.00	$5.00	$2.00	$3.00	6000
7	York	$2.00	$5.00	$4.00	$5.00	2500
8	Demand	6000	4000	2000	1500	
9						
10						
11	**Model**					
12						
13	Total Cost	$54,500.00				
14						
15			Destination			
16	Origin	Boston	Chcago	St. Louis	exington	**Total**
17	Cleveland	5000	0	0	0	5000
18	Bedford	1000	4000	1000	0	6000
19	York	0	0	1000	1500	2500
20	Total	6000	4000	2000	1500	

MODELfile: *foster*. See notes for details about the spreadsheet model.

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12.3 Useful Excel Functions: IF and COUNTIF

The IF function returns one result if a condition is true, and a different result If the condition is false.

=IF(*condition, result if condition is true, result if condition is false*)

The COUNTIF function counts the number of times the condition is true in a given range of cells.

=COUNTIF(*range, condition*)

The next slides show an application of these functions to a what-if model developed to address an inventory problem faced by Gambrell Manufacturing.

Another useful Excel function not entertained in the next example is SUMIF.

=SUMIF(*range, condition, sum_range*)

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12.3 Gambrell Manufacturing Inventory Problem

Gambrell Manufacturing produces car stereos assembled with components the company must carry in inventory to keep production running smoothly.

To keep its components inventory to a minimum, Gambrell uses an inventory policy known as an *order-up-to policy*.

Order-up-to policy:

- If the current number of units in inventory, denoted by H, drops below M units, enough inventory is ordered to get the level back up to M units.
- M is called the order-up-to point.
- Mathematically, if Q is the ordered amount, then $Q = M - H$.

The next slide describes the inventory model for Gambrell Manufacturing.

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12.3 Inventory Model for Gambrell Manufacturing

	A	B	C
1	**Gambrell Manufacturing**		
2	**Parameters**		
3	Component ID	**570**	**578**
4	Inventory On-Hand	5	30
5	Order Up to Point	100	55
6	Cost per unit	4.5	12.5
7			
8	Fixed Cost per Order	120	
9			
10	Minimum Order Size for Discount	50	
11	Discounted to	0.9	
12			
13	**Model**		
14			
15	Component ID	**=B3**	**=C3**
16	Order Quantity	=B5-B4	=C5-C4
17	Cost of Goods	=IF(B16 >= $B$10, $B$11*B6,B6)*B16	=IF(C16 >= $B$10, $B$11*C6,C6)*C16
18			
19	Total Number of Orders	=COUNTIF(B16:E16,">0")	
20			
21	Total Fixed Costs	=B19*B8	
22	Total Cost of Goods	=SUM(B17:E17)	
23	Total Cost	=SUM(B21:B22)	

	A	B	C	D	E
1	**Gambrell Manufacturing**				
2	**Parameters**				
3	Component ID	**570**	**578**	**741**	**755**
4	Inventory On-Hand	5	30	70	17
5	Order Up to Point	100	55	70	45
6	Cost per unit	$4.50	$12.50	$3.26	$4.15
7					
8	Fixed Cost per Order	$120			
9					
10	Minimum Order Size for Discount	50			
11	Discounted to	90%			
12					
13	**Model**				
14					
15	Component ID	**570**	**578**	**741**	**755**
16	Order Quantity	95	25	0	28
17	Cost of Goods	$384.75	$312.50	$0.00	$116.20
18					
19	Total Number of Orders	3			
20					
21	Total Fixed Costs	$360.00			
22	Total Cost of Goods	$813.45			
23	Total Cost	$1,173.45			

MODELfile: *gambrell*. See notes for details about the spreadsheet model.

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12.3 Useful Excel Function: XLOOKUP

The XLOOKUP function allows the user to pull a subset of data from a larger table of data based on some criterion.

=XLOOKUP(*lookup_value*, *lookup_array*, *return_array*, *[if not found]*, *[match_mode]*, *[search_mode]*)

Required arguments:

lookup_value = value to search for

lookup_array = range to search over for the lookup_value

return_array = range from which to return a value based on lookup_value

See notes for the [optional arguments].

The next slides show an application of the XLOOKUP function to a bonus allocation problem faced by Granite Insurance.

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12.3 Granite Insurance Award Bonus Problem

The director of sales at Granite Insurance needs to award performance-based bonuses to the 15 salespeople on the sales force (cells A15:A29).

- The total bonus pool available for the performance-based awards is $250,000 (cell E13).
- The measure of performance for awarding bonuses is the percentage achieved above the sales target (cells B15:B29).
- Based on such metric, each salesperson is placed in one of five bands (cells A7:C11) and awarded bonus points (cells C15:C29).
- Each salesperson receives a monetary award (cells E15:E29) proportional to the collected bonus points (cells D15:D29).

The next slide describes the bonus model for Granite Insurance.

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12.3 Bonus Model for Granite Insurance

	A	B	C	D	E
1	**Granite Insurance Bonus Awards**				
2					
3	**Parameters**			Bonus Pool	250000
4	Bonus Bands to be awarded for				
5	percentage above target sales.				
6	**Lower Limit**	**Upper Limit**	**Bonus Points**		
7	0	0.1	0		
8	0.11	0.5	10		
9	0.51	0.79	15		
10	0.8	0.99	25		
11	1	100	40		
12					
13	**Model**				
14	**Last Name**	**% Above Target Sales**	**Bonus Points**	**% of Pool**	**Bonus Amount**
15	Barth	0.83	=XLOOKUP(B15,$A$7:$A$11,$C$7:$C$11,#N/A,-1,2)	=C15/$C$30	=D15*$E$3
16	Benson	0	=XLOOKUP(B16,$A$7:$A$11,$C$7:$C$11,#N/A,-1,2)	=C16/$C$30	=D16*$E$3
17	Capel	1.18	=XLOOKUP(B17,$A$7:$A$11,$C$7:$C$11,#N/A,-1,2)	=C17/$C$30	=D17*$E$3
18	Choi	0.44	=XLOOKUP(B18,$A$7:$A$11,$C$7:$C$11,#N/A,-1,2)	=C18/$C$30	=D18*$E$3
29	Ruebush	0.85	=XLOOKUP(B29,$A$7:$A$11,$C$7:$C$11,#N/A,-1,2)	=C29/$C$30	=D29*$E$3
30		Total	=SUM(C15:C29)	=SUM(D15:D29)	=SUM(E15:E29)

	A	B	C	D	E
1	**Granite Insurance Bonus Awards**				
2					
3	**Parameters**			Bonus Pool	$250,000
4					
5	Bonus Bands to be awarded for percentage above target sales.				
6	**Lower Limit**	**Upper Limit**	**Bonus Points**		
7	0%	10%	0		
8	11%	50%	10		
9	51%	79%	15		
10	80%	99%	25		
11	100%	10000%	40		
12					
13	**Model**				
14	**Last Name**	**% Above Target Sales**	**Bonus Points**	**% of Pool**	**Bonus Amount**
15	Barth	83%	25	8.5%	$21,186.44
16	Benson	0%	0	0.0%	$0.00
17	Capel	118%	40	13.6%	$33,898.31
18	Choi	44%	10	3.4%	$8,474.58
29	Ruebush	85%	25	8.5%	$21,186.44
30		Total	295	100%	$250,000.00

MODELfile: *granite*. See notes for details about the spreadsheet model.

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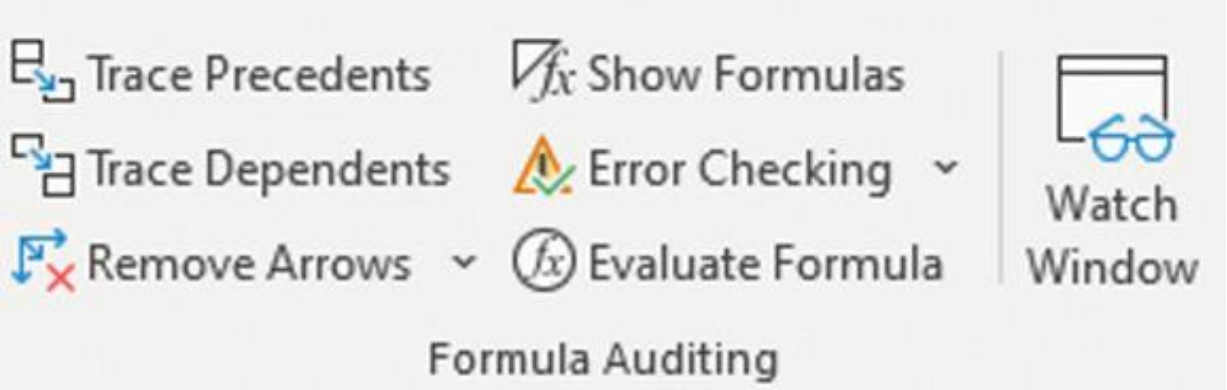
12.4 Auditing Spreadsheet Models

Excel contains a variety of tools to assist you in the development and debugging of spreadsheet models.

In this section, we review the following tools found in the **Formula Auditing group** of the **Formulas** tab:

- Trace Precedents and Dependents
- Show Formulas
- Evaluate Formulas
- Error Checking
- Watch Window



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12.4 Trace Precedent and Dependents

Trace Precedents button

After selecting cells, the trace precedents button creates arrows pointing to the selected cell from cells that are part of the formula in that cell.

Trace Dependents button

After selecting cells, the trace dependents button creates arrows pointing from the selected cell to cells that depend on the selected cell.

Trace Precedents and Trace Dependents can highlight errors in copying and formula construction by showing that incorrect sections of the worksheet are referenced.

Let us consider an example using the Foster Generators model,

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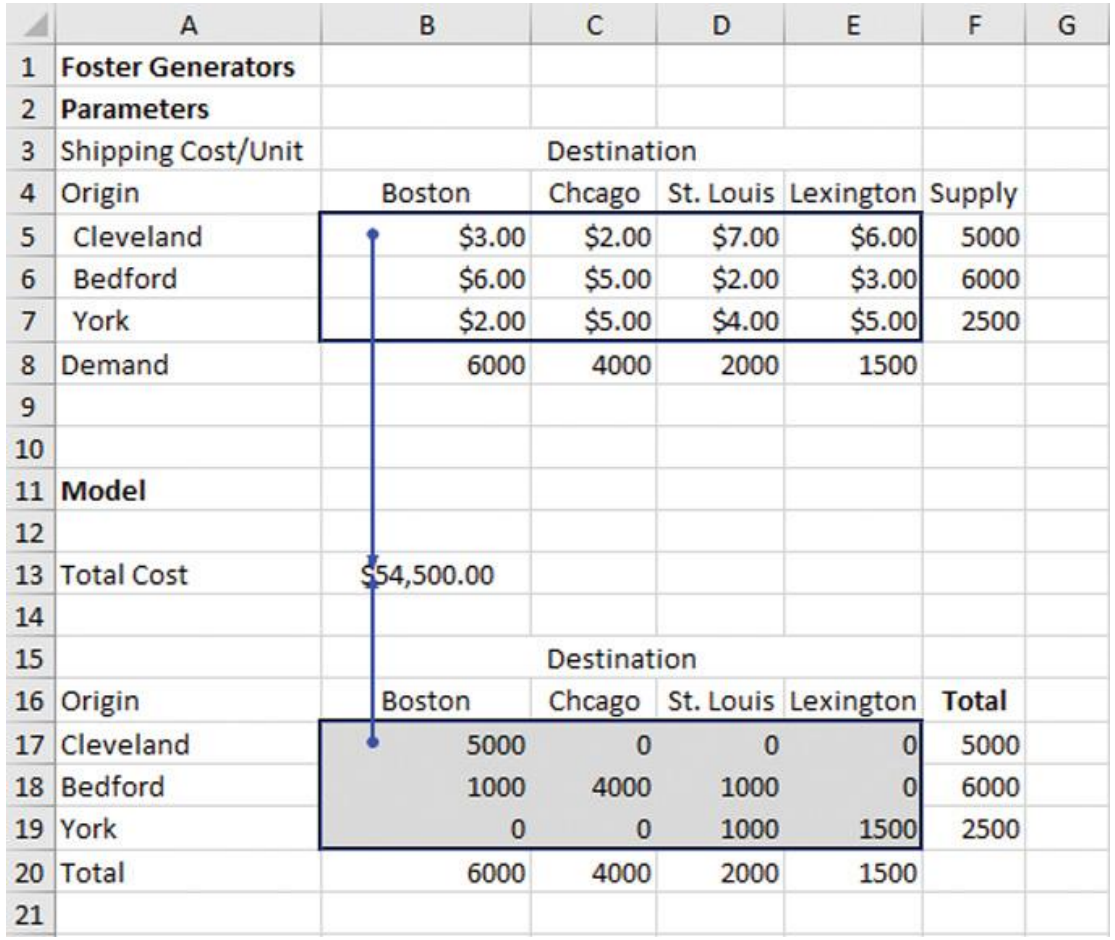
12.4 Trace Precedents for Foster Generators

In this example, we selected cell B13, and clicked the **Trace Precedents** button in the **Formula Auditing** group.

Cell B13 contains the function =SUMPRODUCT(B5:E7,B17:E19).

To show the relationship, arrows are drawn to these areas of the spreadsheet to cell B13.

The arrows may be removed by clicking on the **Remove Arrows** button in the **Formula Auditing** group.



	A	B	C	D	E	F	G
1	**Foster Generators**						
2	**Parameters**						
3	Shipping Cost/Unit			Destination			
4	Origin	Boston	Chcago	St. Louis	Lexington	Supply	
5	Cleveland	$3.00	$2.00	$7.00	$6.00	5000	
6	Bedford	$6.00	$5.00	$2.00	$3.00	6000	
7	York	$2.00	$5.00	$4.00	$5.00	2500	
8	Demand	6000	4000	2000	1500		
9							
10							
11	**Model**						
12							
13	Total Cost	$54,500.00					
14							
15				Destination			
16	Origin	Boston	Chcago	St. Louis	Lexington	**Total**	
17	Cleveland	5000	0	0	0	5000	
18	Bedford	1000	4000	1000	0	6000	
19	York	0	0	1000	1500	2500	
20	Total	6000	4000	2000	1500		
21							

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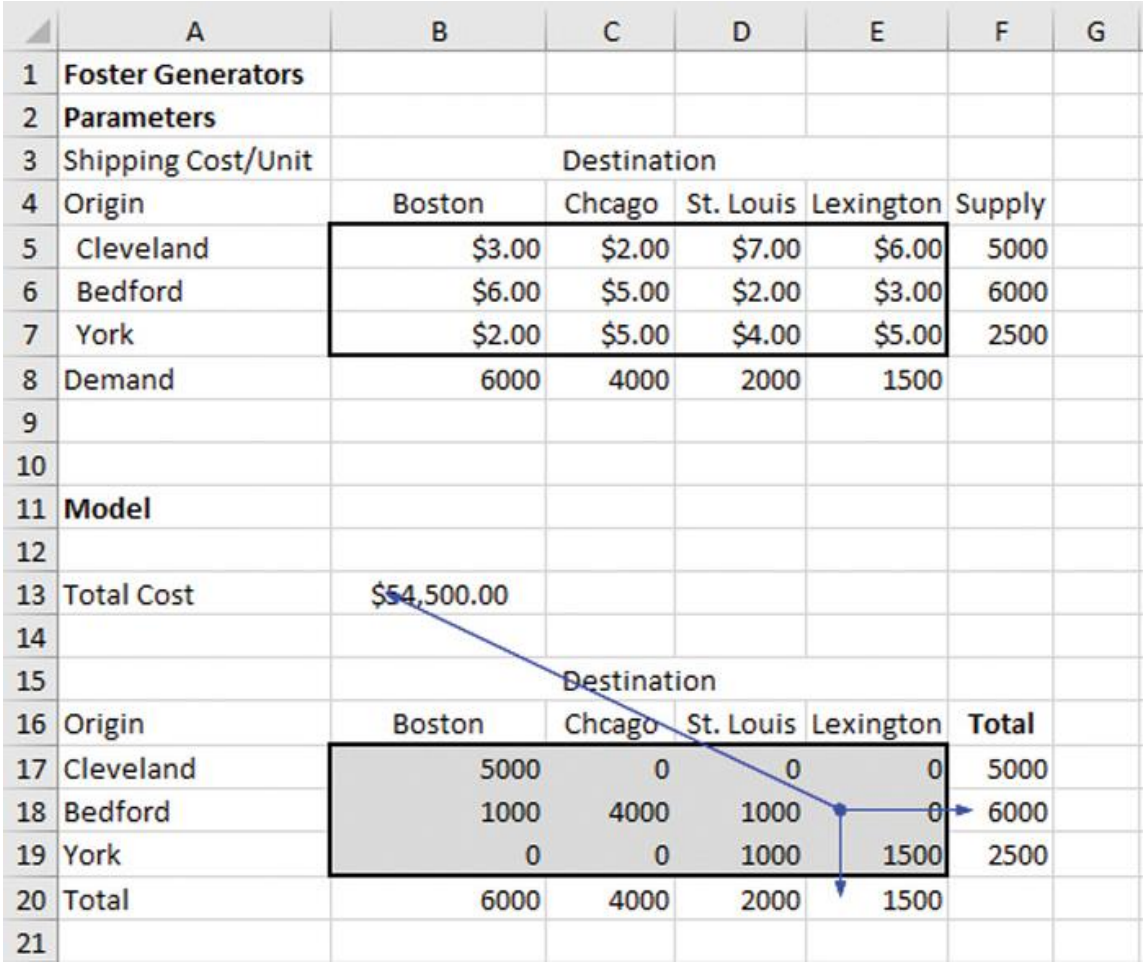
12.4 Trace Dependents for Foster Generators

In this example, we selected cell E18, and clicked the **Trace Dependents** button in the **Formula Auditing** group.

Cell E18 contains the units shipped from Bedford to Lexington, which impacts the cost function (cell B13), the total units shipped from Bedford given (cell F18), and the total units shipped to Lexington (cell E20).

The arrows may be removed by clicking on the **Remove Arrows** button in the **Formula Auditing** group.



	A	B	C	D	E	F	G
1	**Foster Generators**						
2	**Parameters**						
3	Shipping Cost/Unit		Destination				
4	Origin	Boston	Chcago	St. Louis	Lexington	Supply	
5	Cleveland	$3.00	$2.00	$7.00	$6.00	5000	
6	Bedford	$6.00	$5.00	$2.00	$3.00	6000	
7	York	$2.00	$5.00	$4.00	$5.00	2500	
8	Demand	6000	4000	2000	1500		
9							
10							
11	**Model**						
12							
13	Total Cost	$54,500.00					
14							
15			Destination				
16	Origin	Boston	Chcago	St. Louis	Lexington	**Total**	
17	Cleveland	5000	0	0	0	5000	
18	Bedford	1000	4000	1000	0	6000	
19	York	0	0	1000	1500	2500	
20	Total	6000	4000	2000	1500		
21							

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12.4 Show and Evaluate Formulas

Show Formulas

To show all the formulas residing in a worksheet, simply select any cell in the worksheet, and click on **Show Formulas**.

- To revert to hiding the formulas, click **the Show Formulas** button again.

Evaluate Formulas

The Evaluate Formulas button allows you to investigate the calculations of a cell in great detail.

- It provides an excellent means of identifying the exact location of an error in a formula.

Let us consider an example using the Gambrell model,

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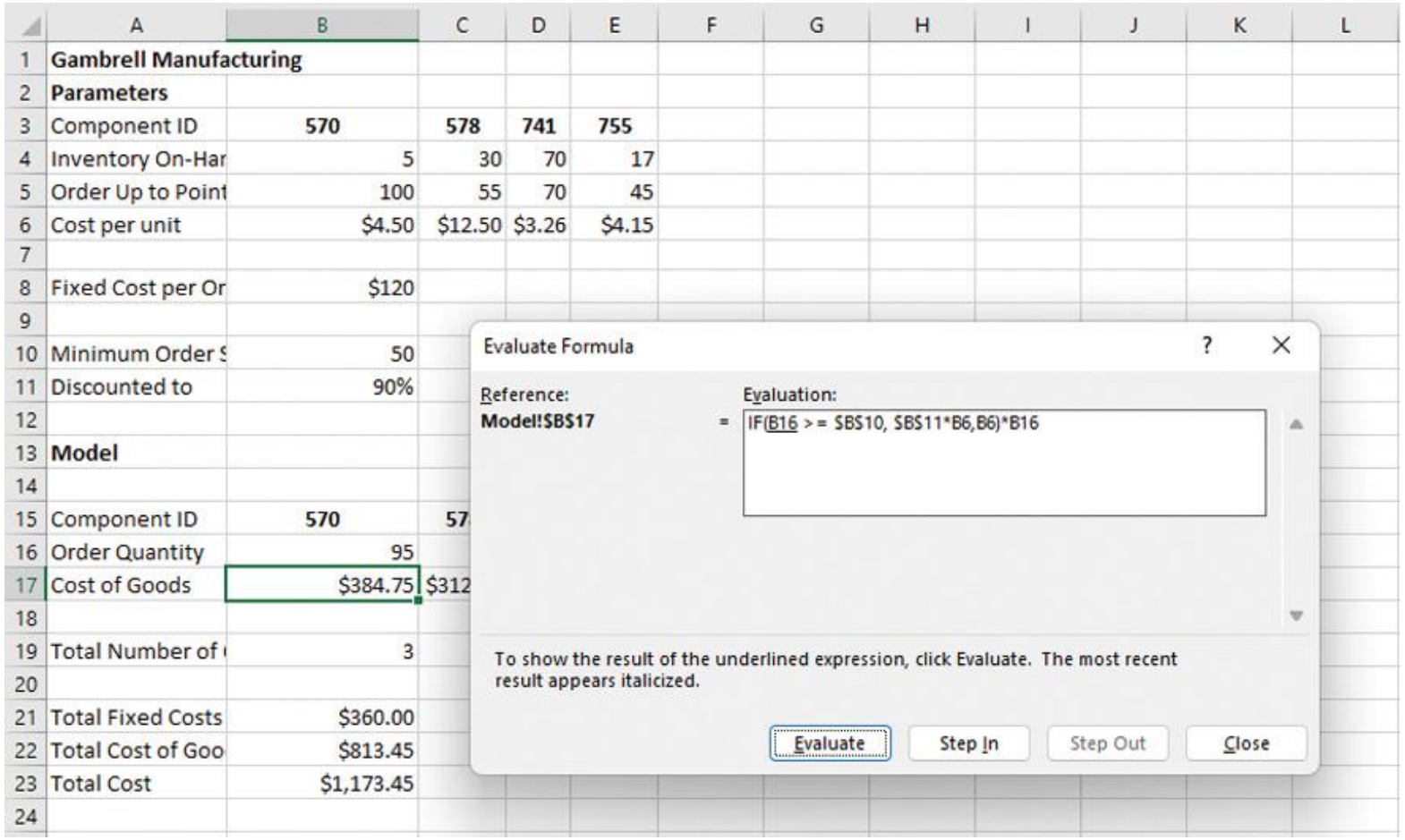
12.4 Evaluate Formulas for Gambrell Manufacturing

As an example, let us investigate cell B17 of the *gambrell* model.

Recall that we are calculating the cost of goods based on whether there is a quantity discount.

See notes for Excel instructions on **Evaluate Formulas**.



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12.4 Error Checking

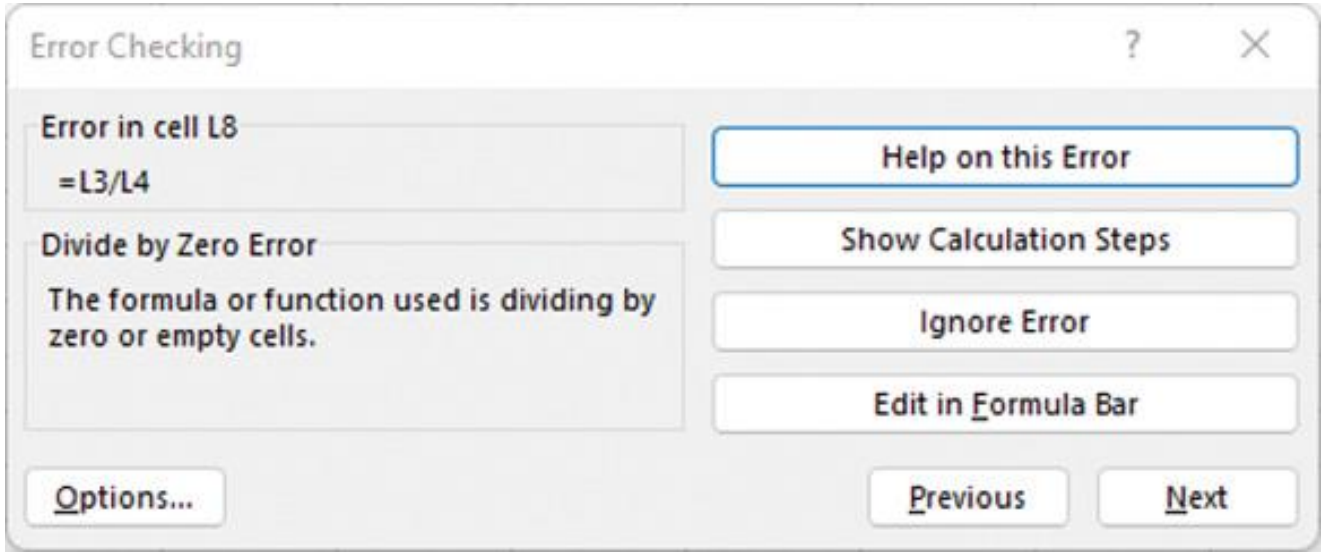
The **Error Checking** button provides an automatic means of checking for mathematical errors within formulas of a worksheet.

Clicking on the **Error Checking** button causes Excel to check every formula in the sheet for calculation errors.

- If an error is found, the Error Checking dialog box appears.

An example of a hypothetical division by zero error is shown to the right.

The Error Checking procedure is particularly helpful for large models where not all cells of the model are visible.



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12.4 Watch Window

The **Watch Window**, located in the **Formula Auditing** group, allows the user to observe the values of cells included in the Watch Window box list.

The user can monitor how the listed cells change with a change in the model without searching through the worksheet or changing worksheet.

- This is useful for large models when not all of the model is observable on the screen or when multiple worksheets are used.

A Watch Window for cell B17 of the Gambrell Manufacturing model is shown to the right.

See notes for Excel instructions on how to use the Watch Window command.

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12.5 Descriptive and Predictive Spreadsheet Models

Decision-making is difficult because of uncertainty and an overwhelming number of choices.

Spreadsheet what-if models are *descriptive* models.

- Basic what-if spreadsheet models can be extended to help deal with uncertainty or the many alternatives a decision-maker may face.

Predictive models can be estimated from data in spreadsheets using tools provided in Excel:

- The Regression tool and other Data Analysis tools, such as Exponential Smoothing and Moving Average, allow us to develop predictive models based on data in the spreadsheet.

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12.5 Prescriptive Spreadsheet Models

Simulation ad optimization models are examples of *prescriptive* models.

- Monte Carlo simulation automates a manual what-if model by replacing static input parameters with a random generation of values for these uncertain inputs.
- Optimization models, characterized by having an objective to be maximized or minimized, can be used to help make smart decisions.
- Excel includes a special tool called Solver that solves optimization models.
  - Solver is used to finding an optimal course of action that maximizes or minimizes the objective on a what-if model while satisfying a set of constraints.

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Summary

- In this chapter, we discussed the principles of building good spreadsheet models,
- What-if spreadsheet models are essential and popular analysis tools that also serve as the basis for optimization and simulation models.
- We first discussed how to use influence diagrams to structure a problem.
- Then, we illustrated how Excel What-If Analysis tools Data Tables, Goal Seek, and Scenario Manager perform detailed and efficient what-if analyses.
- We also discussed several Excel functions that are useful for business analytics.
- We discussed Excel Formula Auditing tools that may be used to debug and monitor spreadsheet models to ensure that they are error-free and accurate.
- We ended the chapter briefly discussing predictive and prescriptive spreadsheet models.

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