TIM-125/225

Management of Technology II: Supply Chain Management

"Excel Tutorial"

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Table of Contents

Purpose

In this tutorial, you will develop intermediate-level Excel skills, as follows:

Pre-processing	1. Setting Up Excel Workbooks
	
	   a. Linking worksheets
	
	   b. Writing formulas
	
	   c. Formatting Spreadsheets

Processing	2. Exploring Scenarios
	
	   a. Entering parameters
	
	   b. Adjusting parameters
	
	   c. Performing sensitivity analysis,
	
	   d. Optimization
	
	   e. Simulation
	
	   f. Summarizing results

Post-Processing	3. Presenting Results
	
	   a. Graphing
	
	   b. Generating reports
	
	   c. Exporting content
	
	   d. Drawing conclusions

Software Automation → ***Rapid Problem Solving***

Figure 1: Structured Approach to Rapid Problem Solving with Software Automation

This tutorial will walk you through the Pre-Processing, Processing, and Post-Processing approach to developing software automation utilizing Microsoft Excel. The lessons you learn will teach you how to solve new problems rapidly, and, efficiently. You will then apply this new knowledge to solving Supply Chain problems in the coursework homework, exams, and project.

Important Note:

The skills identified above are essential for the subsequent work you will be performing in the TIM-125/225 coursework. We recommend you invest the time now and develop your skills as the coursework ramps up quickly. This tutorial can also help you identify your strengths and weaknesses using Excel, so that you can get the help you need and stay current with the coursework. You will be in very good shape for the course, once you can 1) Duplicate the results of this tutorial, 2) Achieve equal to or better quality and 3) Understand the process.

Context

In TIM-105/205 (1), you were taught how to create and implement a quantitative financial model (i.e., NPV Analysis) for product development and commercialization (2). We will use this context[1] to develop your Excel skills as listed above.

Important Note for Mac users

Tutorial platform

This tutorial is currently written for use on the Microsoft Windows operating system, loaded with Microsoft Excel 2010. So please beware: Some of the Graphic User Interface features are slightly different in a Mac environment.

Solver Add-In

As part of this tutorial, we walk you through how to use the *Solver* Add-In to Excel and there are issues with compatibility of this Add-In and the Mac version of Excel.

Therefore, please first read "Getting Started with Excel" on the TIM-125/225 course webpage before working through this tutorial and specifically attempting the portion with the *Solver* Add-In. You will need to make sure that your version of the Microsoft Excel is capable of performing the prescribed computations in Excel, and can utilize the *Solver Add-in*.

If you find that your version of Excel does not support the *Solver Add-In*, two possible resolutions are:

1) Work on a UCSC SOE Windows computer with Excel 2010, with the Solver Add-In enabled, in one of the labs.
2) Update to the **Mac Excel 2011 with Service Pack 1** software:
   a. Mac Excel 2011: ***Office for Mac 2011 Service Pack 1 (14.1.0)*** needed.
      Download Service Pack: **http://support.microsoft.com/kb/2525412**

   b. Mac Excel 2008: http://www.solver.com/mac/dwnmacsolver.htm

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[1] The NPV Analysis is adopted from Ulrich, K. T., and Eppinger, S.D., Product Design and Development, Fourth Edition, McGraw-Hill, 2008. Chapter 15.

Problem Definition

Use the following Base Case scenario parameters:

(a) The total project length is four **(4)** years.

(b) The total Development Cost is $25,000,000.

(c) The average sales price (wholesale) is $2,500 **per unit.**

(d) The average production cost is $1,250 **per unit**.

(e) The total Ramp-up costs are estimated at $2,500,000.

(f) Ongoing market and support costs are $200,000 **per month**.

(g) Development time is 12 months.

(h) Production ramp-up time is 6 months.

(i) Ramp-up starts 9 **months** after the start of product development and continues for 6 **months**.

(j) Ongoing "market and support" starts one **quarter** before Production (of the product) and selling ("sales" of the product) start.

(k) Production (of the product) and selling ("sales" of the product) occur immediately after the end of the ramp-up period, and concludes at the end of year **4 (four)**.

(l) Assume that you could sell 35,000 **units per year**.

(m) The **annual** discount factor is 10% (i.e., 2.5% **per quarter**).

Answer the following questions:

(1) What is the NPV of the Base Case scenario?

(2) What is the maximum development cost beyond which the development of the product cannot be justified? (i.e., what is the development cost which makes NPV=0). Use the *Solver Add-In* to answer this question. Show your work.

(3) Explain the trade-off law for NPV versus development cost.

(4) Explain the trade-off law for NPV versus sales volume.

(5) Create a graph of the trade-off law relationship for the (*Change in NPV, $)* (y-axis) versus (*Change in Development Cost, %)* (x-axis). What is the equation of the Regressed *trendline*? Give the answer in the standard form for an equation of a line: *y=mx+b.*

(6) Create a graph of the Trade-off law relationship for the to the (*Change in NPV, $)* (y-axis) versus (*Change in Sales Volume, %)* (x-axis). What is the equation of the Regressed *trendline*? Give the answer in the standard form for an equation of a line: *y=mx+b.*

(7) If there is a 10% increase in development cost, by how much does the sales volume need to increase, to compensate for the drop in NPV?

Treatment

1. Build a Base Case NPV Scenario
2. Use the Base Case to create: +/- 10%, +/- 20%, +/- 30% Development Cost analysis
3. Use the Base Case to create: +/- 10%, +/- 20%, +/- 30% Sales Volume analysis
4. Create a worksheet with summary tables
5. Graph the results to determine the slope of the line using Regression Analysis *trendline*.
6. Use the *Solver Add-In* to automate the determination of the *Maximum* development cost for the project at which the project is no longer economically practical (i.e., NPV=0).
7. Follow Ulrich's (2) method (p.320) to determine the impact of 10% increase in development cost on NPV and the sales volume needed to compensate for the drop.
8. Check the work.
9. Copy and Paste content into MS Word.
10. Label each Figure (i.e., *Figure #: Title*) and Table (i.e., *Table #: Title*).
11. Explain each Figure and Table.
12. Explain the Results.
13. Discuss the Conclusions.

Important Notes

As you work through this tutorial, it is essential that:

1) Worksheet tab names are formatted <u>exactly</u> as presented in the tutorial, matching letter for letter. This is important because we will be using linked worksheets that will reference the precise spelling of the tabs. A deviation from the exact spelling will cause the worksheets links to fail. Therefore, pay attention to UPPERCase and lower_*case*, and spacing, as it pertains to the formatting of the tab names. We used a consistent nomenclature, therefore you need to adhere to the format we used. You can change it later (and improve it) once you understand how it works; and

2) The numerical scenario data values and formulas must entered in each corresponding cell position, exactly as presented. If the tutorial defines to enter something in a Cell B1 then enter that specific information in Cell B1; otherwise the links will fail, in relation to the rest of this tutorial. We use the *Fixed Cell References* "$" and will discuss this symbol latter; and

3) Save your work often. A simple approach is to email the file to yourself so you have an easily accessible copy in case your computer crashes, that you can get from another computer to continue working to meet deadlines.

Execution: Pre-Processing (Setup)

Step 0:

Below is a checklist for you to make sure you have everything you need before you get started:

1. Make sure that Microsoft Excel is loaded on your computer.
2. Enable the "***Solver Add-In"*** *with Excel*

Windows OS *instructions:*

Useful video guide:

http://office.microsoft.com/en-us/excel-help/video-install-and-activate-the-analysis-toolpak-and-solver-VA101956375.aspx?CTT=1

- Excel 2010: http://office.microsoft.com/en-us/excel-help/load-the-solver-add-in-HP010342660.aspx?CTT=1
- Excel 2007: http://office.microsoft.com/en-us/excel-help/load-the-solver-add-in-HP010021570.aspx?CTT=1
- Excel 2003: http://office.microsoft.com/en-us/excel-help/load-the-solver-add-in-HP001127725.aspx?CTT=1

Mac OS *instructions:*

- Excel 2011: ***Office for Mac 2011 Service Pack 1 (14.1.0)*** needed.

  Download Service Pack: **http://support.microsoft.com/kb/2525412**
- Excel 2008: http://www.solver.com/mac/dwnmacsolver.htm

3. Enable the "***Excel Analysis ToolPak"*** *and* ***"Analysis Toolpak – VBA"*** within Excel**.**

Windows OS *instructions:*

- Excel 2010: http://office.microsoft.com/en-us/excel-help/load-the-analysis-toolpak-HP010021569.aspx?CTT=3
- Excel 2007: http://office.microsoft.com/en-us/excel-help/load-the-analysis-toolpak-HP010021569.aspx
- Excel 2003: http://office.microsoft.com/en-us/excel-help/load-the-analysis-toolpak-HP001127724.aspx

Mac OS *instructions:*

- Excel 2011: http://www.microsoft.com/download/en/details.aspx?displaylang=en&id=17198
- Excel 2008: Not Available. VBA is not Supported.

4. Recommend to print a hard-copy of this Tutorial (double-sided).
5. Have a copy of your TIM-105/205 Lecture Notes on NPV Analysis.
6. Have textbook: Ulrich, K. T., and Eppinger, S.D., Product Design and Development, Fourth Edition, McGraw-Hill, 2008, **Chapter 15**.

Execution: Processing

Step 1: Build a *ScenarioParameters* worksheet

Create a worksheet and name the worksheet Tab: ***ScenarioParameters***

The worksheet is formatted as follows with the parameters:

	A	B
1	**SCENARIO INPUT PARAMETERS**	
2	Sales & Production Volume (units/year)	35,000
3	Development Cost (total $)	25,000,000
4	Unit price ($/unit)	2,500
5	Unit Productions Cost ($/unit)	1,250
6	Ramp-up cost (total $)	2,500,000
7	Marketing & suppost cost ($/year)	2,400,000
8	Annual Discount Factor (%)	10

ScenarioParameters

Figure 1: ScenarioParameters worksheet format

Cell A1 and Cell B1 have been MERGED. Then the SCENARIO INPUT PARAMETERS typed inside this single merged cell.

The project schedule, from inception through end of the production and selling will look like Figure 2.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
1	BaseCase																
2		Year 1				Year 2				Year 3				Year 4			
3	period	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
4	($ values in thousands)	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
5																	
6	Development Cost																
7	Ramp-up cost																
8	Marketing & suppost cost																
9	Production cost																
10	Production volume																
11	Unit production cost																
12	Sales Revenue																
13	Sales volume																
14	Unit price																
15																	
16	Period Cash Flow																
17	PV Year 1, r=10%																
18																	
19	Project NPV, $																

BaseCase

Figure 2: Complete Project Time Line from Inception to End

Observe how, that the production and selling concludes at the "end of year four (4)", as defined in the problem statement. But, given the other events that occur beforehand, the production and selling does not start until Year 2-Q2.

Step 2: Build the *BaseCase* NPV analysis worksheet

Now we show you how to build and setup the **BaseCase** scenario to look as follows:

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
1	BaseCase																
2		Year 1				Year 2				Year 3				Year 4			
3	period	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
4	($ values in thousands)	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
5																	
6	Development Cost	-6,250	-6,250	-6,250	-6,250												
7	Ramp-up cost				-1,250	-1,250											
8	Marketing & suppost cost					-600	-600	-600	-600	-600	-600	-600	-600	-600	-600	-600	-600
9	Production cost						-10,938	-10,938	-10,938	-10,938	-10,938	-10,938	-10,938	-10,938	-10,938	-10,938	-10,938
10	Production volume						8,750	8,750	8,750	8,750	8,750	8,750	8,750	8,750	8,750	8,750	8,750
11	Unit production cost						-1.25	-1.25	-1.25	-1.25	-1.25	-1.25	-1.25	-1.25	-1.25	-1.25	-1.25
12	Sales Revenue						21,875	21,875	21,875	21,875	21,875	21,875	21,875	21,875	21,875	21,875	21,875
13	Sales volume						8,750	8,750	8,750	8,750	8,750	8,750	8,750	8,750	8,750	8,750	8,750
14	Unit price						2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50
15																	
16	Period Cash Flow	-6,250	-6,250	-6,250	-7,500	-1,850	10,338	10,338	10,338	10,338	10,338	10,338	10,338	10,338	10,338	10,338	10,338
17	PV Year 1, r=10%	-6,250	-6,098	-5,949	-6,964	-1,676	9,137	8,914	8,697	8,484	8,278	8,076	7,879	7,687	7,499	7,316	7,138
18																	
19	Project NPV, $	62,166															
20	all units in thousands, $																

Figure 3: Base Case NPV Analysis

Note: The clean looking format for the number values is utilizing a format configuration of: NUMBER, Decimal Places=0 with 1000 Separator (,) and format -1,234. You can achieve this format by selecting all the cells. Then in the Number ribbon (Figure 4), click the Show Number tab icon, ![icon], and configure the number format (Figure 5). Rows 11 and Row 14 are configured to Decimal places = 2.
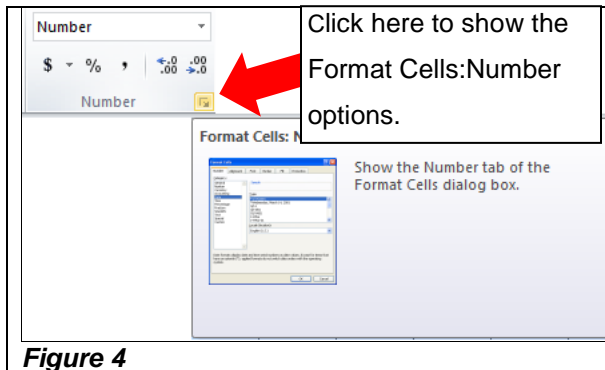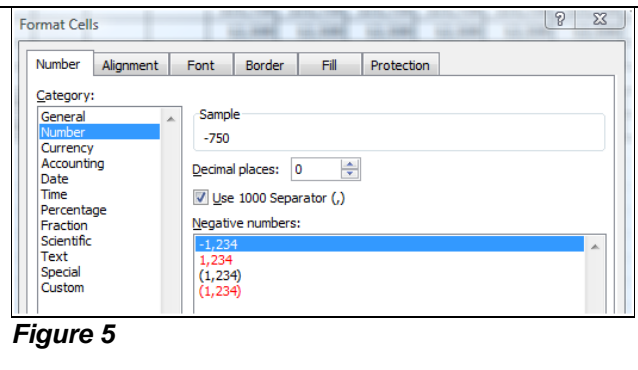

Figure 4

Figure 5

Note: We use the symbol "$" on purpose and it is very important. It is called a *Fixed Cell Reference*. Putting the "$" sign before the column or row variable, causes the link to remain fixed to that cell reference. "One of the major ways to control a cell reference is to set either the column or row reference or both references. This is typically done by using a dollar sign ("$") before the column or row reference (e.g., "$A4", "A$4", or "$A$4"). The dollar sign indicates that the reference will not change, even if the formula is copied and pasted."[2] This is useful when you need to reference a specific input parameter but want to copy and paste formulae. Using the ("$") saves time in programming the worksheets and ensures accuracy.

[2] http://www.sjsu.edu/depts/geography/resource/swdocs/xl-guide/edit/celref.htm

The programming format to create the *BaseCase* worksheet is as follows:

CELL	CELL FORMULAE	COPY TO
B6	=(-1)*ScenarioParameters!$B$3/4*(1/1000) *Note:* Dividing by (1/1000) converts the dollar value from Millions to Thousands. We do this to simply the presentation of the spreadsheet.	C6:E6
E7	=(-1)*ScenarioParameters!$B$6/2*(1/1000)	F7
F8	=(-1)*ScenarioParameters!$B$7/4*(1/1000)	G8:Q8
G9	=(-1)*(ScenarioParameters!$B$5)*(ScenarioParameters!$B$2/4)*(1/1000)	H9:Q9
G10	=ScenarioParameters!$B$2/4	H10:Q10
G11	=G9/G10	H11:Q11
G12	=(ScenarioParameters!$B$4*ScenarioParameters!$B$2/4)*(1/1000)	H12:Q12
G13	=ScenarioParameters!$B$2/4 *Note:* Dividing by 4 converts from Yearly to Quarterly	H13:Q13
G14	=G12/G13	H14:Q14
B16	=SUM(B6+B7+B8+B9+B12)	C16:Q16
B17	=B16	
C17	=C16/(1+(ScenarioParameters!$B$8/100)/4)^B3 *Note:* ScenarioParameters!$B$8/100 converts the parameter of 10 to 10%. Then, division of by 4 converts from Yearly to Quarterly value as needed. Therefore, you get 1+(.025)=1.025 which is the needed value. Lastly, the cell B3 is shifted one to the left for the periods, so we start at one (1) for the exponential factor. This setup allows to quickly change the Discount Factor in the ScenarioParameters, worksheet to automatically update the entire workbook.	D17:Q17
B19	=SUM(B17:Q17)	

If you have programmed the *BaseCase* worksheet as defined above, and made the correct links to the **ScenarioParameters** worksheet, then the Project NPV, $ will equal, precisely, **$62,166.18;** rounded to 0 decimal places, it is $62,166. Recall this value is in thousands. Therefore, the conclusion is that the project has a high NPV value of $62,166K and should be pursued.

Step 3: Create the *+10% DevCost* *Worksheet*

To quickly create a worksheet that is derived on the **BaseCase** worksheet, we will use the worksheet COPY feature of the **BaseCase** worksheet and then make a few small changes.

To copy the worksheet, you will RIGHT-CLICK on the Tab of worksheet **BaseCase**.

Then select "MOVE OR COPY…"
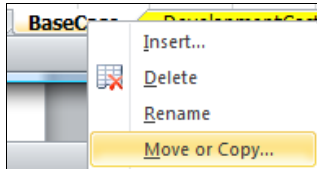
Figure 6: Right Click to Copy a Worksheet

Select the **BaseCase** worksheet, and Check the box to *CREATE A COPY.*
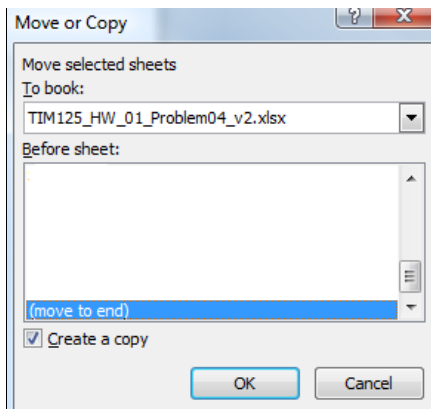
Figure 7: Create a Worksheet Copy

Also, select *MOVE TO END* so the new worksheet will be positioned at the end of the group of worksheets. The Tan bame will be called **BaseCase (2**). So rename the worksheet by double clicking on the Tab, and typing a tab name of: ***+10% DevCost***.

The name must be entered precisely to match this tutorial as we will link to this Tab name later. Then hit enter to save the Tab name. You can also right click on the Tab and select a color to help you identify the sheets. You can see that in we colored ours a light blue,

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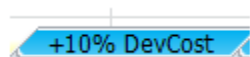
Suggested Reference:

Watch a short and very useful video on YOUTUBE to show you the process of how to:

Move or Copy a Worksheet (3)

http://www.youtube.com/watch?v=OucSxFiLyBc

Once you have the **+10% DevCost** worksheet created. It is quick to edit the worksheet parameters as follows:

The tab name to enter is: *10% DevCost*

1. Cell A1, change to: **Development Cost Analysis**
2. Cell B1: change to: **10%**
3. Cell B6: change to: **=(-1)*(ScenarioParameters!$B$3/4*(1/1000))*(1+$B$1)**
   a. **Note**: Multiplying by (-1) to create the negative effect of cost.
   b. **Note:** Dividing *ScenarioParameters!$B$3* by 4 converts from Yearly to Quarter.
   c. **Note:** Multiplying *ScenarioParameters!$B$3* by (1/1000) converts from Millions to Thousands.
   d. **Note:** Multiplying by *(1+$B$1)*, in which $B$1 is the 10% for sensitivity value. Also, notice the use of "$" before the Column 'B' and Row '1'. Putting the $ sign before the column and row, causes the link to remain fixed to that cell reference. It called **Fixed Cell References**. "One of the major ways to control a cell reference is to set either the column or row reference or both references. This is typically done by using a dollar sign ("$") before the column or row reference (e.g., "$A4", "A$4", or "$A$4"). The dollar sign indicates that the reference will not change, even if the formula is copied and pasted." (4)
4. Copy B6 to C6:E6.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
1	Development Cost Analysis	10%															
2		Year 1				Year 2				Year 3				Year 4			
3	period	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
4	($ values in thousands	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
5																	
6	Development Cost	-6,875	-6,875	-6,875	-6,875												
7	Ramp-up cost				-1,250	-1,250											
8	Marketing & suppost cost					-600	-600	-600	-600	-600	-600	-600	-600	-600	-600	-600	-600
9	Production cost						-10,938	-10,938	-10,938	-10,938	-10,938	-10,938	-10,938	-10,938	-10,938	-10,938	-10,938
10	Production volume						8,750	8,750	8,750	8,750	8,750	8,750	8,750	8,750	8,750	8,750	8,750
11	Unit production cost						-1.25	-1.25	-1.25	-1.25	-1.25	-1.25	-1.25	-1.25	-1.25	-1.25	-1.25
12	Sales Revenue						21,875	21,875	21,875	21,875	21,875	21,875	21,875	21,875	21,875	21,875	21,875
13	Sales volume						8,750	8,750	8,750	8,750	8,750	8,750	8,750	8,750	8,750	8,750	8,750
14	Unit price						2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50
15																	
16	Period Cash Flow	-6,875	-6,875	-6,875	-8,125	-1,850	10,338	10,338	10,338	10,338	10,338	10,338	10,338	10,338	10,338	10,338	10,338
17	PV Year 1, r=10%	-6,875	-6,707	-6,544	-7,545	-1,676	9,137	8,914	8,697	8,484	8,278	8,076	7,879	7,687	7,499	7,316	7,138
18																	
19	Project NPV, $	59,756															
20	all units in thousands, $																

+10% DevCost

Figure 8: +10% DevCost Analysis

If you have followed this process correctly, then the result is a Project NPV of $59,756K for the *10% DevCost worksheet*, as shown in Figure 8.

Step 4: Create the *-10% DevCost* **Workshet**

Create a copy of the *10% DevCost* worksheet.

The tab name to enter is: *-10% DevCost*

Once you have the *-10% DevCost* worksheet created, it is quick to edit the Worksheet parameters as follows:

1. Cell B1: Change to -10%

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
1	Development Cost Analysis	-10%															
2		Year 1				Year 2				Year 3				Year 4			
3	period	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
4	($ values in thousands	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
5																	
6	Development Cost	-5,625	-5,625	-5,625	-5,625												
7	Ramp-up cost					-1,250	-1,250										
8	Marketing & suppost cost						-600	-600	-600	-600	-600	-600	-600	-600	-600	-600	-600
9	Production cost							-10,938	-10,938	-10,938	-10,938	-10,938	-10,938	-10,938	-10,938	-10,938	-10,938
10	Production volume							8,750	8,750	8,750	8,750	8,750	8,750	8,750	8,750	8,750	8,750
11	Unit production cost							-1.25	-1.25	-1.25	-1.25	-1.25	-1.25	-1.25	-1.25	-1.25	-1.25
12	Sales Revenue							21,875	21,875	21,875	21,875	21,875	21,875	21,875	21,875	21,875	21,875
13	Sales volume							8,750	8,750	8,750	8,750	8,750	8,750	8,750	8,750	8,750	8,750
14	Unit price							2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50
15																	
16	Period Cash Flow	-5,625	-5,625	-5,625	-6,875	-1,850	10,338	10,338	10,338	10,338	10,338	10,338	10,338	10,338	10,338	10,338	10,338
17	PV Year 1, r=10%	-5,625	-5,488	-5,354	-6,384	-1,676	9,137	8,914	8,697	8,484	8,278	8,076	7,879	7,687	7,499	7,316	7,138
18																	
19	Project NPV, $	64,576															
20	all units in thousands, $																

-10% DevCost

Figure 9: -10% DevCost NPV Analysis

If you have followed this process correctly, then the result is a Project NPV of $64,576K for the *-10% DevCost worksheet*, as shown in Figure 9.

Step 5: Create the *+20% DevCost* **Workshet**

Create a copy of the *-10% DevCost* worksheet.

The tab name to enter is: *20% DevCost*

Once you have the *20% DevCost* worksheet created, it is quick to edit the Worksheet parameters as follows:

1. Cell B1: Change to 20%

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
1	Development Cost Analysis	20%															
2		Year 1				Year 2				Year 3				Year 4			
3	period	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
4	($ values in thousands	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
5																	
6	Development Cost	-7,500	-7,500	-7,500	-7,500												
7	Ramp-up cost				-1,250	-1,250											
8	Marketing & suppost cost					-600	-600	-600	-600	-600	-600	-600	-600	-600	-600	-600	-600
9	Production cost						-10,938	-10,938	-10,938	-10,938	-10,938	-10,938	-10,938	-10,938	-10,938	-10,938	-10,938
10	Production volume						8,750	8,750	8,750	8,750	8,750	8,750	8,750	8,750	8,750	8,750	8,750
11	Unit production cost						-1.25	-1.25	-1.25	-1.25	-1.25	-1.25	-1.25	-1.25	-1.25	-1.25	-1.25
12	Sales Revenue						21,875	21,875	21,875	21,875	21,875	21,875	21,875	21,875	21,875	21,875	21,875
13	Sales volume						8,750	8,750	8,750	8,750	8,750	8,750	8,750	8,750	8,750	8,750	8,750
14	Unit price						2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50
15																	
16	Period Cash Flow	-7,500	-7,500	-7,500	-8,750	-1,850	10,338	10,338	10,338	10,338	10,338	10,338	10,338	10,338	10,338	10,338	10,338
17	PV Year 1, r=10%	-7,500	-7,317	-7,139	-8,125	-1,676	9,137	8,914	8,697	8,484	8,278	8,076	7,879	7,687	7,499	7,316	7,138
18																	
19	Project NPV, $	57,346															
20	all units in thousands, $																

+20% DevCost

Figure 10: +20% DevCost NPV Analysis

If you have followed this process correctly, then the result is a Project NPV of $57,346K for the *20% DevCost worksheet*, as shown in Figure 10.

Step 6: Create the *-20% DevCost* Worksheet

Repeat a copy of the 2*0% DevCost* worksheet.

The tab name to enter is: *-20% DevCost*

Once you have the *-20% DevCost* worksheet created, it is quick to edit the worksheet parameters as follows:

1. Cell B1: Change to -20%

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
1	Development Cost Analysis	-20%															
2		Year 1				Year 2				Year 3				Year 4			
3	period	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
4	($ values in thousands	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
5																	
6	Development Cost	-5,000	-5,000	-5,000	-5,000												
7	Ramp-up cost				-1,250	-1,250											
8	Marketing & suppost cost					-600	-600	-600	-600	-600	-600	-600	-600	-600	-600	-600	-600
9	Production cost						-10,938	-10,938	-10,938	-10,938	-10,938	-10,938	-10,938	-10,938	-10,938	-10,938	-10,938
10	Production volume						8,750	8,750	8,750	8,750	8,750	8,750	8,750	8,750	8,750	8,750	8,750
11	Unit production cost						-1.25	-1.25	-1.25	-1.25	-1.25	-1.25	-1.25	-1.25	-1.25	-1.25	-1.25
12	Sales Revenue						21,875	21,875	21,875	21,875	21,875	21,875	21,875	21,875	21,875	21,875	21,875
13	Sales volume						8,750	8,750	8,750	8,750	8,750	8,750	8,750	8,750	8,750	8,750	8,750
14	Unit price						2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50
15																	
16	Period Cash Flow	-5,000	-5,000	-5,000	-6,250	-1,850	10,338	10,338	10,338	10,338	10,338	10,338	10,338	10,338	10,338	10,338	10,338
17	PV Year 1, r=10%	-5,000	-4,878	-4,759	-5,804	-1,676	9,137	8,914	8,697	8,484	8,278	8,076	7,879	7,687	7,499	7,316	7,138
18																	
19	Project NPV, $	66,986															
20	all units in thousands, $																

◄ ◄ ► ►I   **-20% DevCost**

Figure 11: -20% DevCost NPV Analysis

If you have followed this process correctly, then the result is a Project NPV of $66,986K for the *-20% DevCost worksheet*, as shown in Figure 11.

Step 7: Create the *+30% DevCost* Worksheet

Create a copy of the *-20% DevCost* worksheet.

The tab name to enter is: *30% DevCost*

Once you have the *30% DevCost* worksheet created, it is quick to edit the worksheet parameters as follows:

1. Cell B1: Change to 30%

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
1	Development Cost Analysis	**30%**															
2		Year 1				Year 2				Year 3				Year 4			
3	period	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
4	($ values in thousands	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
5																	
6	Development Cost	-8,125	-8,125	-8,125	-8,125												
7	Ramp-up cost					-1,250	-1,250										
8	Marketing & suppost cost						-600	-600	-600	-600	-600	-600	-600	-600	-600	-600	-600
9	Production cost							-10,938	-10,938	-10,938	-10,938	-10,938	-10,938	-10,938	-10,938	-10,938	-10,938
10	Production volume							8,750	8,750	8,750	8,750	8,750	8,750	8,750	8,750	8,750	8,750
11	Unit production cost							-1.25	-1.25	-1.25	-1.25	-1.25	-1.25	-1.25	-1.25	-1.25	-1.25
12	Sales Revenue							21,875	21,875	21,875	21,875	21,875	21,875	21,875	21,875	21,875	21,875
13	Sales volume							8,750	8,750	8,750	8,750	8,750	8,750	8,750	8,750	8,750	8,750
14	Unit price							2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50
15																	
16	Period Cash Flow	-8,125	-8,125	-8,125	-9,375	-1,850	10,338	10,338	10,338	10,338	10,338	10,338	10,338	10,338	10,338	10,338	10,338
17	PV Year 1, r=10%	-8,125	-7,927	-7,733	-8,706	-1,676	9,137	8,914	8,697	8,484	8,278	8,076	7,879	7,687	7,499	7,316	7,138
18																	
19	Project NPV, $	54,936															
20	all units in thousands, $																

+30% DevCost

Figure 12: 30% DevCost NPV Analysis

If you have followed this process correctly, then the result is a Project NPV of $54,936K for the *30% DevCost worksheet*, as shown in Figure 12.

Step 8: Create the *-30% DevCost* Worksheet

Create a copy of the *30% DevCost* worksheet.

The tab name to enter is: *-30% DevCost*

Once you have the *-30% DevCost* worksheet created, it is quick to edit the worksheet parameters as follows:

1. Cell B1: Change to -30%

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
1	Development Cost Analysis	-30%															
2		Year 1				Year 2				Year 3				Year 4			
3	period, n	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
4	($ values in thousands	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
5																	
6	Development Cost	-4,375	-4,375	-4,375	-4,375												
7	Ramp-up cost					-1,250	-1,250										
8	Marketing & suppost cost					-600	-600	-600	-600	-600	-600	-600	-600	-600	-600	-600	-600
9	Production cost						-10,938	-10,938	-10,938	-10,938	-10,938	-10,938	-10,938	-10,938	-10,938	-10,938	-10,938
10	Production volume						8,750	8,750	8,750	8,750	8,750	8,750	8,750	8,750	8,750	8,750	8,750
11	Unit production cost						-1.25	-1.25	-1.25	-1.25	-1.25	-1.25	-1.25	-1.25	-1.25	-1.25	-1.25
12	Sales Revenue						21,875	21,875	21,875	21,875	21,875	21,875	21,875	21,875	21,875	21,875	21,875
13	Sales volume						8,750	8,750	8,750	8,750	8,750	8,750	8,750	8,750	8,750	8,750	8,750
14	Unit price						2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50
15																	
16	Period Cash Flow	-4,375	-4,375	-4,375	-5,625	-1,850	10,338	10,338	10,338	10,338	10,338	10,338	10,338	10,338	10,338	10,338	10,338
17	PV Year 1, r=10%	-4,375	-4,268	-4,164	-5,223	-1,676	9,137	8,914	8,697	8,484	8,278	8,076	7,879	7,687	7,499	7,316	7,138
18																	
19	Project NPV, $	69,396															
20	all units in thousands, $																

-30% DevCost

Figure 13: -30% DevCost NPV Analysis

If you have followed this process correctly, then the result is a Project NPV of $69,396K for the *-30% DevCost worksheet*, as show in Figure 13.

Step 9: Create the *DevelopmentCost_Sensitivity* summary worksheet

Now we want to consolidate all the results into one worksheet, to rapidly discern the results.

To do this, Insert a new, blank worksheet. This is done under the HOME->INSERT menu option.(or you use the Shift+F11 shortcut).
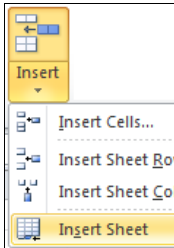

Figure 14: Insert Sheet (Shift+F11)

Name the Tab: DevelopmentCost_Sensitivity

Format and program the worksheet as follows:

	A	B	C	D	E	F	G
1	Base Dev Cost, $	Change in Developm ent	Development Cost, $ Thousands	Change in Development Cost, $ Thousands	NPV, $ Thousands	Change in NPV, %	Change in NPV, $ Thousands
2	=ScenarioParameters!$B$3/1000	0.3	=A2*(1+B2)	=C2-A2	='+30% DevCost'!B19	=(E2-$E$5)/$E$5	=E2-$E$5
3	=ScenarioParameters!$B$3/1000	0.2	=A3*(1+B3)	=C3-A3	='+20% DevCost'!B19	=(E3-$E$5)/$E$5	=E3-$E$5
4	=ScenarioParameters!$B$3/1000	0.1	=A4*(1+B4)	=C4-A4	='+10% DevCost'!B19	=(E4-$E$5)/$E$5	=E4-$E$5
5	=ScenarioParameters!$B$3/1000	0	=A5*(1+B5)	=C5-A5	=BaseCase!B19	=(E5-$E$5)/$E$5	=E5-$E$5
6	=ScenarioParameters!$B$3/1000	-0.1	=A6*(1+B6)	=C6-A6	='-10% DevCost'!B19	=(E6-$E$5)/$E$5	=E6-$E$5
7	=ScenarioParameters!$B$3/1000	-0.2	=A7*(1+B7)	=C7-A7	='-20% DevCost'!B19	=(E7-$E$5)/$E$5	=E7-$E$5
8	=ScenarioParameters!$B$3/1000	-0.3	=A8*(1+B8)	=C8-A8	='-30% DevCost'!B19	=(E8-$E$5)/$E$5	=E8-$E$5

DevelopmentCost_Sensitivity

Figure 15: Cell Programming for the DevelopmentCost_Sensitivity worksheet

You will notice that the text in Cell A1 is formatted into in three lines, within one Cell. This is done using the ALT-ENTER command to create a Line Break, within the Cell. Type "Change In", then press ALT-ENTER on the keyboard, type "Development", then press ALT-ENTER again, type "Cost,%", then press ENTER on the keyboard. This process will create the three line break, within one Cell. Then you can Center the text using the built-in alignment tool .

Figure 16: Format of the DevelopmentCost_Sensitivity Worksheet

In Figure 16, is shown the final output format for the **DevelopmentCost_Sensitivity** worksheet. These results are now fully linked to all the worksheets, which are connected to the **ScenarioParameters** worksheet. Now, if you change one parameter in the scenario, the Sensitivity Analysis is instantly updated for you. You are now capable of rapidly solving new problems!

Step 10: Worksheet Tab Review

You can make sure your worksheet tab names look as follows. You can drag and drop to move them to different positions along the horizontal workbook axis.
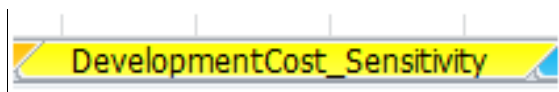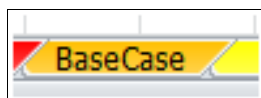
Step 11: Graph the Change in NPV ($) vs. Change in DevCost (%)

Next, you want to graph the relationship between the *(Chain in NPV, $ Thousand)(y-axis)* vs. *(Change in Development Cost, %)(x-axis)*.

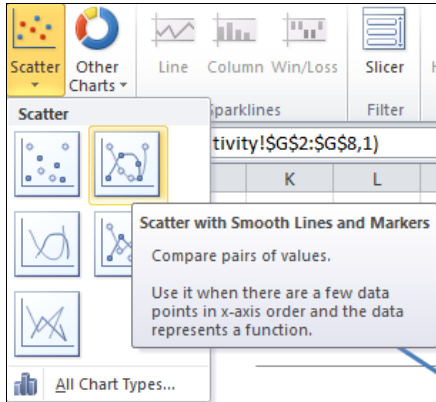To do this, you *Insert a Chart.* You can select the *Scatter with Smooth Lines and Markers.*

Figure 17: Chart Format Option
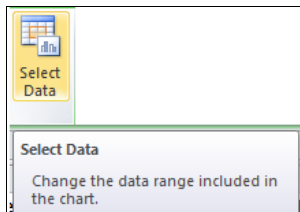
Next, Select the Data.

Figure 18: Select the Data
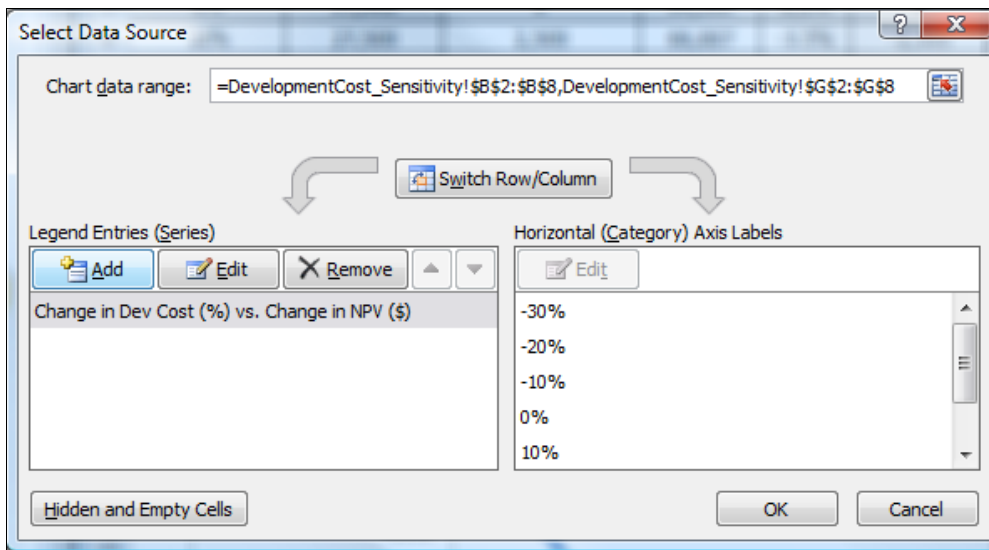
Then ADD a data series:

Figure 19: Add a Data Series

Configure the Series as follows, in which you type the text into the white box. If you see "={1}" in the Series Y values white space, delete it. Then enter the information below
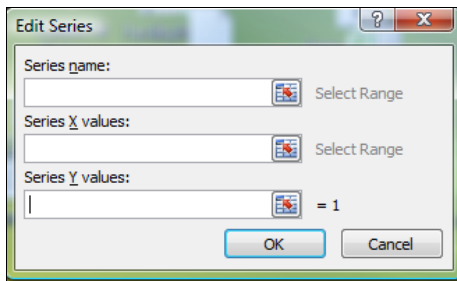

Figure 20: Edit Data Series X and Y axis

SERIES NAME: Change in NPV ($) vs Change in Dev Cost (%)

SERIES X VALUES: =DevelopmentCost_Sensitivity!$B$2:$B$8

SERIES Y VALUES: =DevelopmentCost_Sensitivity!$G$2:$G$8

Lastly, using the LAYOUT Ribbon, you will find all the options to Label each axis and change the units of the graph along with other visual tools
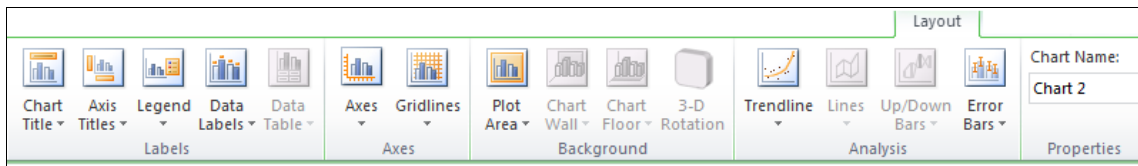

Figure 21: Layout Ribbon Tool to Label Charts

The end result, should look similar to the following chart in Figure 22:
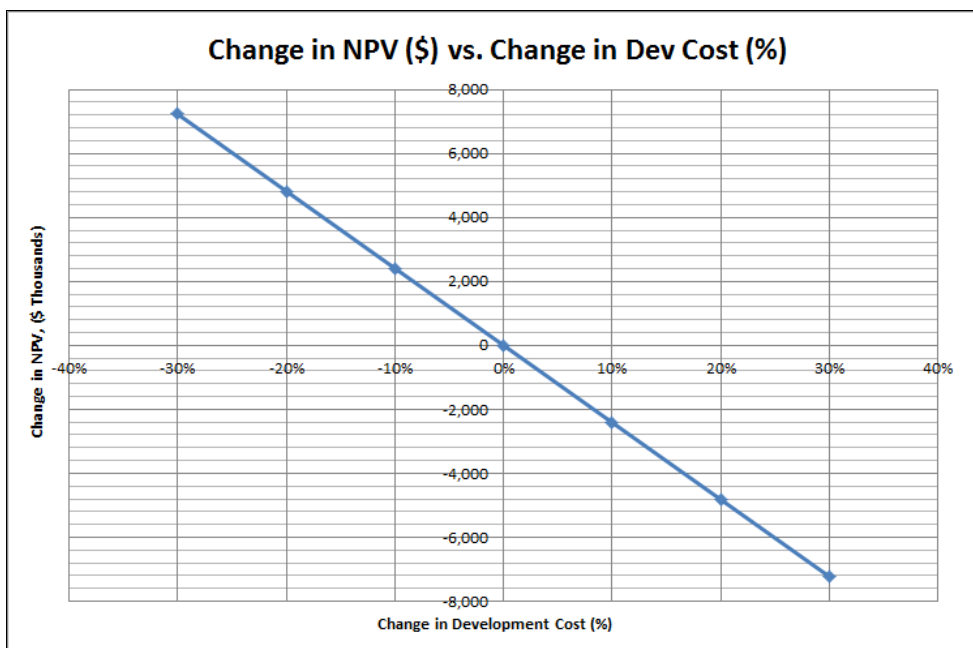

Figure 22: Change in NPV ($) vs. Change in DevCost (%)

One last useful technique is to determine the slope of the line. There is a useful tool in Excel called *Trendline.* You can search to learn more about Excel Trendline.

The shortcut approach is to right-click on the line, and selects the ADD TRENDLINE.
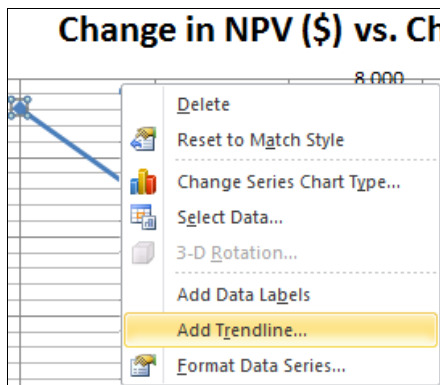
Figure 23: Add Trendline Shortcut (right-click)

Then format the Trendline as follows:
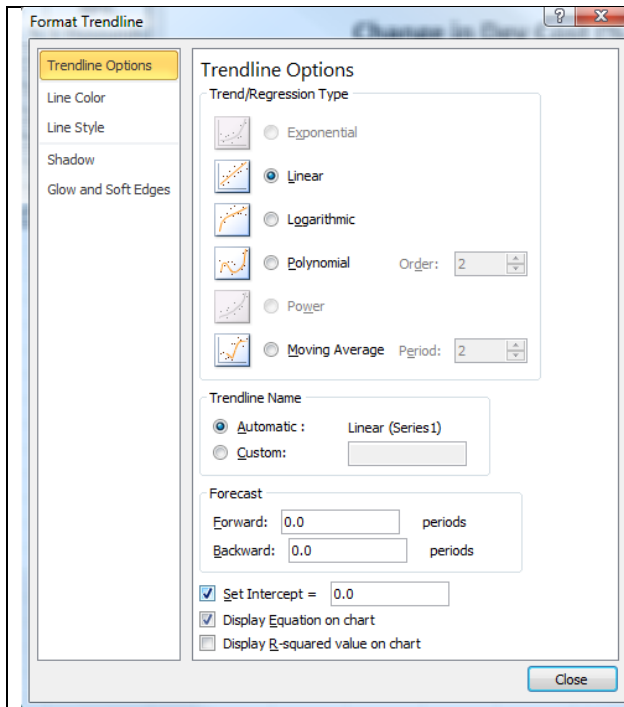
Figure 24: Trendline Configuration

For this data series, we set the Regression Line to *Linear*, because we are assuming linearity in the data with the Base Case crossing at x=0 and y=0, set Intercept to equal 0. Restated, we are including the BaseCase, which crosses both the X and Y axis at exactly zero and therefore, zero will be the Intercept of the equation.

Also, the important feature here is to check the box to: **Display Equation on Chart**. This will automate the regression analysis and put the equation of the line on the chart.

The new Chart will look as show in Figure 25. Nnotice a thin black line was created inside the original line and the equation of the line is now visible:
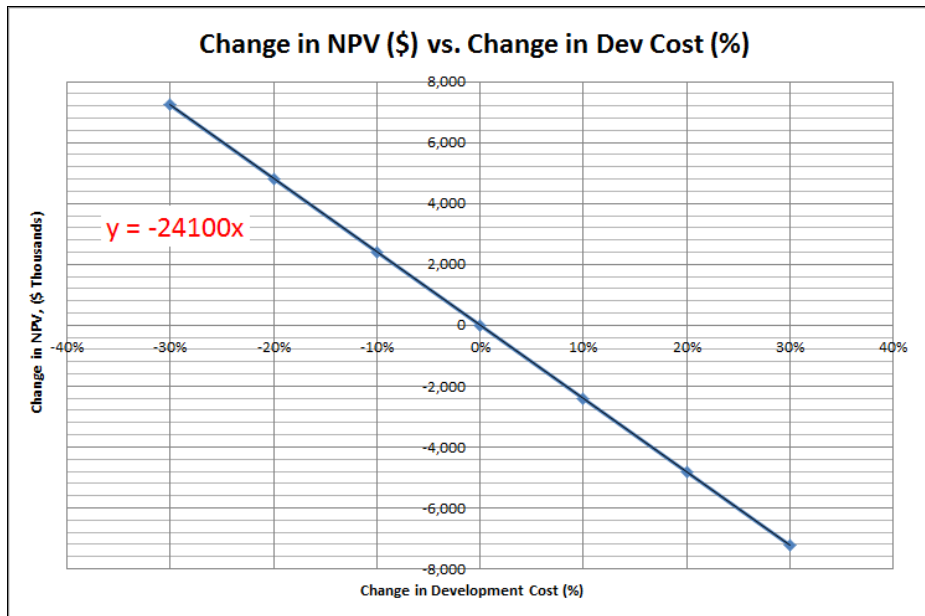
Figure 25: Change in NPV ($) vs. Change in DevCost (%)

The equation in this example, in *y=mx+b* format, is $y = -24100x + 0$. In which **m=-24100** and **b=0**. That translates to a trade-off law: For each 10% increase (x-axis value) in development cost, there is a $2410 (in thousands) <u>reduction</u> in NPV.

To format the textbox containing the equation, like in Figure 25, click on the floating textbox that contains the equation, and then change the Font Color and Font Size and Fill the box with a color, all to help it stand out. In this example, the font has been increased to size 18, colored Red, and filled with a White background to make it easier to read against the grid lines. You can also move the textbox and change its location, as necessary.
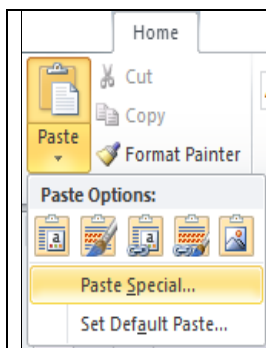
Figure 26: "Paste Special" to Insert Graphics

You can copy the Chart in Excel, then open an MS Word document and then can use the "Paste Special" option to insert as a image (JPEG, BITMAP, or PNG) to ensure it is inserted uniformly into the document. The format of BITMAP is the least compressed and therefore will increase the size of your document the most. However, "what you see it what you get", so is a safe option until you are comfortable adjusting the graphic formats that minimize the file size and maximize readability.

When you paste images into MS Word, you can automate the process of the sequential numbering and labeling of the Figures/Table using *Insert Captions*.

Useful Instructions <u>Adding/Deleting Captions</u> for Figures & Tables:
http://office.microsoft.com/en-us/word-help/add-or-delete-captions-HP001228982.aspx

Step 12: Create the *+10% SalesVol* **Worksheet**

Create a copy of the ***BaseCase*** worksheet.

The Tab name to enter is: ***10% SalesVol***

Once you have the ***10% SalesVol*** worksheet created, it is quick to edit the worksheet parameters as follows:

1. Cell A1, change to **Sales Volume Analysis**

2. Cell B1: change to **10**%

3. Cell G9: change to:
   =(-1)*(ScenarioParameters!$B$5)*((ScenarioParameters!$B$2/4) *(1+$B$1))*(1/1000)

   a. ***Note:*** ScenarioParameters!$B$2 is the link to *Sales & Production Volume (units/year).*
   b. ***Note:*** ScenarioParameters!$B$5 is the link to the *Unit Productions Cost ($/unit).*
   c. ***Note:*** Dividing *ScenarioParameters!$B$2* by *4*, converts Volume from Yearly to Quarterly
   d. ***Note:*** Multiplying *(ScenarioParameters!$B$2/4)* by *(1+$B$1)*, in which $B$1 is the sensitivity value, creates the change in measure for sensitivity.
   e. ***Note:*** Multiplying (1/1000), converts from Millions $ to Thousands $.

4. Cell G10: change to:
   =(ScenarioParameters!$B$2/4)*(1+$B$1)

   a. ***Note:*** ScenarioParameters!$B$2 is the link to *Sales & Production Volume (units/year).*
   b. ***Note:*** Dividing *ScenarioParameters!$B$2* by *4*, converts Volume from Yearly to Quarterly.
   c. ***Note:*** Multiplying *(ScenarioParameters!$B$2/4)* by *(1+$B$1)*, in which $B$1 is the sensitivity value, creates the change in measure for sensitivity.

5. Cell G12: change to:
   =(ScenarioParameters!$B$2)*((ScenarioParameters!$B$4/4)*(1+$B$1))*(1/1000)

   a. ***Note:*** ScenarioParameters!$B$2 is the link to *Sales & Production Volume (units/year).*
   b. ***Note:*** ScenarioParameters!$B$4 is the link to *Unit price ($/unit).*
   c. ***Note:*** Dividing *ScenarioParameters!$B$4* by *4*, converts Volume from Yearly to Quarterly
   d. ***Note:*** Multiplying *(ScenarioParameters!$B$4/4)* by *(1+$B$1)*, in which $B$1 is the sensitivity value, creates the change in measure for sensitivity.
   e. ***Note:*** Multiplying (1/1000), converts from Millions $ to Thousands $.

6. Cell G13: change to:
   =(ScenarioParameters!$B$2/4)*(1+$B$1)

   a. Note: ScenarioParameters!$B$2 is the link to *Sales & Production Volume (units/year).*
   b. Note: Dividing ScenarioParameters!$B$2 by *4*, converts Volume from Yearly to Quarterly.
   c. Note: Multiplying *(ScenarioParameters!$B$2/4)* by *(1+$B$1)*, in which $B$1 is the sensitivity value, creates the change in measure for sensitivity.

7. Copy G9 to H10:Q10.

8. Copy G10 to H10:Q10.

9. Copy G12 to H10:Q10.

10. Copy G13 to H10:Q10

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
1	Sales Volume Analysis	**10%**															
2		Year 1				Year 2				Year 3				Year 4			
3	period	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
4	($ values in thousands	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
5																	
6	Development Cost	-6,250	-6,250	-6,250	-6,250												
7	Ramp-up cost					-1,250	-1,250										
8	Marketing & suppost cost					-600	-600	-600	-600	-600	-600	-600	-600	-600	-600	-600	-600
9	Production cost						-12,031	-12,031	-12,031	-12,031	-12,031	-12,031	-12,031	-12,031	-12,031	-12,031	-12,031
10	Production volume						9,625	9,625	9,625	9,625	9,625	9,625	9,625	9,625	9,625	9,625	9,625
11	Unit production cost						-1.25	-1.25	-1.25	-1.25	-1.25	-1.25	-1.25	-1.25	-1.25	-1.25	-1.25
12	Sales Revenue						24,063	24,063	24,063	24,063	24,063	24,063	24,063	24,063	24,063	24,063	24,063
13	Sales volume						9,625	9,625	9,625	9,625	9,625	9,625	9,625	9,625	9,625	9,625	9,625
14	Unit price						2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50
15																	
16	Period Cash Flow	-6,250	-6,250	-6,250	-7,500	-1,850	11,431	11,431	11,431	11,431	11,431	11,431	11,431	11,431	11,431	11,431	11,431
17	PV Year 1, r=10%	-6,250	-6,098	-5,949	-6,964	-1,676	10,104	9,857	9,617	9,382	9,153	8,930	8,712	8,500	8,292	8,090	7,893
18																	
19	Project NPV, $	71,594															
20	all units in thousands, $																

+10% SalesVol

Figure 27: 10% Sales Volume NPV Analysis

If you have followed this process correctly, then the result is a Project NPV of $71,594K for the 10% *SalesVol worksheet*, as show in Figure 27.

Step 13: Create the *-10% SalesVol* Worksheet

Create a copy of the "**10% SalesVol" worksheet**.

The Tab name to enter is: **-10% SalesVol**

Once you have the **-10% SalesVol** worksheet created, it is quick to edit the worksheet parameters as follows:

1. Cell B1: change to: **-10%**

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
1	Sales Volume Analysis	-10%															
2		Year 1				Year 2				Year 3				Year 4			
3	period	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
4	($ values in thousands	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
5																	
6	Development Cost	-6,250	-6,250	-6,250	-6,250												
7	Ramp-up cost				-1,250	-1,250											
8	Marketing & suppost cost					-600	-600	-600	-600	-600	-600	-600	-600	-600	-600	-600	-600
9	Production cost						-9,844	-9,844	-9,844	-9,844	-9,844	-9,844	-9,844	-9,844	-9,844	-9,844	-9,844
10	Production volume						7,875	7,875	7,875	7,875	7,875	7,875	7,875	7,875	7,875	7,875	7,875
11	Unit production cost						-1.25	-1.25	-1.25	-1.25	-1.25	-1.25	-1.25	-1.25	-1.25	-1.25	-1.25
12	Sales Revenue						19,688	19,688	19,688	19,688	19,688	19,688	19,688	19,688	19,688	19,688	19,688
13	Sales volume						7,875	7,875	7,875	7,875	7,875	7,875	7,875	7,875	7,875	7,875	7,875
14	Unit price						2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50
15																	
16	Period Cash Flow	-6,250	-6,250	-6,250	-7,500	-1,850	9,244	9,244	9,244	9,244	9,244	9,244	9,244	9,244	9,244	9,244	9,244
17	PV Year 1, r=10%	-6,250	-6,098	-5,949	-6,964	-1,676	8,170	7,971	7,776	7,587	7,402	7,221	7,045	6,873	6,706	6,542	6,382
18																	
19	Project NPV, $	52,739															
20	all units in thousands, $																

-10% SalesVol

Figure 28: -10% Sale Volume NPV Analysis

If you have followed this process correctly, then the result is a Project NPV of $52,739K for the *-10% SalesVol worksheet*, as show in Figure 28.

Step 14: Create the *+20% SalesVol* **Worksheet**

Create a copy of the "*-10% SalesVol*" *worksheet.*

The Tab name to enter is: **20% SalesVol**

1. Cell B1: change to **20%**

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
1	Sales Volume Analysis	**20%**															
2	**20%**	Year 1				Year 2				Year 3				Year 4			
3	period	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
4	($ values in thousands	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
5																	
6	Development Cost	-6,250	-6,250	-6,250	-6,250												
7	Ramp-up cost				-1,250	-1,250											
8	Marketing & suppost cost					-600	-600	-600	-600	-600	-600	-600	-600	-600	-600	-600	-600
9	Production cost						-13,125	-13,125	-13,125	-13,125	-13,125	-13,125	-13,125	-13,125	-13,125	-13,125	-13,125
10	Production volume						10,500	10,500	10,500	10,500	10,500	10,500	10,500	10,500	10,500	10,500	10,500
11	Unit production cost						-1.25	-1.25	-1.25	-1.25	-1.25	-1.25	-1.25	-1.25	-1.25	-1.25	-1.25
12	Sales Revenue						26,250	26,250	26,250	26,250	26,250	26,250	26,250	26,250	26,250	26,250	26,250
13	Sales volume						10,500	10,500	10,500	10,500	10,500	10,500	10,500	10,500	10,500	10,500	10,500
14	Unit price						2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50
15																	
16	Period Cash Flow	-6,250	-6,250	-6,250	-7,500	-1,850	12,525	12,525	12,525	12,525	12,525	12,525	12,525	12,525	12,525	12,525	12,525
17	PV Year 1, r=10%	-6,250	-6,098	-5,949	-6,964	-1,676	11,070	10,800	10,537	10,280	10,029	9,785	9,546	9,313	9,086	8,864	8,648
18																	
19	Project NPV, $	81,021															
20	all units in thousands, $																

+20% SalesVol

Figure 29: 20% Sales Volume NPV Analysis

If you have followed this process correctly, then the result is a Project NPV of $81,021K for the *20% SalesVol worksheet*, as shown in Figure 29.

Step 15: Create the *-20% SalesVol* Worksheet

Create a copy of the "**20% SalesVol" worksheet**.

The Tab name to enter is: **-20% SalesVol**

1. Cell B1: change to **-20%**

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
1	Sales Volume Analysis	**-20%**															
2		Year 1				Year 2				Year 3				Year 4			
3	period	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
4	($ values in thousands	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
5																	
6	Development Cost	-6,250	-6,250	-6,250	-6,250												
7	Ramp-up cost				-1,250	-1,250											
8	Marketing & suppost cost					-600	-600	-600	-600	-600	-600	-600	-600	-600	-600	-600	-600
9	Production cost						-8,750	-8,750	-8,750	-8,750	-8,750	-8,750	-8,750	-8,750	-8,750	-8,750	-8,750
10	Production volume						7,000	7,000	7,000	7,000	7,000	7,000	7,000	7,000	7,000	7,000	7,000
11	Unit production cost						-1.25	-1.25	-1.25	-1.25	-1.25	-1.25	-1.25	-1.25	-1.25	-1.25	-1.25
12	Sales Revenue						17,500	17,500	17,500	17,500	17,500	17,500	17,500	17,500	17,500	17,500	17,500
13	Sales volume						7,000	7,000	7,000	7,000	7,000	7,000	7,000	7,000	7,000	7,000	7,000
14	Unit price						2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50
15																	
16	Period Cash Flow	-6,250	-6,250	-6,250	-7,500	-1,850	8,150	8,150	8,150	8,150	8,150	8,150	8,150	8,150	8,150	8,150	8,150
17	PV Year 1, r=10%	-6,250	-6,098	-5,949	-6,964	-1,676	7,203	7,028	6,856	6,689	6,526	6,367	6,211	6,060	5,912	5,768	5,627
18																	
19	Project NPV, $	43,311															
20	all units in thousands, $																
		-20% SalesVol															

Figure 30: -20% SalesVol NPV Analysis

If you have followed this process correctly, then the result is a Project NPV of $43,311 for the *-20% SalesVol worksheet*, as show in Figure 30.

Step 16: Create the *+30% SalesVol* Worksheet

Create a copy of the "*-20% SalesVol*" *worksheet*.

The Tab name to enter is: ***30% SalesVol***

1. Cell B1: Change to ***30%***

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
1	Sales Volume Analysis	30%															
2		Year 1				Year 2				Year 3				Year 4			
3	period	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
4	($ values in thousands	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
5																	
6	Development Cost	-6,250	-6,250	-6,250	-6,250												
7	Ramp-up cost				-1,250	-1,250											
8	Marketing & suppost cost					-600	-600	-600	-600	-600	-600	-600	-600	-600	-600	-600	-600
9	Production cost						-14,219	-14,219	-14,219	-14,219	-14,219	-14,219	-14,219	-14,219	-14,219	-14,219	-14,219
10	Production volume						11,375	11,375	11,375	11,375	11,375	11,375	11,375	11,375	11,375	11,375	11,375
11	Unit production cost						-1.25	-1.25	-1.25	-1.25	-1.25	-1.25	-1.25	-1.25	-1.25	-1.25	-1.25
12	Sales Revenue						28,438	28,438	28,438	28,438	28,438	28,438	28,438	28,438	28,438	28,438	28,438
13	Sales volume						11,375	11,375	11,375	11,375	11,375	11,375	11,375	11,375	11,375	11,375	11,375
14	Unit price						2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50
15																	
16	Period Cash Flow	-6,250	-6,250	-6,250	-7,500	-1,850	13,619	13,619	13,619	13,619	13,619	13,619	13,619	13,619	13,619	13,619	13,619
17	PV Year 1, r=10%	-6,250	-6,098	-5,949	-6,964	-1,676	12,037	11,743	11,457	11,178	10,905	10,639	10,379	10,126	9,879	9,638	9,403
18																	
19	Project NPV, $	90,449															
20	all units in thousands, $																
	◄ ◄ ► ►◄	+30% SalesVol															

Figure 31: 30% Sales Volume NPV Analysis

If you have followed this process correctly, then the result is a Project NPV of $90,449K for the *30% SalesVol worksheet*, as show in Figure 31.

Step 17: Create the *-30% SalesVol* Worksheet

Create a copy of the "**30% SalesVol" worksheet**.

The Tab name to enter is: **-30% SalesVol**

1. Cell B1: Change to **-30%**

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
1	Sales Volume Analysis	-30%															
2		Year 1				Year 2				Year 3				Year 4			
3	period	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
4	($ values in thousands	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
5																	
6	Development Cost	-6,250	-6,250	-6,250	-6,250												
7	Ramp-up cost				-1,250	-1,250											
8	Marketing & suppost cost					-600	-600	-600	-600	-600	-600	-600	-600	-600	-600	-600	-600
9	Production cost						-7,656	-7,656	-7,656	-7,656	-7,656	-7,656	-7,656	-7,656	-7,656	-7,656	-7,656
10	Production volume						6,125	6,125	6,125	6,125	6,125	6,125	6,125	6,125	6,125	6,125	6,125
11	Unit production cost						-1.25	-1.25	-1.25	-1.25	-1.25	-1.25	-1.25	-1.25	-1.25	-1.25	-1.25
12	Sales Revenue						15,313	15,313	15,313	15,313	15,313	15,313	15,313	15,313	15,313	15,313	15,313
13	Sales volume						6,125	6,125	6,125	6,125	6,125	6,125	6,125	6,125	6,125	6,125	6,125
14	Unit price						2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50
15																	
16	Period Cash Flow	-6,250	-6,250	-6,250	-7,500	-1,850	7,056	7,056	7,056	7,056	7,056	7,056	7,056	7,056	7,056	7,056	7,056
17	PV Year 1, r=10%	-6,250	-6,098	-5,949	-6,964	-1,676	6,237	6,085	5,936	5,791	5,650	5,512	5,378	5,247	5,119	4,994	4,872
18																	
19	Project NPV, $	33,884															
20	all units in thousands, $																
	-30% SalesVol																

Figure 32: -30% Sales Volume NPV Analysis

If you have followed this process correctly, then the result is a Project NPV of $33,884 for the *-30% SalesVol worksheet*, as show in Figure 32.

Step 18: Create the *SalesVolume_Sensitivity* **summary worksheet**

Create a new worksheet and name the worksheet Tab: ***SalesVolume_Sensitivity***

Format and program the worksheet as follows:

	A	B	C	D	E	F	G
	Base Sales Volume, Qty	**Change in Sales Volume, %**	**Sales Volume, Qty**	**Change in Sales Volume, Qty**	**Change in NPV, %**	**NPV, $ Thousands**	**Change in NPV, $ Thousands**
1							
2	=ScenarioParameters!$B$2/4	0.3	=$A$2*(1+B2/100)	=C2-A2	=(F2-$F$5)/$F$5	='+30% SalesVol'!B19	=F2-$F$5
3	=ScenarioParameters!$B$2/4	0.2	=$A$2*(1+B3/100)	=C3-A3	=(F3-$F$5)/$F$5	='+20% SalesVol'!B19	=F3-$F$5
4	=ScenarioParameters!$B$2/4	0.1	=$A$2*(1+B4/100)	=C4-A4	=(F4-$F$5)/$F$5	='+10% SalesVol'!B19	=F4-$F$5
5	**=ScenarioParameters!$B$2/4**	0	=$A$2*(1+B5/100)	=C5-A5	=(F5-$F$5)/$F$5	=BaseCase!B19	=F5-$F$5
6	=ScenarioParameters!$B$2/4	-0.1	=$A$2*(1+B6/100)	=C6-A6	=(F6-$F$5)/$F$5	='-10% SalesVol'!B19	=F6-$F$5
7	=ScenarioParameters!$B$2/4	-0.2	=$A$2*(1+B7/100)	=C7-A7	=(F7-$F$5)/$F$5	='-20% SalesVol'!B19	=F7-$F$5
8	=ScenarioParameters!$B$2/4	-0.3	=$A$2*(1+B8/100)	=C8-A8	=(F8-$F$5)/$F$5	='-30% SalesVol'!B19	=F8-$F$5

| ◄ ◄ ► ► | SalesVolume_Sensitivity |

Figure 33: Programming format for SalesVolume_Sensitivity Summary Table

	A	B	C	D	E	F	G
	Base Sales Volume, Qty	**Change in Sales Volume, %**	**Sales Volume, Qty**	**Change in Sales Volume, Qty**	**Change in NPV, %**	**NPV, $ Thousands**	**Change in NPV, $ Thousands**
1							
2	8,750	30%	8,776	26	45%	90,449	28,282
3	8,750	20%	8,768	18	30%	81,021	18,855
4	8,750	10%	8,759	9	15%	71,594	9,427
5	8,750	**0%**	8,750	0	0%	62,166	0
6	8,750	-10%	8,741	-9	-15%	52,739	-9,427
7	8,750	-20%	8,733	-18	-30%	43,311	-18,855
8	8,750	-30%	8,724	-26	-45%	33,884	-28,282

| ◄ ◄ ► ► | **SalesVolume_Sensitivity** |

Figure 34: SalesVolume_Sensitivity Summary Table Results

As shown in Figure 34, the table is linked to all the Sales Volume worksheets and provides a clearly organized summary of the **SalesVolume_Sensitivity**.

Step 19: Graph the Change in NPV ($) vs. Change in Sales Volume (%)

Lastly, graph the relationship between the (*Change in NPV, $ Thousands*) vs. (*Change in Sales Volume, %)* as shown in Figure 35.
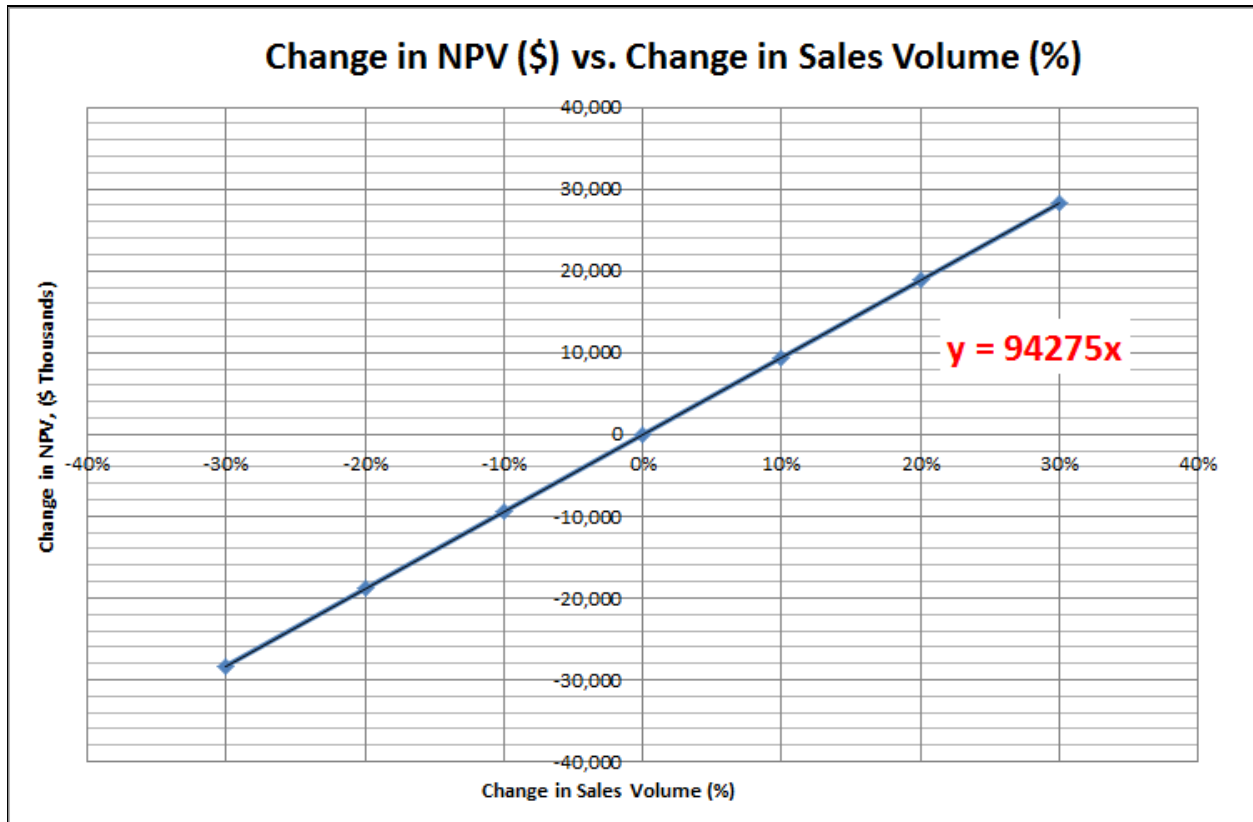

Figure 35: Change in NPV ($) vs. Change in Sales Volume (%)

The equation in this example, in y=mx+b format, is $y = 94275x$.

That translates to a trade-off law: For each 10% (x-axis value) increase in Sales Volumes, there is $9,427.50K increase in NPV.

Step 20: Using *Solver* to Determine Max Development Cost

> **Note:** Recall that in TIM-105 (1), you were given a problem on the Final Exam to determine the maximum development cost, for which a project would no longer be feasible. Note, that on the Final Exam, we also gave you (via email), a process for solving the problem.
>
> Now, we will walk you through an alternative method for solving this problem using an Add-In tool in Excel called *SOLVER*. This tool will be extremely helpful later in this course (TIM-125/225) and in your project. You can reference the "Getting Started in Visual Basic" on the TIM-125/225 course website to learn more.

A fast approach (i.e., takes under 1 minute for the author to do) to solving the maximum development cost problem is using the *Solver* Excel Add-in, to quickly determine what is the maximum development cost is the as follows:

On the **ScenarioParameters** worksheet, create a Cell Reference link to the NPV value in the **BaseCase** worksheet.

As shown in Figure 36, on **ScenarioParameters** Cell B1 enter: *=BaseCase!B19*. This will make a cell reference to the cell B19 of the **BaseCase**, which contains the NPV we want the *Solver Add-In* to optimize.

	A	B
1	**SCENARIO INPUT PARAMETERS**	
2	Sales & Production Volume (units/year)	35000
3	Development Cost (total $)	25000000
4	Unit price ($/unit)	2500
5	Unit Productions Cost ($/unit)	1250
6	Ramp-up cost (total $)	2500000
7	Marketing & suppost cost ($/year)	2400000
8	Annual Discount Factor (%)	10
9		
10		
11	Base-Case NPV	=BaseCase!B19
12		

ScenarioParameters

Figure 36: Programming of the ScenarioParemeters link to the BaseCase NPV

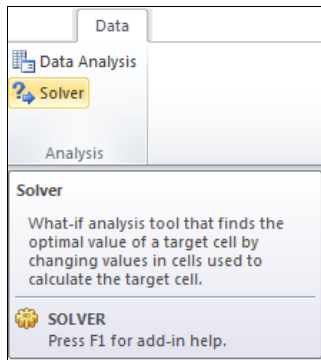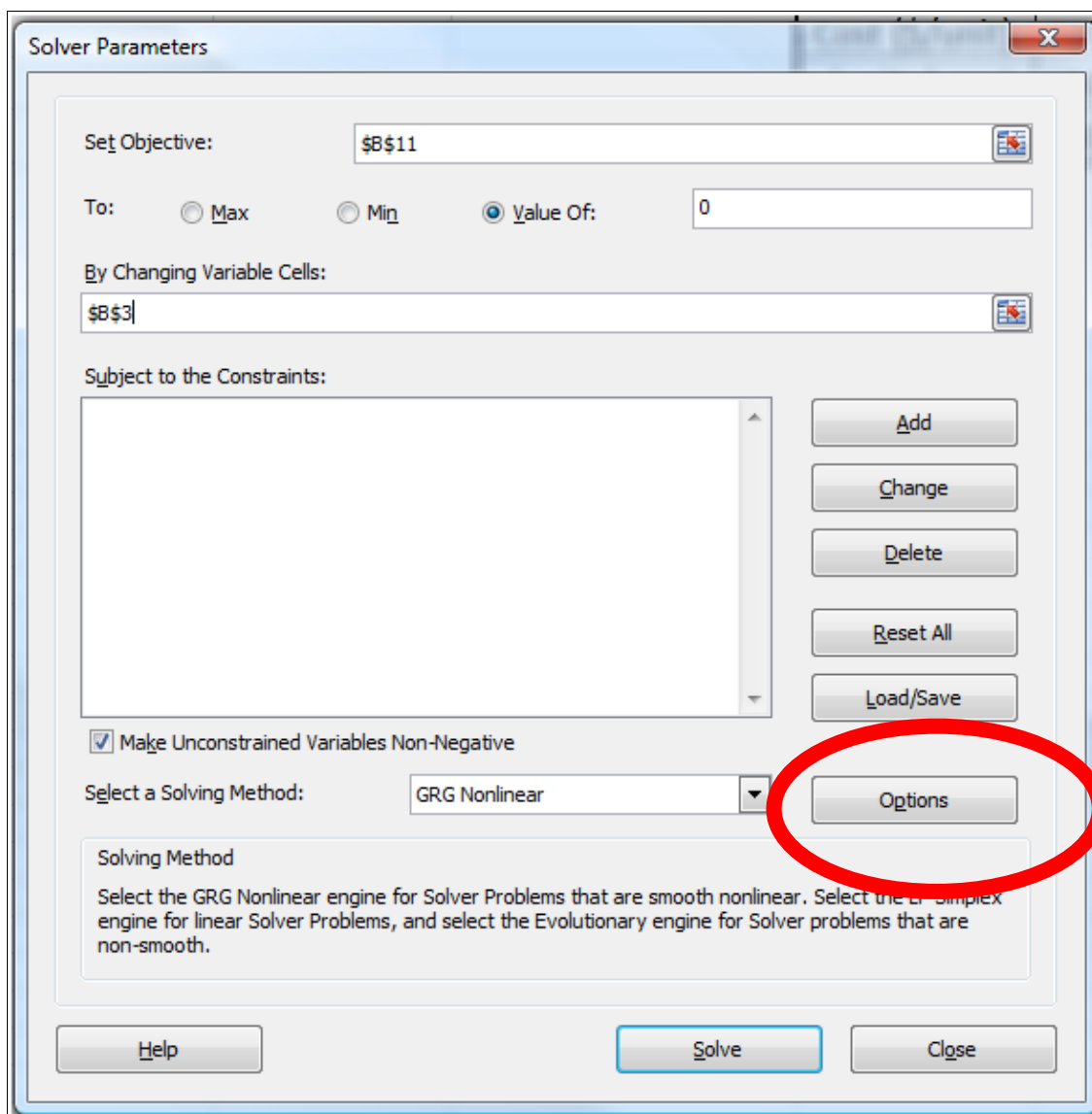Next, Open the *Solver* in the DATA: Analysis Ribbon:

Figure 37

Figure 38: Solver Configuration

To configure *Solver* to perform a simple optimization, to determine the optimal values in Cell $B$3, that makes Cell $B$11 equal to Value of 0 (zero), *Solver* will automatically make many

rapid changes in Cell $B$3 until Cell $B$11 reaches zero (0). Then it will stop and insert the solution in cell $B$3. This process will be almost instantaneous. Select the *GRG Nonlinear* Solving Method.

You need to also adjust a few of the OPTIONS to adjust for the accuracy of the optimizations. You can find the Options next the Solving Method (see Figure 38).
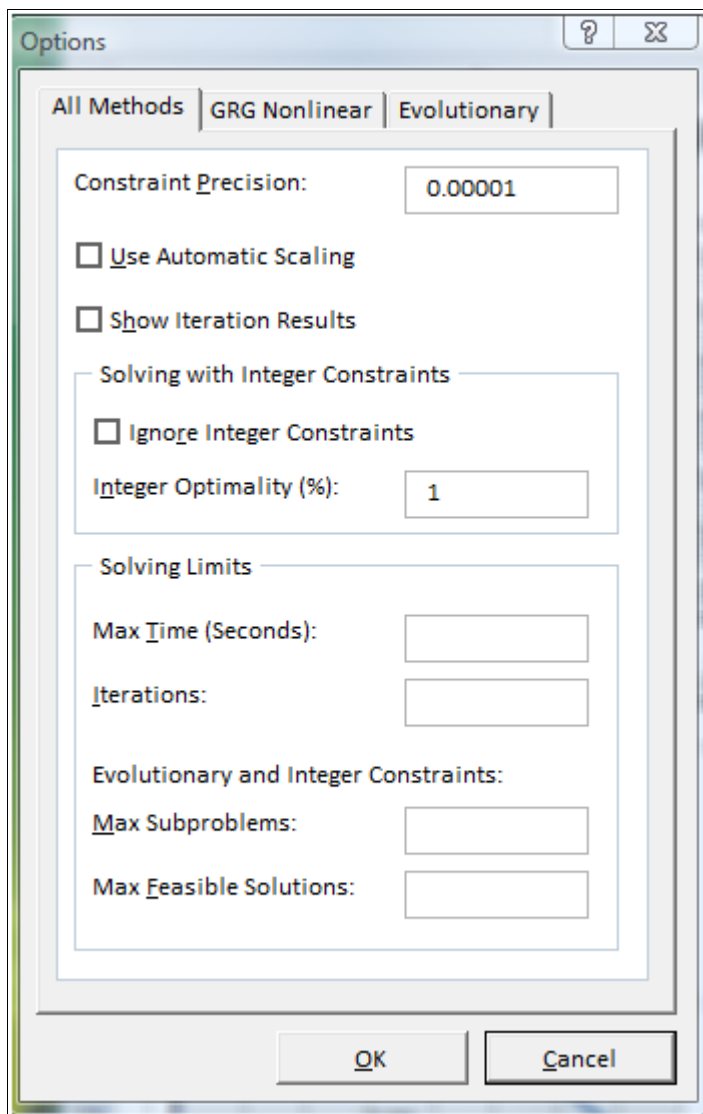
Figure 39: Adjustment of Options for Constraint Precision

Set the OPTIONS: ALL METHODS: CONSTRAINT PRECISION to: **0.00001**

Do not check any of the boxes.
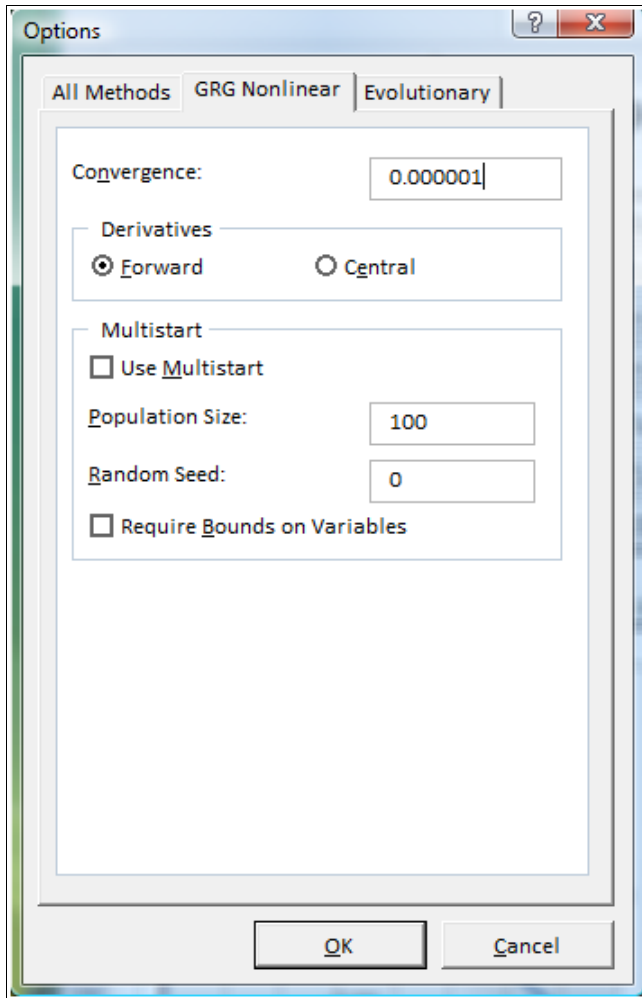
Figure 40

Set the Convergence for the *GRG NonLinear* Engine to: **0.000001**

Leave the Derivate as Forward, and leave the Multi-start and Required Bonds unchecked.

Now click the Solve button to run the optimization.

If you did it correctly, then the result will be a maximum development cost = $**89,487,343.115**

In the next windows that popups up, you will have the option to KEEP or RESTORE the results. And, o have Reports generated for your work. These reports are good to include with your work and results.
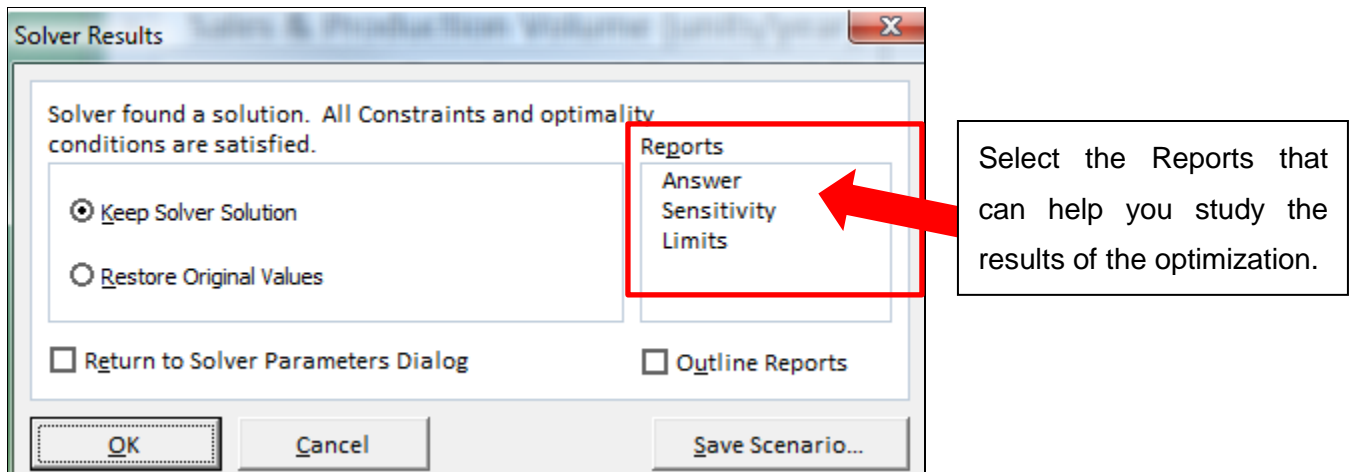
Figure 41: Solver Results

If you agree with the on-screen result, then select the *Keep Solver Solution*. Or, you can *Restore the Original Values* and investigate your framework.

Before clicking *OK*, select the Reports (e.g., Answer) that you want to include with your results. When you click OK, *Solve*r will automatically create and insert a new worksheet called *ANSWER REPORT* with this information.

(Hint: Submit these reports to help earn the Extra Credit in TIM-125/225 Homework #1)

An Example of the *Solver* Results *Answer* Report for this problem is show in Figure 42.

Figure 42: Example of Solver "Answer" Report.

	Year 1				Year 2				Year 3				Year 4			
BaseCase - MAX DEVELOPMENT COST SOLUTION																
period	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
($ values in thousands)	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Development Cost	-22,372	-22,372	-22,372	-22,372												
Ramp-up cost				-1,250	-1,250											
Marketing & suppost cost					-600	-600	-600	-600	-600	-600	-600	-600	-600	-600	-600	-600
Production cost						-10,938	-10,938	-10,938	-10,938	-10,938	-10,938	-10,938	-10,938	-10,938	-10,938	-10,938
Production volume						8,750	8,750	8,750	8,750	8,750	8,750	8,750	8,750	8,750	8,750	8,750
Unit production cost						-1.25	-1.25	-1.25	-1.25	-1.25	-1.25	-1.25	-1.25	-1.25	-1.25	-1.25
Sales Revenue						21,875	21,875	21,875	21,875	21,875	21,875	21,875	21,875	21,875	21,875	21,875
Sales volume						8,750	8,750	8,750	8,750	8,750	8,750	8,750	8,750	8,750	8,750	8,750
Unit price						2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50
Period Cash Flow	-22,372	-22,372	-22,372	-23,622	-1,850	10,338	10,338	10,338	10,338	10,338	10,338	10,338	10,338	10,338	10,338	10,338
PV Year 1, r=10%	-22,372	-21,826	-21,294	-21,935	-1,676	9,137	8,914	8,697	8,484	8,278	8,076	7,879	7,687	7,499	7,316	7,138
Project NPV, $	0.00															
all units in thousands, $																

Figure 43: Maximum development Cost after using Solver

After you *Keep the Solver Solution*, as show in Figure 43, look at the automatically updated **BaseCase** worksheet (Figure 43). The NPV should be equal to zero and the Quarterly development Cost = -22,372 (if you are using 2 decimal places, then it is -22,371.84 per quarter).

<div align="center">

Great!

What you previously solved using tedious trial and error,

now takes seconds, thanks to software automation.

</div>

We realize it took some time to learn how build these worksheets and to learn the techniques. From here on out you have the knowledge for Rapid Problem Solving. You will easily recoup the time invested by solving problems in the future faster than you would through continued trial and error brute force methods. You have learned how to program this type of analysis, for subsequent work to perform automated optimization analysis that is fast and precise, within Microsoft Excel.

Re-enforced your learning:

To illustrate how you can rapidly solving problems through a structured process of software automation:

Go back to the Ulrich textbook (2), and re-solve the problem in Exhibit 15-3, using the given parameters in the textbook and the linked worksheets you built from this tutorial.

You should now be able to determine the Max Development Cost in less than one minute!

Results: Post-Processing

Step 21: The Trade-off for Change in NPV ($) vs. Change in DevCost (%)

Here we present the overall result of the trade-off between the *(Chain in NPV, $ Thousand)* vs. *(Change in Development Cost, %)*.

	B	C	D	E	F	G
1	Change in Development Cost, %	Development Cost, $ Thousands	Change in Development Cost, $ Thousands	NPV, $ Thousands	Change in NPV, %	Change in NPV, $ Thousands
2	30%	32,500	7,500	54,936	-11.63%	-7,230
3	20%	30,000	5,000	57,346	-7.75%	-4,820
4	10%	27,500	2,500	59,756	-3.88%	-2,410
5	0%	25,000	0	62,166	0.00%	0
6	-10%	22,500	-2,500	64,576	3.88%	2,410
7	-20%	20,000	-5,000	66,986	7.75%	4,820
8	-30%	17,500	-7,500	69,396	11.63%	7,230

DevelopmentCost_Sensitivity

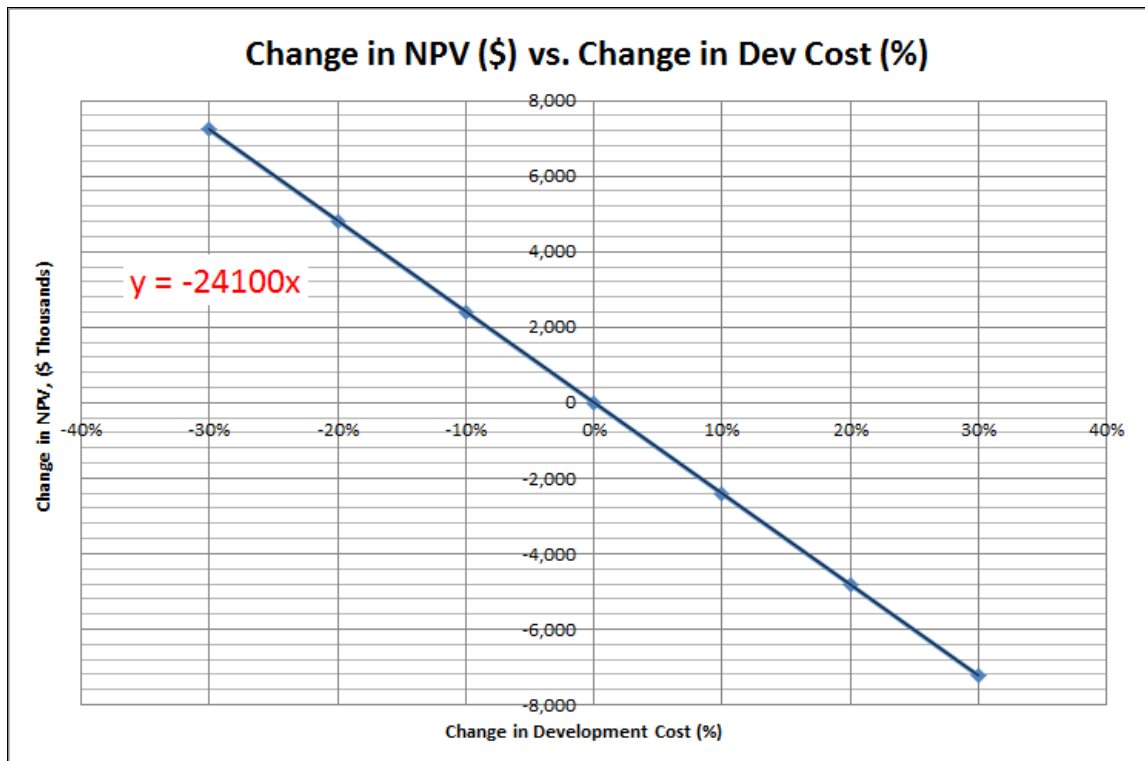*Figure 44: Format of the DevelopmentCost_Sensitivity Worksheet*

Figure 45: Change in NPV ($) vs. Change in DevCost (%)

The equation in this example, in y=mx+b format, is $y = -24100x$.   *m=-24100 and b=0*

That translates to trade-off law: For each 10% increase in Development Cost, there is a $2410 (in thousands) <u>reduction</u> in NPV.

Step 22: The Trade-off for Change in NPV ($) vs. Change in Sales Volumes (%)

Here we present the overall result of the trade-off between the (**Change in NPV, $ Thousands)** **vs.** (**Change in Sales Volume, %)**.

	A	B	C	D	E	F	G
1	Base Sales Volume, Qty	Change in Sales Volume, %	Sales Volume, Qty	Change in Sales Volume, Qty	Change in NPV, %	NPV, $ Thousands	Change in NPV, $ Thousands
2	8,750	30%	8,776	26	45%	90,449	28,282
3	8,750	20%	8,768	18	30%	81,021	18,855
4	8,750	10%	8,759	9	15%	71,594	9,427
5	8,750	0%	8,750	0	0%	62,166	0
6	8,750	-10%	8,741	-9	-15%	52,739	-9,427
7	8,750	-20%	8,733	-18	-30%	43,311	-18,855
8	8,750	-30%	8,724	-26	-45%	33,884	-28,282

SalesVolume_Sensitivity

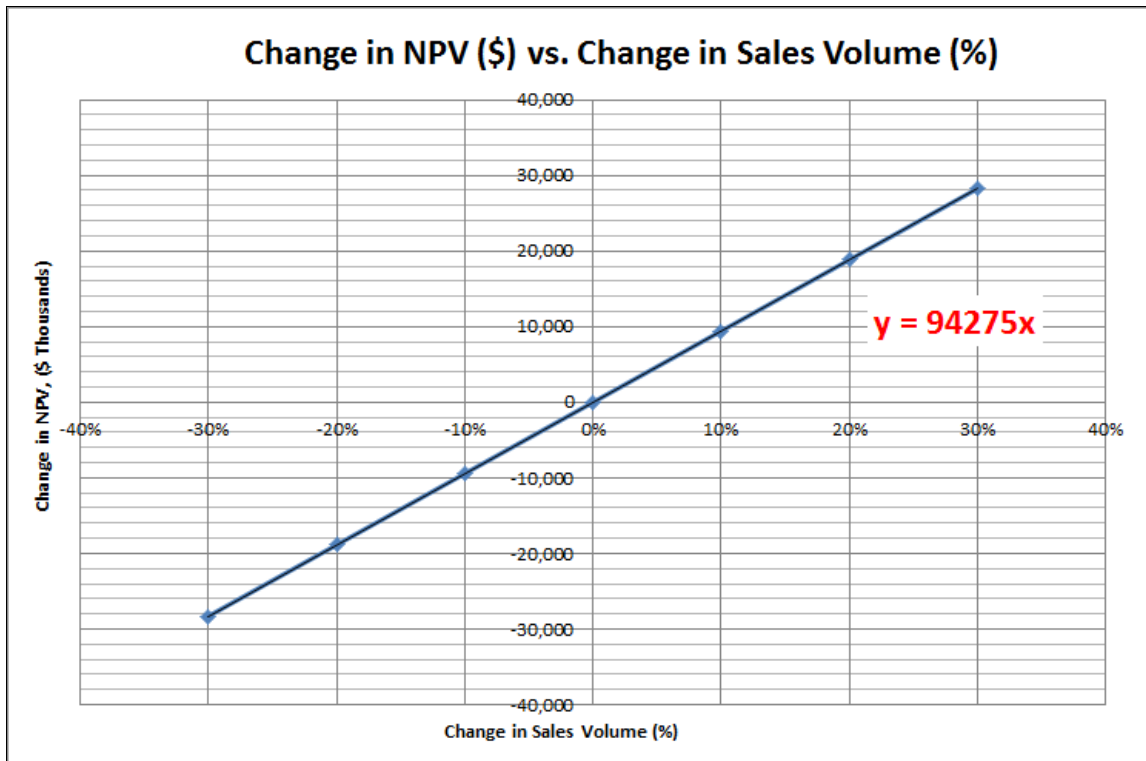*Figure 46: SalesVolume_Sensitivity Summary Table Results*

Figure 47: Change in NPV ($) vs. Change in Sales Volume (%)

The equation in this example, in y=mx+b format, is $y = 94275x$. *m=94275 and b=0*

That translates to a trade-off law: For each 10% (x-axis value) increase in Sales Volumes, there is a $9,427.50 (in thousands) <u>increase</u> in NPV.

Step 23: Determine Maximum Development Cost with *Solver*

Utilizing *Solver*, the maximum development Cost for proceeding with the project = $**89,487,343**

	A	B	C	D	E	F	G
1		**Microsoft Excel 14.0 Answer Report**					
2		**Worksheet: [TIM125_HW_01_Problem04_Tutorial_v8.xlsm]ScenarioParameters**					
3		**Report Created: 01/06/2012 9:00:00 AM**					
4		**Result: Solver found a solution. All Constraints and optimality conditions are satisfied.**					
5		**Solver Engine**					
6		Engine: GRG Nonlinear					
7		Solution Time: 0.031 Seconds.					
8		Iterations: 1 Subproblems: 0					
9		**Solver Options**					
10		Max Time Unlimited, Iterations Unlimited, Precision 0.00001					
11		Convergence 0.000001, Population Size 100, Random Seed 0, Derivatives Forward					
12		Max Subproblems Unlimited, Max Integer Sols Unlimited, Integer Tolerance 1%					
13							
14	**Objective Cell (Value Of)**						
15		**Cell**	**Name**	**Original Value**	**Final Value**		
16		$B$11	Base-Case NPV, $ (in thousands)	$ 62,166	$ -		
17							
18							
19	**Variable Cells**						
20		**Cell**	**Name**	**Original Value**	**Final Value**	**Integer**	
21		$B$4	Development Cost (total $)	25,000,000	89,487,343	Contin	
22							
23							
24	**Constraints**						
25		**Cell**	**Name**	**Cell Value**	**Formula**	**Status**	**Slack**
26		$B$11	Base-Case NPV, $ (in thousands)	$ -	$B$11=0	Binding	0

⊞ ◀ ▶ ▶⊞   Answer Report 1

Figure 48: Example of Solver "Answer" Report.

The Objective Cell (NPV) has Original Value of $62,166 and Final Value of $0

The Final Value of the variable (Development Cost Total Cost, $) is: 89,487,343

Step 24: Relationship of Development Cost to Sales Volume[3]

Shown in Figure 49, a 10% increase in development cost equates to a **decrease** in NPV of 3.88%.

	B	C	D	E	F	G
1	Change in Development Cost, %	Development Cost, $ Thousands	Change in Development Cost, $ Thousands	NPV, $ Thousands	Change in NPV, %	Change in NPV, $ Thousands
2	30%	32,500	7,500	54,936	-11.63%	-7,230
3	20%	30,000	5,000	57,346	-7.75%	-4,820
4	10%	27,500	2,500	59,756	-3.88%	-2,410
5	0%	25,000	0	62,166	0.00%	0
6	-10%	22,500	-2,500	64,576	3.88%	2,410
7	-20%	20,000	-5,000	66,986	7.75%	4,820
8	-30%	17,500	-7,500	69,396	11.63%	7,230

DevelopmentCost_Sensitivity

Figure 49: Development Cost Sensitivity Analysis Summary

Show in Figure 50, a 10% increase in Sales Volume equates to an **increase** in NPV of 15%.

	A	B	C	D	E	F	G
1	Base Sales Volume, Qty	Change in Sales Volume, %	Sales Volume, Qty	Change in Sales Volume, Qty	Change in NPV, %	NPV, $ Thousands	Change in NPV, $ Thousands
2	8,750	30%	8,776	26	45%	90,449	28,282
3	8,750	20%	8,768	18	30%	81,021	18,855
4	8,750	10%	8,759	9	15%	71,594	9,427
5	8,750	0%	8,750	0	0%	62,166	0
6	8,750	-10%	8,741	-9	-15%	52,739	-9,427
7	8,750	-20%	8,733	-18	-30%	43,311	-18,855
8	8,750	-30%	8,724	-26	-45%	33,884	-28,282

SalesVolume_Sensitivity

Figure 50: SalesVolume Sensitivity Analysis Summary

Therefore, under the assumption of linearity, a 2.59% increase in Sales Volume would increase NPV by 3.88%.

$$\frac{10\%}{15\%} * 3.88\% = 2.59\%$$

(1)

To summarize, a 2.59% increase in Sales Volume is needed to offset the 3.88% drop in NPV created from the 10% increase in development cost.

---

[3] Adopted from Ulrich and Eppinger, 4th Edition

Conclusions

In this tutorial you have now learned a powerful and structured approach, to problem solving using linked Excel Worksheets with the *Solver* Add-In for optimization, to perform sensitivity analysis.

The result of completing this tutorial is that you have gained knowledge of a structured approach to rapid problem solving using software automation (Figure 51):
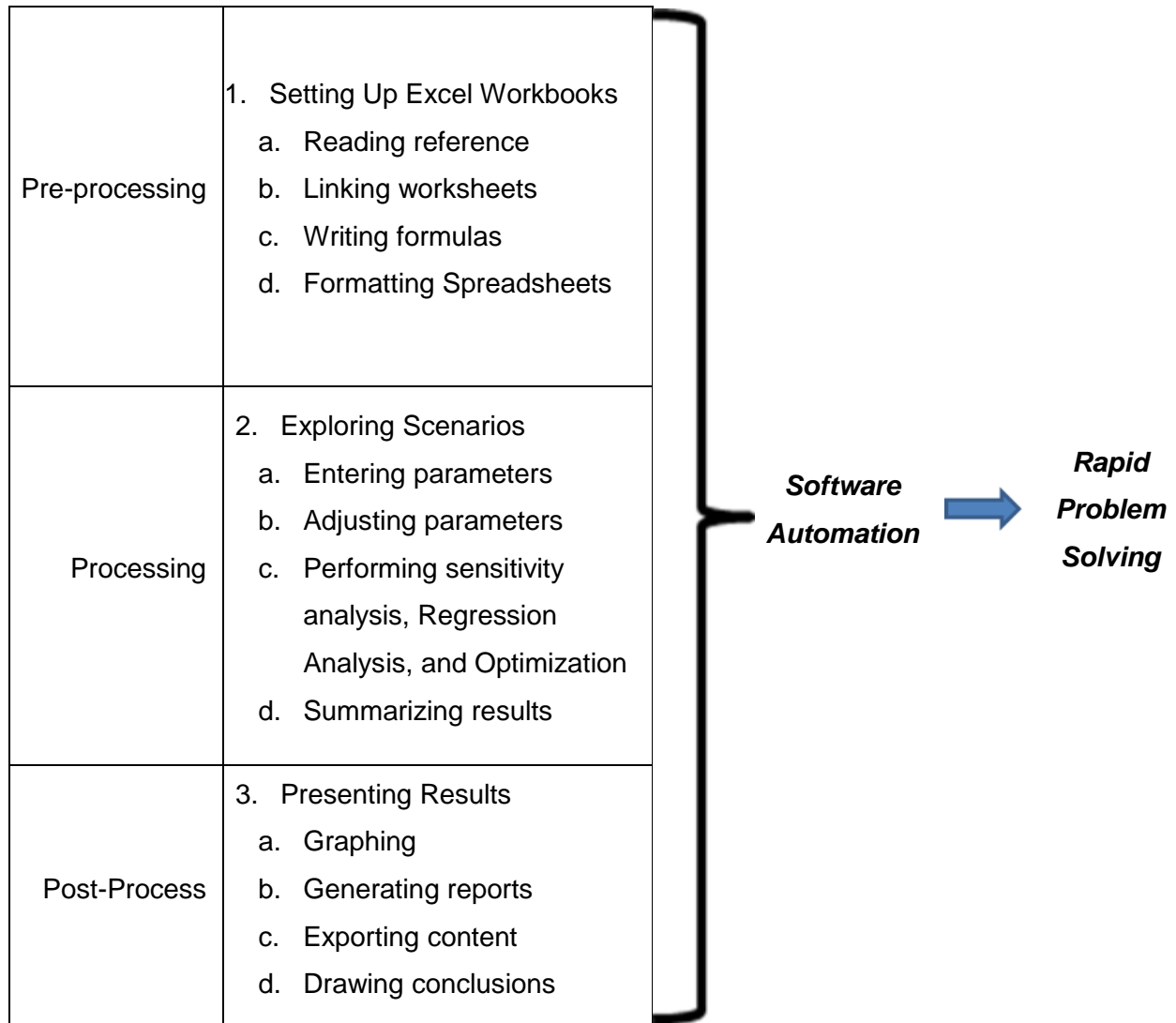

Pre-processing	1. Setting Up Excel Workbooks
	   a. Reading reference
	   b. Linking worksheets
	   c. Writing formulas
	   d. Formatting Spreadsheets

Processing	2. Exploring Scenarios
	   a. Entering parameters
	   b. Adjusting parameters
	   c. Performing sensitivity analysis, Regression Analysis, and Optimization
	   d. Summarizing results

Post-Process	3. Presenting Results
	   a. Graphing
	   b. Generating reports
	   c. Exporting content
	   d. Drawing conclusions

Software Automation → *Rapid Problem Solving*

Figure 51: Structured Approach to Rapid Problem Solving with Software Automation

You are now ready to take the next step and apply this new knowledge towards optimization of Supply Chain quantitative models.

Works Cited

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3. **techtutortv.** Move or Copy a Worksheet in Excel 2007. *www.YouTube.com.* [Online] [Cited: 01 07, 2012.] <http://www.youtube.com/watch?v=OucSxFiLyBc>.

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