EM384: Analytical Methods for Engineering Management

Lesson 4: Sensitivity Analysis using Spreadsheets I

20 January 2023

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Lesson Objectives

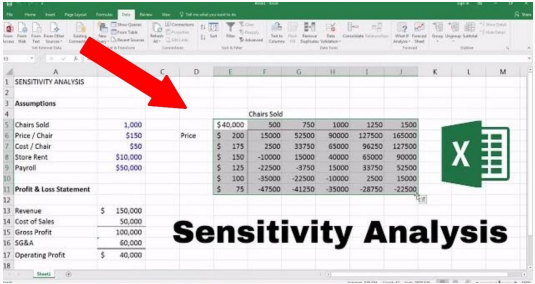
Lesson 4 Objectives

- Understand 'Base Case' and 'What-If' analysis and apply using spreadsheet models.
- Apply 1-way and 2-way data tables to a problem.

Sensitivity Analysis

Sensitivity analysis is examining the effect that changing model inputs has on your model outputs.

- The tools you learn in Excel are simply ways for you to look at your model output(s) when you change the value of your parameter(s) or variable(s).
- Excel helps us to deal with the uncertainty coming from having to predict, project, and assume different input parameters.



Base Case Analysis

The base case analysis is your starting scenario with your initial assumptions. It provides a starting point for your sensitivity analysis. Base-case can describe the following:

- Current policy, most likely scenario, best- or worst-case scenarios.

Answers questions such as:

- If we follow last year's plan, how much profit should we expect next year?
- How many items do we expect to sell next week?

”What If” Analysis

”What if” Analysis is another term for sensitivity analysis.

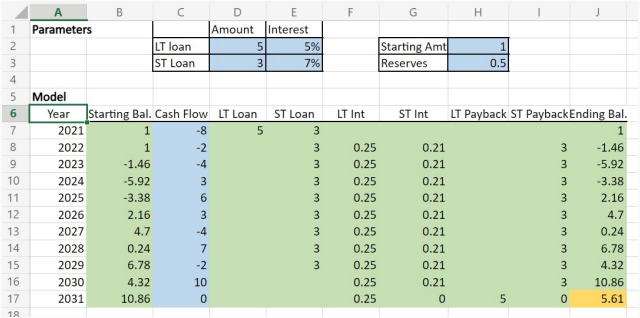
- Analyzes how key outputs change with changes in one or more of the inputs
- May vary a parameter, a decision variable, or the model structure.
- Varying a Parameter.
- Asking what if given information were different.
- Helps us appreciate the potential importance of the numerical assumptions of model.
- Varying a Decision Variable.
- Exploring outcomes we can influence.
- Leads us to better decisions.

Excel One-way and Two-way Data Tables are a useful tool.

Sensitivity Analysis

In-class Example

Download the Lesson 02 PE (Solution) file and select the Everglade PE tab.



	A	B	C	D	E	F	G	H	I	J
1	**Parameters**			Amount	Interest					
2			LT loan	5	5%		Starting Amt	1		
3			ST Loan	3	7%		Reserves	0.5		
4										
5	**Model**									
6	Year	Starting Bal.	Cash Flow	LT Loan	ST Loan	LT Int	ST Int	LT Payback	ST Payback	Ending Bal.
7	2021	1	-8	5	3					1
8	2022	1	-2		3	0.25	0.21		3	-1.46
9	2023	-1.46	-4		3	0.25	0.21		3	-5.92
10	2024	-5.92	3		3	0.25	0.21		3	-3.38
11	2025	-3.38	6		3	0.25	0.21		3	2.16
12	2026	2.16	3		3	0.25	0.21		3	4.7
13	2027	4.7	-4		3	0.25	0.21		3	0.24
14	2028	0.24	7		3	0.25	0.21		3	6.78
15	2029	6.78	-2		3	0.25	0.21		3	4.32
16	2030	4.32	10			0.25	0.21		3	10.86
17	2031	10.86	0			0.25	0	5	0	5.61
18										

- The model is organized with the parameters at the top and the spreadsheet model at the bottom
- Let's assume now that we want to conduct a sensitivity analysis on the ending balance in the year 2031.
- If we built the model correctly, then we can change the parameters at the top and the model will update correctly.

Sensitivity Analysis

Change the LT Loan amount in cell **D2** to 10, the SL Loan amount in cell **D3** to 5, and the starting amount in cell **H2** to 3.

	A	B	C	D	E	F	G	H	I	J
1	**Parameters**			Amount	Interest					
2			LT loan	10	5%		Starting Amt	3		
3			ST Loan	5	7%		Reserves	0.5		
4										
5	**Model**									
6	Year	Starting Bal.	Cash Flow	LT Loan	ST Loan	LT Int	ST Int	LT Payback	ST Payback	Ending Bal.
7	2021	3	-8	10	5					10
8	2022	10	-2		5	0.5	0.35		5	7.15
9	2023	7.15	-4		5	0.5	0.35		5	2.3
10	2024	2.3	3		5	0.5	0.35		5	4.45
11	2025	4.45	6		5	0.5	0.35		5	9.6
12	2026	9.6	3		5	0.5	0.35		5	11.75
13	2027	11.75	-4		5	0.5	0.35		5	6.9
14	2028	6.9	7		5	0.5	0.35		5	13.05
15	2029	13.05	-2		5	0.5	0.35		5	10.2
16	2030	10.2	10			0.5	0.35		5	14.35
17	2031	14.35	0			0.5	0	10	0	3.85

- Notice that the model updates all of the appropriate cells that point to your parameters, and the recalculates all of the formulas.
- Your ending balance of $3.85 million is automatically recalculated.
- We see that our spreadsheet model allows us to change parameters values and quickly see what the effect is on the model outputs.
- We can use data tables to analyze the effect of changing parameters on our model outputs.

One-Way Data Tables

One-way Data Tables

First we have to decide what parameter we want to vary and what values to give it. Let's say we want to vary **LT Loan Amount** between $1 million and $9 million. In cells **L7** to **L15**, enter the values 1 through 9 as shown.

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	**Parameters**			Amount	Interest								
2			LT loan	10	5%		Starting Amt	3					
3			ST Loan	5	7%		Reserves	0.5					
4													
5	**Model**												
6	Year	Starting Bal.	Cash Flow	LT Loan	ST Loan	LT Int	ST Int	LT Payback	ST Payback	Ending Bal.			
7	2021	3	-8	10	5					10		1	
8	2022	10	-2		5	0.5	0.35		5	7.15		2	
9	2023	7.15	-4		5	0.5	0.35		5	2.3		3	
10	2024	2.3	3		5	0.5	0.35		5	4.45		4	
11	2025	4.45	6		5	0.5	0.35		5	9.6		5	
12	2026	9.6	3		5	0.5	0.35		5	11.75		6	
13	2027	11.75	-4		5	0.5	0.35		5	6.9		7	
14	2028	6.9	7		5	0.5	0.35		5	13.05		8	
15	2029	13.05	-2		5	0.5	0.35		5	10.2		9	
16	2030	10.2	10			0.5	0.35		5	14.35			
17	2031	14.35	0			0.5	0	10	0	3.85			
18													

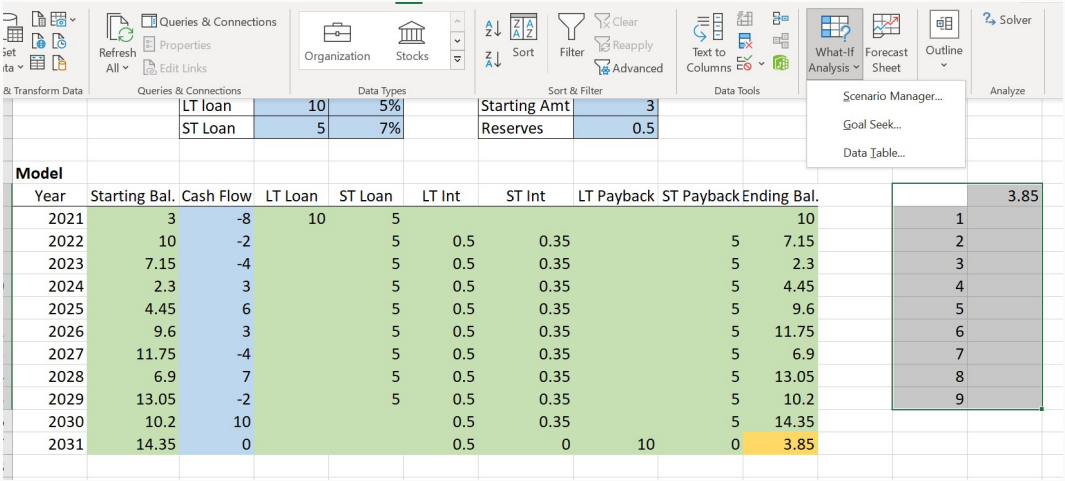
One-way Data Tables

Next we have to decide what output we want to see change in our sensitivity analysis. Let's say we want to see the effect of LT Loan amount on **Ending balance** in the year 2031. **One cell above, and one cell to the right** of your column of new parameters (this placement is important), make a formula that points to your ending balance.

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	**Parameters**			Amount	Interest								
2			LT loan	10	5%		Starting Amt	3					
3			ST Loan	5	7%		Reserves	0.5					
4													
5	**Model**												
6	Year	Starting Bal.	Cash Flow	LT Loan	ST Loan	LT Int	ST Int	LT Payback	ST Payback	Ending Bal.			=J17
7	2021	3	-8	10	5					10		1	
8	2022	10	-2		5	0.5	0.35		5	7.15		2	
9	2023	7.15	-4		5	0.5	0.35		5	2.3		3	
10	2024	2.3	3		5	0.5	0.35		5	4.45		4	
11	2025	4.45	6		5	0.5	0.35		5	9.6		5	
12	2026	9.6	3		5	0.5	0.35		5	11.75		6	
13	2027	11.75	-4		5	0.5	0.35		5	6.9		7	
14	2028	6.9	7		5	0.5	0.35		5	13.05		8	
15	2029	13.05	-2		5	0.5	0.35		5	10.2		9	
16	2030	10.2	10			0.5	0.35		5	14.35			
17	2031	14.35	0			0.5	0	10	0	3.85			
18													

One-way Data Tables

Select the range of cells that includes the new column of parameters, and your formula. Then click on the **data** tab, then the **What-if Analysis** button. Click on **Data Table**.

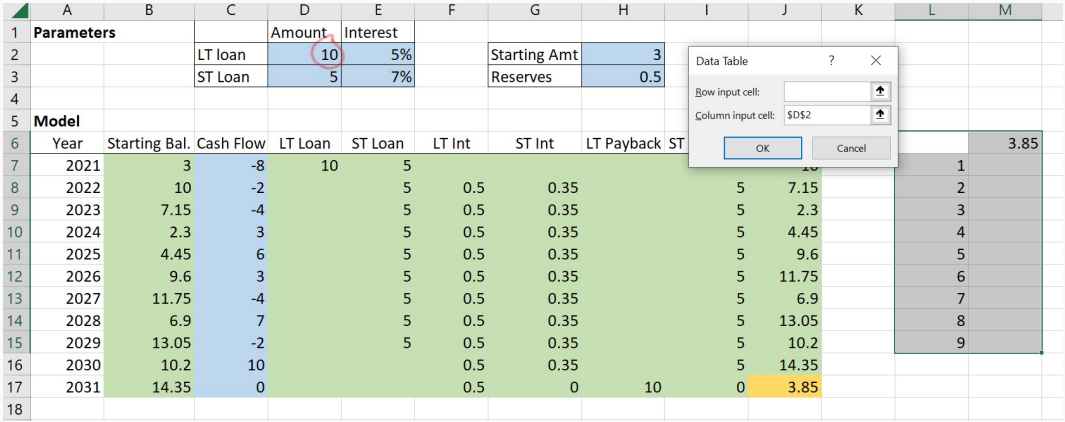


		LT loan	10	5%		Starting Amt	3				
		ST Loan	5	7%		Reserves	0.5				
	Model										
	Year	Starting Bal.	Cash Flow	LT Loan	ST Loan	LT Int	ST Int	LT Payback	ST Payback	Ending Bal.	
	2021	3	-8	10	5					10	
	2022	10	-2		5	0.5	0.35		5	7.15	
	2023	7.15	-4		5	0.5	0.35		5	2.3	
	2024	2.3	3		5	0.5	0.35		5	4.45	
	2025	4.45	6		5	0.5	0.35		5	9.6	
	2026	9.6	3		5	0.5	0.35		5	11.75	
	2027	11.75	-4		5	0.5	0.35		5	6.9	
	2028	6.9	7		5	0.5	0.35		5	13.05	
	2029	13.05	-2		5	0.5	0.35		5	10.2	
	2030	10.2	10			0.5	0.35		5	14.35	
	2031	14.35	0			0.5	0	10	0	3.85	

	3.85
1	
2	
3	
4	
5	
6	
7	
8	
9	

One-way Data Tables

Leave **Row Input Cell** blank. For **Column Input Cell**, select the cell that has your LT Loan amount parameter (**D2**). Click **OK**.



	A	B	C	D	E	F	G	H	I	J	K	L	M
1	**Parameters**			Amount	Interest								
2			LT loan	10	5%		Starting Amt	3					
3			ST Loan	5	7%		Reserves	0.5					
4													
5	**Model**												
6	Year	Starting Bal.	Cash Flow	LT Loan	ST Loan	LT Int	ST Int	LT Payback	ST				3.85
7	2021	3	-8	10	5							1	
8	2022	10	-2		5	0.5	0.35		5	7.15		2	
9	2023	7.15	-4		5	0.5	0.35		5	2.3		3	
10	2024	2.3	3		5	0.5	0.35		5	4.45		4	
11	2025	4.45	6		5	0.5	0.35		5	9.6		5	
12	2026	9.6	3		5	0.5	0.35		5	11.75		6	
13	2027	11.75	-4		5	0.5	0.35		5	6.9		7	
14	2028	6.9	7		5	0.5	0.35		5	13.05		8	
15	2029	13.05	-2		5	0.5	0.35		5	10.2		9	
16	2030	10.2	10			0.5	0.35		5	14.35			
17	2031	14.35	0			0.5	0	10	0	3.85			
18													

Data Table

Row input cell:

Column input cell: D2

OK Cancel

One-way Data Tables

Excel will automatically fill out the One-way data table. What does this data table tell us? How can we check that the table is correct? How can we make the numbers easier to read?

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	**Parameters**			Amount	Interest								
2			LT loan	10	5%		Starting Amt	3					
3			ST Loan	5	7%		Reserves	0.5					
4													
5	**Model**												
6	Year	Starting Bal.	Cash Flow	LT Loan	ST Loan	LT Int	ST Int	LT Payback	ST Payback	Ending Bal.			3.85
7	2021	3	-8	10	5					10		1	8.35
8	2022	10	-2		5	0.5	0.35		5	7.15		2	7.85
9	2023	7.15	-4		5	0.5	0.35		5	2.3		3	7.35
10	2024	2.3	3		5	0.5	0.35		5	4.45		4	6.85
11	2025	4.45	6		5	0.5	0.35		5	9.6		5	6.35
12	2026	9.6	3		5	0.5	0.35		5	11.75		6	5.85
13	2027	11.75	-4		5	0.5	0.35		5	6.9		7	5.35
14	2028	6.9	7		5	0.5	0.35		5	13.05		8	4.85
15	2029	13.05	-2		5	0.5	0.35		5	10.2		9	4.35
16	2030	10.2	10			0.5	0.35		5	14.35			
17	2031	14.35	0			0.5	0	10	0	3.85			
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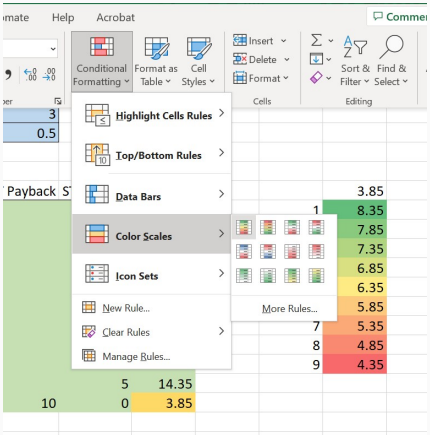
One-way Data Tables

Excel will automatically fill out the One-way data table. What does this data table tell us? How can we check that the table is correct? How can we make the numbers easier to read?

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	**Parameters**			Amount	Interest								
2			LT loan	10	5%		Starting Amt	3					
3			ST Loan	5	7%		Reserves	0.5					
4													
5	**Model**												
6	Year	Starting Bal.	Cash Flow	LT Loan	ST Loan	LT Int	ST Int	LT Payback	ST Payback	Ending Bal.			3.85
7	2021	3	-8	10	5					10		1	8.35
8	2022	10	-2		5	0.5	0.35		5	7.15		2	7.85
9	2023	7.15	-4		5	0.5	0.35		5	2.3		3	7.35
10	2024	2.3	3		5	0.5	0.35		5	4.45		4	6.85
11	2025	4.45	6		5	0.5	0.35		5	9.6		5	6.35
12	2026	9.6	3		5	0.5	0.35		5	11.75		6	5.85
13	2027	11.75	-4		5	0.5	0.35		5	6.9		7	5.35
14	2028	6.9	7		5	0.5	0.35		5	13.05		8	4.85
15	2029	13.05	-2		5	0.5	0.35		5	10.2		9	4.35
16	2030	10.2	10			0.5	0.35		5	14.35			
17	2031	14.35	0			0.5	0	10	0	3.85			
18													

One-way Data Tables



- The one-way data table tells us how the ending balance in 2031 will change when we vary the LT Loan amount between 1 and 9 million.
- We can check to make sure the table is correct by manually changing the LT Loan amount parameter and comparing the output of our model with the data in the table.
- We can make it easier to read by using conditional formatting.

One-Way Data Tables

LT Loan Amount	Ending Bal in 2031 (in millions of $)
	3.85
1	8.35
2	7.85
3	7.35
4	6.85
5	6.35
6	5.85
7	5.35
8	4.85
9	4.35

- Finally, we can clean it up by adding labels so it is easily interpreted.

Two-Way Data Tables

Two-Way Data Tables

- A one-way data table allows us to see a change in output for a change in a single parameter/variable.
- To see the effect of two parameters, we need to use a two-way data table.

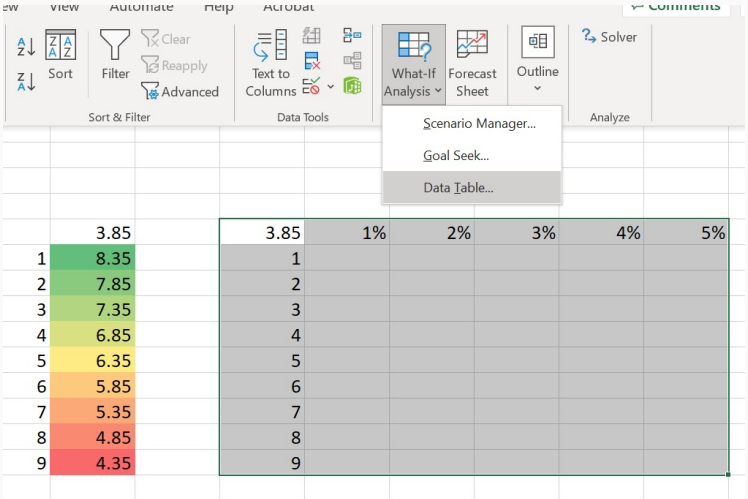
Two-Way Data Tables

- Let's examine the sensitivity of our ending balance to LT Loan amount and LT Loan interest rate. To the right of your model, create a new column for LT Loan amount and a row above for LT Loan interest rate.
- In the top left cell of your new table (this placement is important), make a formula that points to your model ending balance in 2031.

yback	Ending Bal.		3.85	=J17	1%	2%	3%	4%	5%
	10	1	8.35	1					
5	7.15	2	7.85	2					
5	2.3	3	7.35	3					
5	4.45	4	6.85	4					
5	9.6	5	6.35	5					
5	11.75	6	5.85	6					
5	6.9	7	5.35	7					
5	13.05	8	4.85	8					
5	10.2	9	4.35	9					
5	14.35								
0	3.85								

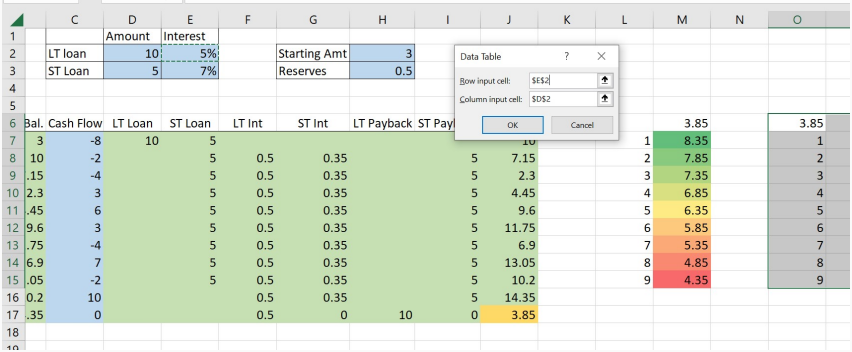
Two-Way Data Tables

Select the range cells of your new table. Then click on the **data** tab, then the **What-if Analysis** button. Click on **Data Table**.



Two-Way Data Tables

For **Row Input Cell**, select the cell that contains your LT Loan interest rate. For **Column Input Cell**, select the cell that has your LT Loan amount parameter (**D2**). Click **OK**.



	C	D	E	F	G	H	I	J	K	L	M	N	O
1		Amount	Interest										
2	LT loan	10	5%		Starting Amt	3							
3	ST Loan	5	7%		Reserves	0.5							
4													
5													
6	Bal.	Cash Flow	LT Loan	ST Loan	LT Int	ST Int	LT Payback	ST Pay			3.85		3.85
7	3	-8	10	5				10		1	8.35		1
8	10	-2		5	0.5	0.35		5 7.15		2	7.85		2
9	.15	-4		5	0.5	0.35		5 2.3		3	7.35		3
10	2.3	3		5	0.5	0.35		5 4.45		4	6.85		4
11	.45	6		5	0.5	0.35		5 9.6		5	6.35		5
12	9.6	3		5	0.5	0.35		5 11.75		6	5.85		6
13	.75	-4		5	0.5	0.35		5 6.9		7	5.35		7
14	6.9	7		5	0.5	0.35		5 13.05		8	4.85		8
15	.05	-2		5	0.5	0.35		5 10.2		9	4.35		9
16	0.2	10			0.5	0.35		5 14.35					
17	.35	0			0.5	0	10	0 3.85					
18													

An easy way to remember which one goes in row and column, remember that Row is the parameter that is the **top row** of your data table. Column is the parameter that is the **left column** of your data table.

Two-Way Data Tables

- Add some conditional formatting and labels, and you have a easy to read two-way data table.
- The value at the top left only reflects the output of your model in your ”base case” (with parameters that are in your model now).
- What trends can you see from this sensitivity analysis?

Ending Balance in 2031 (in millions of $)						
		LT Loan Interest Rate				
	3.85	1%	2%	3%	4%	5%
LT Loan Amount	1	8.75	8.65	8.55	8.45	8.35
	2	8.65	8.45	8.25	8.05	7.85
	3	8.55	8.25	7.95	7.65	7.35
	4	8.45	8.05	7.65	7.25	6.85
	5	8.35	7.85	7.35	6.85	6.35
	6	8.25	7.65	7.05	6.45	5.85
	7	8.15	7.45	6.75	6.05	5.35
	8	8.05	7.25	6.45	5.65	4.85
	9	7.95	7.05	6.15	5.25	4.35

Practical Exercise

Conclusion

Next Class

Homework:

- Read Lesson Handout ”Analysis Using Spreadsheets” Chapter 4.5
- Finish Homework Set 1

Next Lesson:

- Understand ’Breakeven’ analysis and apply using spreadsheet models.
- Apply ’Goal-Seek’ to a problem.