

A Simple Model

Broken Models and Circular References

NOTES TO ACCOMPANY VIDEOS

These notes are intended to supplement the videos on ASimpleModel.com. They are not to be used as stand-alone study aids, and are not written as comprehensive overviews of the topic detailed. The purpose of these notes is to provide a tangible collection of the visuals used in the videos with comments highlighting the more important aspects covered.

Integrating Financial Statements

004 Broken Models & Circular References

The purpose of this video (and the one that follows) is to help avoid extreme frustration as you learn to build models. This video focuses on circular reference errors, which can cause a model to “ref out.” The saying is used because Excel will display “#REF!” for invalid cell references. If an error occurs Excel might also display #DIV/0! or #VALUE! depending on the kind of error.

To demonstrate what happens when your model “refs out” on account of a circular reference error the video starts out by creating one in the model:

Integrated Financial Statements

Company Name
(000s)

	Historical 20X1	Historical 20X2	Projected 20X3	Projected 20X4	Projected 20X5	Projected 20X6	Projected 20X7
INCOME STATEMENT							
Revenue	74,452		0	0	0	0	0
Growth (%)	NA	-100.0%	10.0%	10.0%	10.0%	10.0%	10.0%
Cost of Goods Sold	64,440	72,524	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
% of Sales	86.6%	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
Gross Profit	10,012	(72,524)	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
% of Sales	13.4%	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
Operating Expenses (SG&A)	6,389	6,545	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
% of Sales	8.6%	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
Operating Income (EBIT)	3,623	(79,069)	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
Interest Expense	518	474	415	341	300	260	220
Pretax Income	3,105	(79,543)	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
Income Tax Expense	1,087	1,382	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
Tax Rate	NM	NM	35.0%	35.0%	35.0%	35.0%	35.0%
Net Income	2,018	(80,925)	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
Operating Income (EBIT)	3,623	(79,069)	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
Depreciation	2,648	2,981	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
Amortization	0	0	0	0	0	0	0
EBITDA	6,271	(76,088)	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
BALANCE SHEET	20X1	20X2	20X3	20X4	20X5	20X6	20X7
Current Assets							
Cash	1,773	2,000	2,000	3,325	4,816	6,501	8,449
Accounts Receivable	7,750	8,852	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
Inventory	4,800	5,700	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
Prepaid Expenses	456	1,849	1,849	1,849	1,849	1,849	1,849
Total Current Assets	14,779	18,401	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!

As a first-time modeler this can be pretty terrifying, but it is so common that it is actually used to play pranks on analysts (or I just had evil superiors...). Fortunately it is also easy to fix.

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Fixing the error requires two steps. First you must undo what caused the error, and in this example the error was caused by deleting revenue in period 20X2.

Integrated Financial Statements

Company Name

(000s)

	Historical 20X1	Historical 20X2	Projected 20X3	Projected 20X4	Projected 20X5	Projected 20X6	Projected 20X7
INCOME STATEMENT							
Revenue	74,452	83,492	91,841	101,025	111,128	122,241	134,465
Growth (%)	NA	12.1%	10.0%	10.0%	10.0%	10.0%	10.0%
Cost of Goods Sold	64,440	72,524	79,634	87,597	96,357	105,992	116,592
% of Sales	86.6%	86.9%	86.7%	86.7%	86.7%	86.7%	86.7%
Gross Profit	10,012	10,968	12,208	13,428	14,771	16,248	17,873
% of Sales	13.4%	13.1%	13.3%	13.3%	13.3%	13.3%	13.3%
Operating Expenses (SG&A)	6,389	6,545	7,540	8,294	9,124	10,036	11,040
% of Sales	8.6%	7.8%	8.2%	8.2%	8.2%	8.2%	8.2%
Operating Income (EBIT)	3,623	4,423	4,667	5,134	5,647	6,212	6,833
Interest Expense	518	474	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
Pretax Income	3,105	3,949	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
Income Tax Expense	1,087	1,382	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
Tax Rate	NM	NM	35.0%	35.0%	35.0%	35.0%	35.0%
Net Income	2,018	2,567	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!

You will notice that replacing revenue is an improvement, but your model still shows multiple errors. Step two is to delete the source of the circularity, which in this case is interest expense.

Integrated Financial Statements

Company Name

(000s)

	Historical 20X1	Historical 20X2	Projected 20X3	Projected 20X4	Projected 20X5	Projected 20X6	Projected 20X7
INCOME STATEMENT							
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Operating Income (EBIT)	3,623	4,423	4,667	5,134	5,647	6,212	6,833
Interest Expense	518	474					
Pretax Income	3,105	3,949	4,667	5,134	5,647	6,212	6,833
Income Tax Expense	1,087	1,382	1,634	1,797	1,977	2,174	2,392
Tax Rate	NM	NM	35.0%	35.0%	35.0%	35.0%	35.0%
Net Income	2,018	2,567	3,034	3,337	3,671	4,038	4,442

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With interest expense deleted you have fixed the error and the model will calculate properly. At that point you can link the model back to interest expense and keep working.

Integrated Financial Statements

Company Name
(000s)

INCOME STATEMENT	Historical	Historical	Projected	Projected	Projected	Projected	Projected
	20X1	20X2	20X3	20X4	20X5	20X6	20X7
Revenue	74,452	83,492	91,841	101,025	111,128	122,241	134,465
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Operating Income (EBIT)	3,623	4,423	4,667	5,134	5,647	6,212	6,833
Interest Expense	518	474	415	341	300	260	220
Pretax Income	3,105	3,949	4,252	4,793	5,347	5,952	6,613
Income Tax Expense	1,087	1,382	1,488	1,678	1,872	2,083	2,315
Tax Rate	NM	NM	35.0%	35.0%	35.0%	35.0%	35.0%
Net Income	2,018	2,567	2,764	3,116	3,476	3,869	4,299

Having fixed the error the video explores the cause of the circular reference error. In other words, what happens in the model that causes so many cells to display an error message?

Lets take a look at the full model on the following page for an explanation.

The screenshot shows an Excel spreadsheet with a circular reference error. The error message "CIRCULAR REFERENCE" is prominently displayed in a red jagged circle over a cell. The spreadsheet is divided into several sections: "Supporting Schedules" at the top, "DEBT SCHEDULE" in the middle, and "PP&E SCHEDULE" at the bottom. The "DEBT SCHEDULE" section includes a "REVOLVER / LINE OF CREDIT" table and an "INTEREST EXPENSE" table. The "INTEREST EXPENSE" table shows values for years 20X1 through 20X7, with a total interest expense of 220 for 20X7. The "NET INCOME" is also shown as 4,299 for 20X7. The error occurs because the "INTEREST EXPENSE" calculation depends on "NET INCOME", which in turn depends on "INTEREST EXPENSE", creating a circular dependency.

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The circular reference is created as follows:

1. **Interest Expense** is used to calculate Net Income
2. Net Income is used to calculate Cash Flow
3. Cash Flow is used to calculate the Revolver / Line of Credit
4. Revolver / Line of Credit impacts the amount of **Interest Expense**
 - More (or less) debt requires greater (or smaller) interest payments

As you can see the calculation creates a circular reference (or in this case an oddly shaped loop).

The video demonstrates how this occurs in a couple models to provide more visuals.

Integrated Financial Statements

Company Name (000s)	Historical 20X1	Historical 20X2	Projected 20X3	Projected 20X4	Projected 20X5	Projected 20X6	Projected 20X7
INCOME STATEMENT							
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% of Sales	8.6%	7.8%	8.2%	8.2%	8.2%	8.2%	8.2%
Operating Income (EBIT)	3,623	4,423	4,667	5,134	5,647	6,212	6,833
Interest Expense	518	474	415	341	300	260	220
Pretax Income	3,105	3,949	4,252	4,793	5,347	5,952	6,613
Income Tax Expense	1,087	1,382	1,488	1,678	1,872	2,083	2,315
Tax Rate	NM	NM	35.0%	35.0%	35.0%	35.0%	35.0%
Net Income	2,018	2,567	2,764	3,116	3,476	3,869	4,299
Operating Income (EBIT)	3,623	4,423	4,667	5,134	5,647	6,212	6,833
Depreciation	2,448	2,981	3,273	3,600	3,960	4,356	4,792
Amortization	0	0	0	0	0	0	0
EBITDA	6,211	7,404	7,940	8,734	9,607	10,568	11,625
BALANCE SHEET							
Current Assets							
Cash	1,773	2,000	2,000	3,325	4,816	6,501	8,449
Accounts Receivable	7,750	8,852	9,649	10,614	11,675	12,842	14,127
Inventory	4,800	5,700	6,095	6,705	7,375	8,113	8,924
Prepaid Expenses	456	1,849	1,849	1,849	1,849	1,849	1,849
Total Current Assets	14,779	18,401	19,593	22,492	25,715	29,306	33,348
Fixed Assets							
PP&E, Net of Accum. Depreciation	10,913	10,932	11,159	11,559	12,099	12,743	13,451
TOTAL ASSETS	25,692	29,333	30,752	34,051	37,814	42,049	46,799
Current Liabilities							
Accounts Payable	5,665	6,656	7,155	7,870	8,657	9,523	10,475
Line of Credit	792	1,375	32	0	0	0	0
Current Maturities of Long Term Debt	500	500	500	500	500	500	500
Total Current Liabilities	6,957	8,531	7,687	8,370	9,157	10,023	10,975
Long Term Liabilities							
Long Term Debt, Net of Current Maturities	5,000	4,500	4,000	3,500	3,000	2,500	2,000
TOTAL LIABILITIES	11,957	13,031	11,687	11,870	12,157	12,523	12,975
Common Stock	15	15	15	15	15	15	15
Additional Paid In Capital	5,000	5,000	5,000	5,000	5,000	5,000	5,000
Retained Earnings	8,720	11,287	14,051	17,166	20,642	24,511	28,809
TOTAL EQUITY	13,735	16,302	19,066	22,181	25,657	29,526	33,824
TOTAL LIABILITIES & EQUITY	25,692	29,333	30,752	34,051	37,814	42,049	46,799
Check	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BALANCE SHEET ASSUMPTIONS							
AR Days	38	39	38	38	38	38	38
Inventory Days	27	29	28	28	28	28	28
AP Days	32	33	33	33	33	33	33
CASH FLOW STATEMENT							
CASH FLOW FROM OPERATING ACTIVITIES							
Net Income			2,764	3,116	3,476	3,869	4,299
Add Back Non-Cash Items							
Depreciation			3,273	3,600	3,960	4,356	4,792
Amortization			0	0	0	0	0
Changes in Working Capital							
Accounts Receivable			(797)	(965)	(1,061)	(1,167)	(1,284)
Inventory			(385)	(610)	(670)	(738)	(811)
Accounts Payable			499	715	787	866	952
Net Cash Provided by Operating Activities			5,343	5,857	6,491	7,186	7,947
CASH FLOW FROM INVESTING ACTIVITIES							
Capital Expenditures - Purchase of PP&E			(3,500)	(4,000)	(4,500)	(5,000)	(5,500)
Net Cash Used in Investing Activities			(3,500)	(4,000)	(4,500)	(5,000)	(5,500)
CASH FLOW FROM FINANCING ACTIVITIES							
Revolving Credit Facility (Line of Credit)			(1,343)	(32)	0	0	0
Long Term Debt			(500)	(500)	(500)	(500)	(500)
Net Cash Provided by (Used in) Fnce Activities			(1,843)	(532)	(500)	(500)	(500)
Net Cash Flow			0	1,325	1,491	1,686	1,947
Beginning Cash Balance	2,000	2,000	3,325	4,816	6,501	8,449	
Ending Cash Balance			2,000	3,325	4,816	6,501	8,449

Supporting Schedules

Company Name (000s)	20X1	20X2	20X3	20X4	20X5	20X6	20X7
DEBT SCHEDULE							
Cash Balance @ Beg of Year (End of Last Year)			2,000	2,000	3,325	4,816	6,501
Plus: Free Cash Flow from Operations and Investing			1,843	1,857	1,991	2,186	2,447
Plus: Free Cash Flow from Financing (BEFORE L.O.C.)			(500)	(500)	(500)	(500)	(500)
Less: Minimum Cash Balance			2,000	2,000	2,000	2,000	2,000
Total Cash Available or (Required) from L.O.C.			1,343	1,357	2,816	4,501	6,449
Line of Credit	792	1,375	32	0	0	0	0
Debt							
Long Term Debt, Net of Current Maturities	5,000	4,500	4,000	3,500	3,000	2,500	2,000
Current Portion of Long Term Debt	500	500	500	500	500	500	500
Interest Expense							
Interest Rate on Long Term Debt			8.0%	8.0%	8.0%	8.0%	8.0%
Interest Rate on Line of Credit			5.0%	5.0%	5.0%	5.0%	5.0%
Interest Expense on Long Term Debt			380	340	300	260	220
Interest Expense on Line of Credit			35	1	0	0	0
Total Interest Expense			415	341	300	260	220
PP&E SCHEDULE							
Beg. PP&E, Net of Accum. Depreciation			10,932	11,159	11,559	12,099	12,743
Plus: Capital Expenditures			3,500	4,000	4,500	5,000	5,500
Less: Depreciation			2,448	2,981	3,273	3,600	4,356
Depreciation as % of Revenues			3.56%	3.57%	3.56%	3.56%	3.56%
End. PP&E, Net of Accum. Depreciation			11,159	11,559	12,099	12,743	13,451

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The video then demonstrates how to Enable Iterative Calculation in Excel. Without this functionality enabled, Excel will not properly calculate any circular references.

To turn on iterative calculation select the File menu → Options → Formulas → and check the box for “Enable iterative calculation” (circled red below).

The screenshot shows the Excel Options dialog box with the Formulas tab selected. The 'Enable iterative calculation' checkbox is checked and circled in red. The 'Maximum Iterations' is set to 100 and 'Maximum Change' is set to 0.001. The 'Error Checking' section is also visible, with 'Enable background error checking' checked.

	8,720	11,287	14,051	17,166	20,642	24,511	28,800
TOTAL EQUITY	13,735	16,302	19,066	22,181	25,657	29,526	33,824
TOTAL LIABILITIES & EQUITY	25,692	29,333	30,752	34,051	37,814	42,049	46,799
Check	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Integrating Financial Statements

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The video concludes by offering a more elegant solution to fix circular reference errors. Rather than delete and relink interest expense every time your model refs out, you can use a formula to work around it.

The “=IF” formula checks whether a condition is met, and then returns one value if TRUE, and another value if FALSE (definition of =IF formula taken from Excel).

Condition: B21 = “ON”

Value if TRUE: Links to Interest Expense (cell E128)

Value if FALSE: 0

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Company Name
(000s)

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% of Sales	8.6%	7.8%	8.2%	8.2%	8.2%	8.2%	8.2%
Operating Income (EBIT)	3,623	4,423	4,667	5,134	5,647	6,212	6,833
Interest Expense	ON	518	474	=IF(\$B\$21="ON",E128,0)	300	260	220
Pretax Income	3,105	3,949	4,252	4,793	5,347	5,952	6,613
Income Tax Expense	1,087	1,382	1,488	1,678	1,872	2,083	2,315
Tax Rate	NM	NM	35.0%	35.0%	35.0%	35.0%	35.0%
Net Income	2,018	2,567	2,764	3,116	3,476	3,869	4,299
Operating Income (EBIT)	3,623	4,423	4,667	5,134	5,647	6,212	6,833
Depreciation	2,648	2,981	3,273	3,600	3,980	4,356	4,792
Amortization	0	0	0	0	0	0	0
EBITDA	6,271	7,404	7,940	8,734	9,607	10,568	11,625

In this way, you can input “OFF” in cell B21 while you are working on the model, and work without creating circular reference errors. Once you’re done with the model input “ON” to run interest expense through the model.