INTRODUCING RISK MODELING IN CORPORATE FINANCE

Domingo Castelo Joaquin*, Han Bin Kang**

Abstract

This paper aims to introduce a simulation modeling in the context of a simplified capital budgeting problem. It walks the reader from creating and running a simulation in a spreadsheet environment to interpreting simulation results to gain insight and understanding about the problem. The uncertainty lies primarily in the level of sales in the first year of the project and in the growth rate of sales thereafter, manufacturing cost as a percentage of sales, and the salvage value of fixed assets. The simulation is carried out within a spreadsheet environment using @Risk.

Keywords: Corporate Finance, Risk, Risk Modeling

** Associate Professor of Finance and joined the Department of Finance, Law & Insurance in 1998. Illinois State University*
***Professor at the Department of Finance, Insurance and Law, Illinois State University, Normal, Illinois*

1 Introduction

This teaching note aims to introduce risk modeling in corporate finance by showing, in the context of a simplified capital budgeting case, how to create and run a simulation in a spreadsheet environment, and how to interpret simulation results to gain insight and understanding about the problem. Instead of having to reinvent simulation in an Excel environment, we employ spreadsheet-based simulation software. This way, students can focus on structuring problems that make managerial sense and on interpreting results for the purpose of supporting and improving the quality of executive decisions.

This note provides step-by-step instruction for simulating the net present value and the internal rate of return of a five-year project. The step-by-step and teach by example approach is adopted from Winston, Albright, and Broadie (2001). The uncertainty lies primarily in the level of sales in the first year of the project and in the growth rate of sales thereafter, manufacturing cost as a percentage of sales, and the salvage value of fixed assets. The simulation is carried out within a spreadsheet environment using @Risk. In the example, initial sales level follows a triangular distribution; the annual sales growth rates are independent and identically distributed with a normal distribution; manufacturing costs as a percentage of sales are independent and identically distributed with a triangular distribution; finally, the salvage value of plant, property and equipment is uniformly distributed. The problem is similar to a standard capital budgeting problem like one would find in an intermediate finance text like Benninga (2006) or Titman and Martin's (2011) valuation text. See Clemens and Reilly (2001) for general guidelines and case examples on how to structure hard decision problems. The specific distributional assumptions are given in the next Section. It is followed by a detailing of the steps for converting an excel model into a simulation model. The note concludes with a discussion of the simulation outputs.

2 A capital budgeting simulation exercise

2.1 The Milk 4 All Ice Cream Project

The Milk 4 All Company is considering branching into the ice-cream business. It will need a machine costing $1,000,000. The machine will be depreciated over ten years to zero salvage value. However, the ice-cream project is expected to last for only five years. The sale price of the machine at the end of five years will be uniformly distributed with a minimum value of $300,000 and a maximum value of $500,000.

Sales in year 1 follow the triangular distribution with a minimum value of $2,000,000, a most likely value of $3,000,000 and a maximum value of $7,000,000. Thereafter, sales are forecasted to grow exponentially at a rate that is normally distributed with a mean 5 percent and a standard deviation of 2 percent a year.

In each year, manufacturing costs as a percentage of sales have a triangular distribution with a minimum value of 75 percent, a maximum value of 95 percent, and a most likely value of 85 percent. Fixed cash cost (rent) is expected to be $100,000 in the first year. Thereafter the fixed cash cost is expected to grow at the expected inflation rate at 4 percent a year.

The project will require an initial investment of $100,000 in net working capital. From year 1 onwards, the project requires net working capital level to equal to 10 percent of next year's projected sales.

Profits are subject to a 30 percent tax rate. The Milk 4 All Company is profitable enough so that any losses at the project level translate to a tax deduction at the corporate level. In other words, negative tax at the project level is a realistic scenario. The cost of capital is 14 percent. The risk free rate is equal to 6%.

Perform a simulation in answering the following questions. Apply the following simulation settings: 1,000 iterations, Latin Hypercube, Expected Value, Collect all, and 54321 as the fixed seed number. You are to turn in:

a) A hard copy summarizing your final answers and recommendations.

b) A hard copy supporting evidence (Excel spreadsheets, Quick Report and Detailed Statistics Report)

c) An electronic copy (CD or floppy) of the spreadsheet work

2.2 Questions

a) Assume that sales in year 1 follow the triangular distribution with a minimum value of $2,000,000, a most likely value of $3,000,000 and a maximum value of $7,000,000. Calculate the probability that year 1 sales will be greater than $5,000,000 and the probability that year 1 sales will be between $2,500,000 and $5,000,000.

b) Given that manufacturing costs as a percentage of sales have a triangular distribution with a minimum value of 75 percent, a maximum value of 95 percent, and a most likely value of 85 percent, calculate the probability that manufacturing cost as a percentage of sales is greater than 80% and the probability that manufacturing cost as a percentage of sales is less than 80%.

c) Calculate the average NPV of the project over the 1000 iterations. Construct the 95% confidence interval for the NPV.

Hint: Use $\mu_{npv} \pm 1.96 * \sigma_{npv} / \sqrt{N}$

where N=number of iterations in the simulation.

d) Calculate the probability that the NPV is negative and the probability that NPV is greater than $1,500,000.

e) Use the tornado diagram to rank the uncertain variables in terms of their influence on the NPV.

f) What are your recommendations about the project? Explain.

3 Converting an excel model into a simulation model

3.1 Getting Started

First Excel needs to be opened. If @Risk is installed properly, Excel will open with @Risk toolbars appended to the regular Excel toolbars. In this case, you can ignore the rest of the paragraph. If you did not see the @Risk toolbars appended to the regular Excel toolbars, you need to check if @Risk is installed properly. To do this, click on *Tools > Add-Ins* from the menu bar. Look for Risk in the dialog box. If you see it, put a check mark in the small box to the left of Risk, then click OK to save and exit. At this point, Excel should load @Risk, and you should see the @Risk toolbars. If Risk is not listed as an available add-in, you will need to look for the underlying files. Click on Browser and tell Excel where you installed it. If you are not sure where the file is located, from the Windows toolbar, select *Start > Find > Files or Folders*. Search for "Risk.xla" and use that location for the browser dialog box in the Excel add-in dialog box. If you cannot find Risk.xla, then @Risk was not installed properly. Before calling for help, make sure that you ran the executable file.

Next, open the file "Risk Modeling in Corporate Finance.xls." The excel model, with the excel formulas linking the various components of free cash flows to the project NPV and IRR, is given in the Appendix.,Before using @Risk, you should work through the model. How do you calculate Free Cash Flows? How do you calculate the present value of cash flows and the NPV? The spreadsheet allows you to enter the distribution of sales over the life of the project.

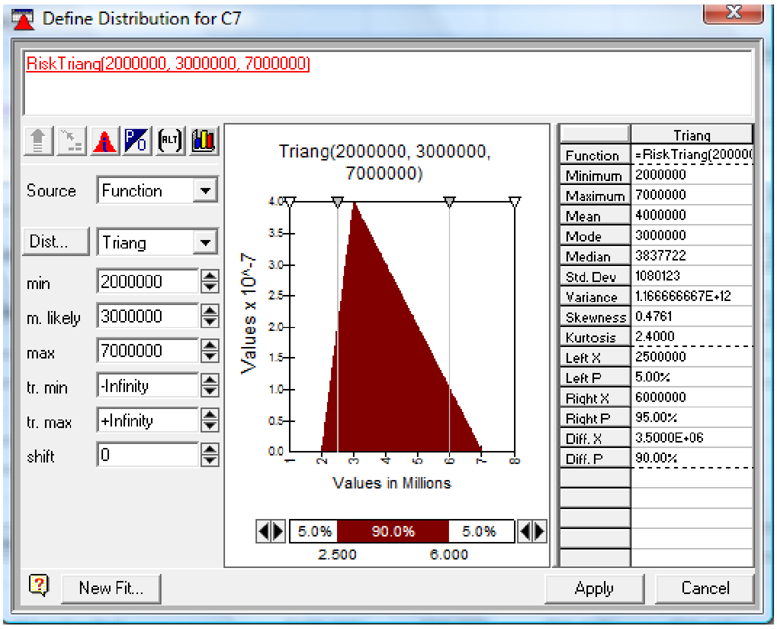
3.2 Input Cells

Before beginning the simulation, you need to know about two kinds of cells that @Risk uses. *Input cells* are random variables. In this model, the level of sales in the first year of the project and in the growth rate of sales thereafter, manufacturing cost as a percentage of sales, and the salvage value of fixed assets are random variables. Input cells themselves use placeholders that are numeric values, as opposed to formulas, and @Risk replaces these placeholders as it draws new values from a distribution.

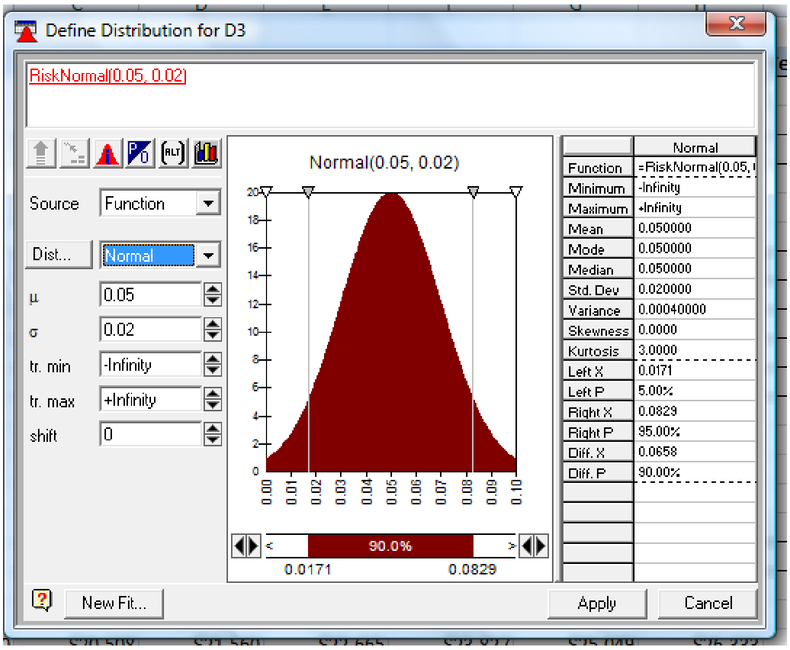
a. Year 1 Sales. Right-click on C7. Select *@Risk > Model > Define Distributions*. Click the Dist button and select Triang. Set the minimum value to 2000000, most likely value to 3000000 and the maximum value to 7,000,000. If the shift window has a non-zero entry, change it to zero. Then click apply. See Screen 1.

b. Sales Growth Rates. Right-click on D3. Select *@Risk > Model > Define Distributions*. Set the mean value to 0.05 and the standard deviation to 0.02. If the shift window has a non-zero entry, change it to zero. Then click apply. See Screen 2. Copy the formula in D3 to E3:J3.

Screen 1. Define Input: Sales in Year 1



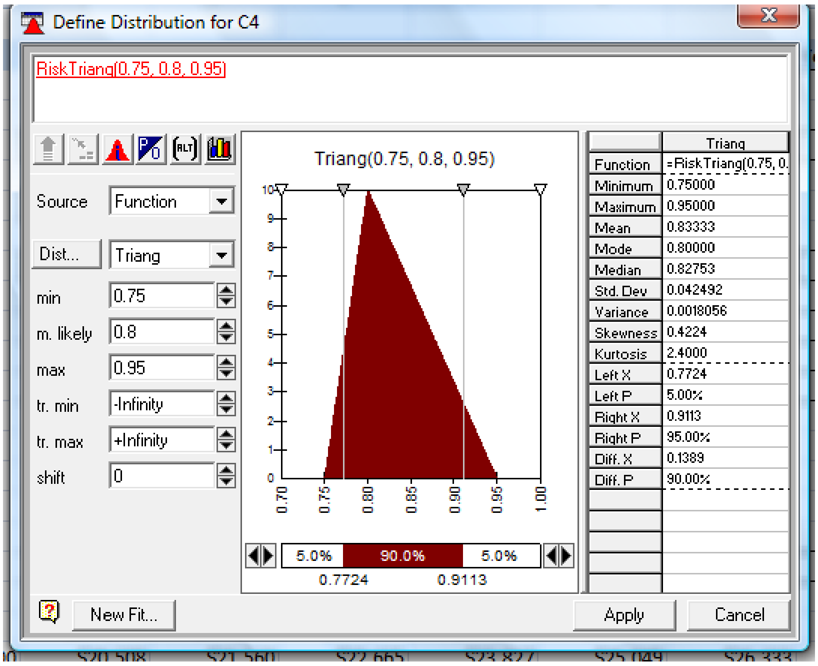
Screen 2. Define Input: Sales Growth Rates



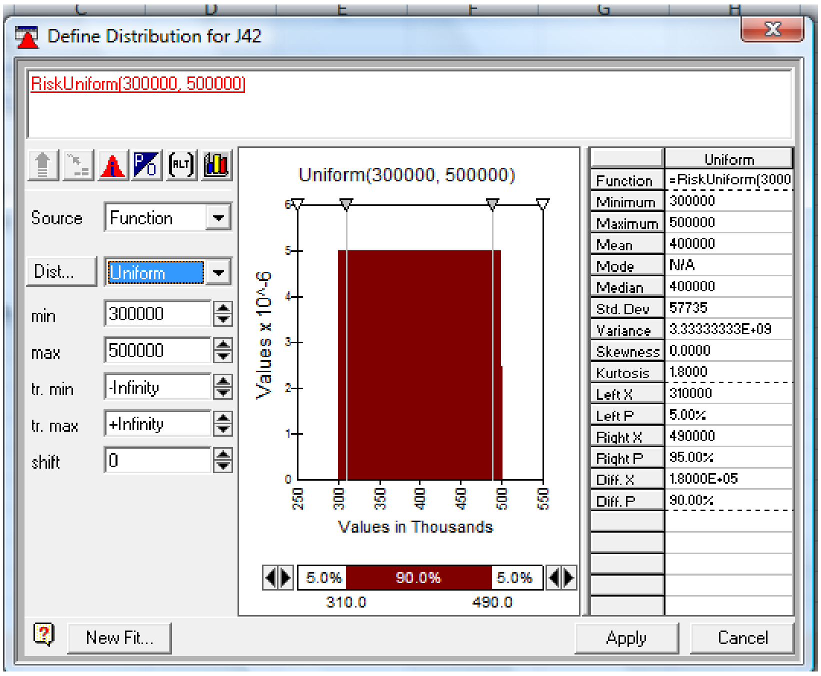
c. Manufacturing Cost as a % of Sales. Right-click on C4. Select *@Risk > Model > Define Distributions*. Click the Dist button and select Triang. Set the minimum value to 0.75, most likely value to 0.80 and the maximum value to 0.95. If the shift window has a non-zero entry, change it to zero. Then click apply. See Screen 3. Copy the formula in C4 to D4:J4.

d. Salvage Value of Fixed Assets. Right-click on J42. Select @Risk > Model > Define Distributions. Click the Dist button and select Uniform. Set the minimum value to 300000 and the maximum value to 500000. If the shift window has a non-zero entry, change it to zero. Then click apply. See screen 4.

Screen 3. Define Input: Manufacturing Cost as a % of Sales



Screen 4. Define Input: Salvage Value of Fixed Assets



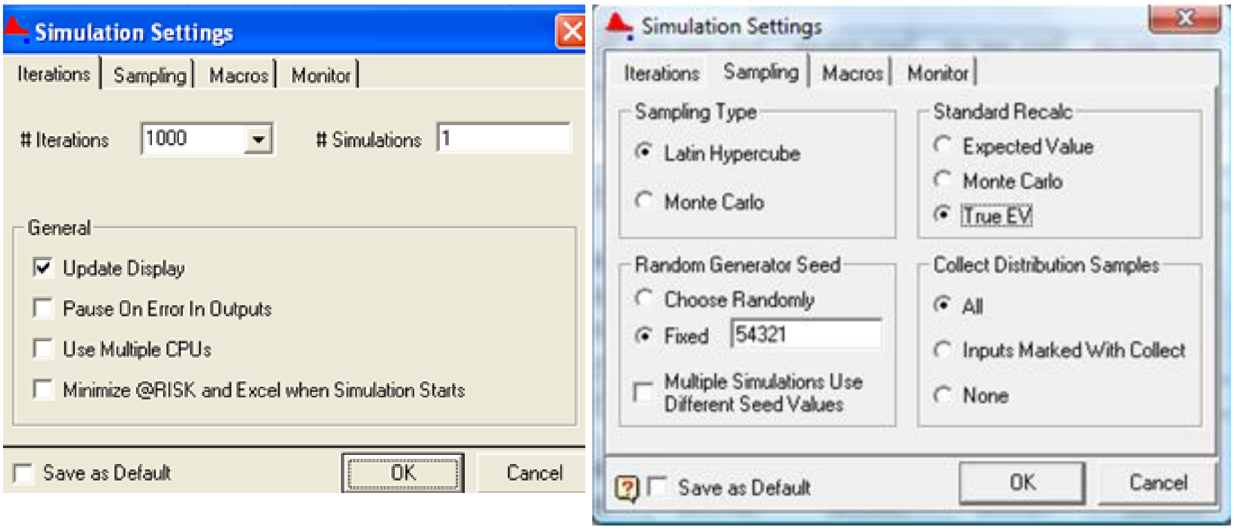
3.3 Output Cells

Output Cells are the forecasts of the model, or the things we are interested in understanding. @Risk runs a simulation by repeatedly selecting random variables for each of the input cells and recalculating the spreadsheet for each draw of the random variables. @Risk then stores the values of the *output cells* so that it can report the distribution. To define the net present value of future cash flows as an output cell, click on B29. On the Excel menu bar, select *@Risk* > *Model* > *Add Output*. You will be prompted to provide a name for the output cell. Then click OK to save and exit. To define the IRR as an output cell, click on B30. On the Excel menu bar, select *@Risk* > *Model* > *Add Output*. You will be prompted to provide a name for the output cell. Then click OK to save and exit.

4 Interpreting simulation results

This model is already set up to run, but you need to tell @Risk how many trials (sets of random variables) it will draw. To do this, from the Excel menu bar select *@Risk* > *Simulation* > *Settings* and enter 1,000 or some other number as the *"# Iterations."* See **Screen 5.** Click the Iterations tab if you do not see these selections. Then click on the Sampling Tab and check True EV in the Standard Recalc Menu. Next, check Fixed in the Random Generator Seed Menu and enter a seed number, say, 54321. Click OK to save and exit.

Screen 5. Simulation Settings



You are now ready to run the simulation. Click on *@Risk* > *Simulation* > *Start*. You will probably see a number of @Risk-Results windows open up and they will be continually updated until you get to the number of trials you specified. If the results windows do not appear, open them from the *@Risk* > *Results* > *Show Results Window*. If @Risk is running then the @Risk Results window will be updated at the frequency specified in the Monitor tab of the Simulation Settings dialog box. When the simulation is done, you will see a table like Screen 6. The @Risk Results Window provides access to Output and Input Statistics, Histograms, Tornado Charts, as well as the Input and Output data points generated by the simulation.

Screen 6. @Risk Results Window

Summary Statistics

	Name	Cell	Minimum	Mean	Maximum	x1	p1	x2	p2	x2-x1	p2-p1	Errors
Output 1	Net Present Value / Year 0	B29	-1055076	269173	2734310	-704893.4	5%	1525139	95%	2230032	90%	0
Output 2	IRR / Year 0	B30	1.907264E-0	0.1381859	0.3028288	5.758087E-0	5%	0.2329748	95%	0.1753939	90%	0
Input 1	Sales Growth / Year 2	D3	-1.764365E-0	4.999743E-0	0.1199617	0.0170647	5%	8.279535E-0	95%	6.573065E-0	90%	0
Input 2	Sales Growth / Year 3	E3	-2.454996E-0	4.998727E-0	0.1131015	1.697191E-0	5%	8.287495E-0	95%	6.590305E-0	90%	0
Input 3	Sales Growth / Year 4	F3	-0.020482	5.000076E-0	0.1257676	1.706661E-0	5%	8.288176E-0	95%	6.581514E-0	90%	0
Input 4	Sales Growth / Year 5	G3	-1.336822E-0	5.000124E-0	0.1180376	1.709496E-0	5%	8.273575E-0	95%	0.0656408	90%	0
Input 5	Sales Growth / Year 6	H3	-3.664659E-0	4.997978E-0	0.1181735	1.699444E-0	5%	8.282107E-0	95%	6.582663E-0	90%	0
Input 6	Sales Growth / Year 7	I3	-1.942081E-0	5.001611E-0	0.1320211	1.697198E-0	5%	8.289567E-0	95%	6.592369E-0	90%	0
Input 7	Sales Growth / Year 8	J3	-1.246155E-0	5.000402E-0	0.1175897	1.691996E-0	5%	8.278433E-0	95%	6.586437E-0	90%	0
Input 8	Manufacturing cost as % of sa	C4	0.7519594	0.8333321	0.945752	0.7722492	5%	0.9110701	95%	0.1388209	90%	0
Input 9	Manufacturing cost as % of sa	D4	0.7525191	0.8333325	0.9454128	0.7722508	5%	0.9111553	95%	0.1389045	90%	0
Input 10	Manufacturing cost as % of sa	E4	0.7518986	0.8333336	0.945536	0.7722748	5%	0.9110742	95%	0.1387994	90%	0
Input 11	Manufacturing cost as % of sa	F4	0.7521769	0.8333305	0.9457134	0.7721398	5%	0.9109251	95%	0.1387853	90%	0
Input 12	Manufacturing cost as % of sa	G4	0.752526	0.8333374	0.9485779	0.7722884	5%	0.9110186	95%	0.1387302	90%	0
Input 13	Manufacturing cost as % of sa	H4	0.7521462	0.8333282	0.9466287	0.7723316	5%	0.9109905	95%	0.1386589	90%	0
Input 14	Manufacturing cost as % of sa	I4	0.7521056	0.8333347	0.9484144	0.7722234	5%	0.911203	95%	0.1389796	90%	0
Input 15	Manufacturing cost as % of sa	J4	0.7520271	0.8333318	0.9457543	0.7723224	5%	0.9108925	95%	0.1385701	90%	0

At the @Risk Results Window, click on *Insert* > *Detailed Statistics*. You will see

Screen 7. Detailed Statistics

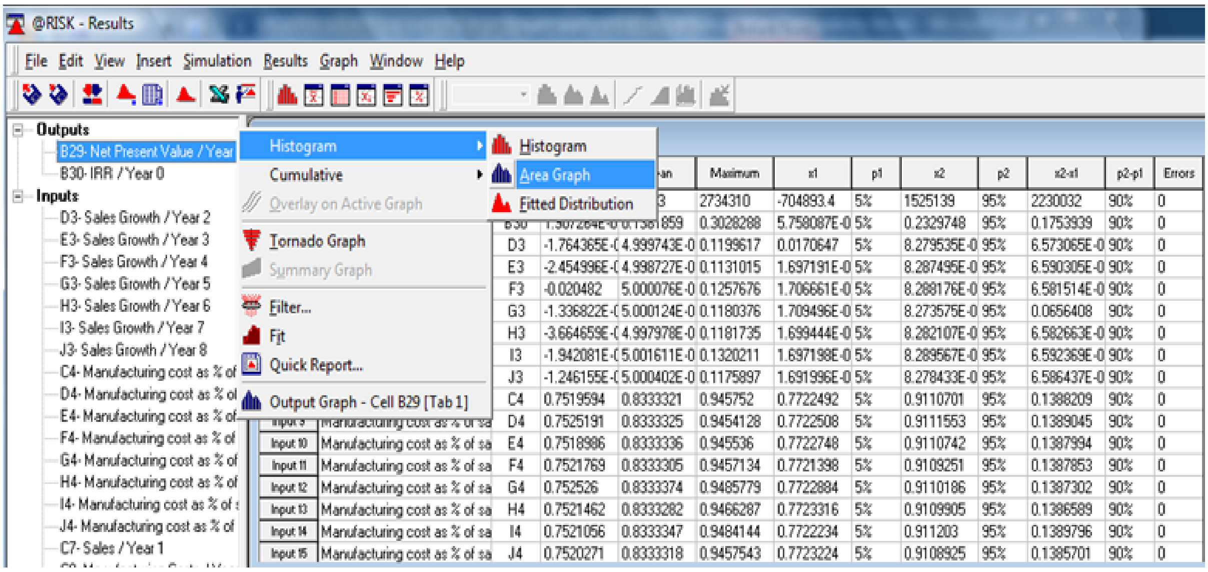
Detailed Statistics

Name	Net Present Value / Yea	IRR / Year 0	Sales Growth / Year 2	Sales Growth / Year 3	Sales Growth / Year 4
Description	Output	Output	RiskNormal(0.05, 0.02)	RiskNormal(0.05, 0.02)	RiskNormal(0.05, 0.02)
Cell	B29	B30	D3	E3	F3
Minimum	-1055076	1.907264E-02	-1.764365E-02	-2.454996E-02	-0.020482
Maximum	2734310	0.3028288	0.1199617	0.1131015	0.1257676
Mean	269173	0.1381859	4.999743E-02	4.998727E-02	5.000076E-02
Std Deviation	707489.8	5.501738E-02	2.002653E-02	0.0200126	2.004565E-02
Variance	5.005418E+11	3.026912E-03	4.010621E-04	4.005043E-04	4.018282E-04
Skewness	0.507263	0.2757924	-7.329926E-04	-1.943292E-02	5.802519E-03
Kurtosis	2.576362	2.347613	3.02124	3.017986	3.074309
Errors Calculated	0	0	0	0	0
Mode	-332709.3	0.1482986	4.974131E-02	4.925296E-02	4.415213E-02
5% Perc	-704893.4	5.758087E-02	0.0170647	1.697191E-02	1.706661E-02
10% Perc	-595214.3	6.828316E-02	2.434228E-02	2.428306E-02	2.433672E-02
15% Perc	-473389.8	7.829808E-02	2.926357E-02	2.918836E-02	2.925722E-02
20% Perc	-390463.3	8.622012E-02	3.311505E-02	3.313845E-02	3.309809E-02
25% Perc	-306436.8	9.336832E-02	3.645858E-02	3.645317E-02	3.645853E-02

In this table, the mean of output cell B29 is µPV = $269,173. This provides an estimate of the project NPV. The standard deviation of output cell B29 is σ_{NPV} = $707,489. This provides an estimate of the standard deviation of the project NPV. Given μ_{NPV} and σ_{NPV}, the 95% confidence interval for the present value is μ_{NPV} +/- 1.96*σ_{NPV}/ √N, where N equals the number of iterations in the simulation. The mean of output cell B30 is μ_{IRR} = 0.1381. This provides an estimate of the average project IRR.

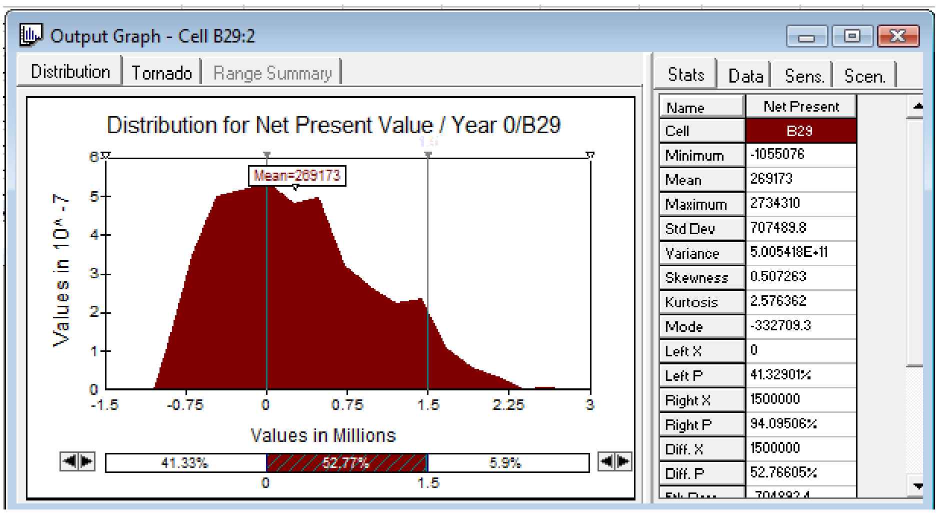
Suppose you want to determine the probability that the NPV will be less than $1,000 or be greater than $2,000. To answer this question, right-click the B42-Net Present Value/Year output item on the left panel of the @Risk Results Window.

Screen 8. @Risk Results Window



Then, choose Histogram>Area Graph. You will see screen 9.

Screen 9. Histogram of Project NPV

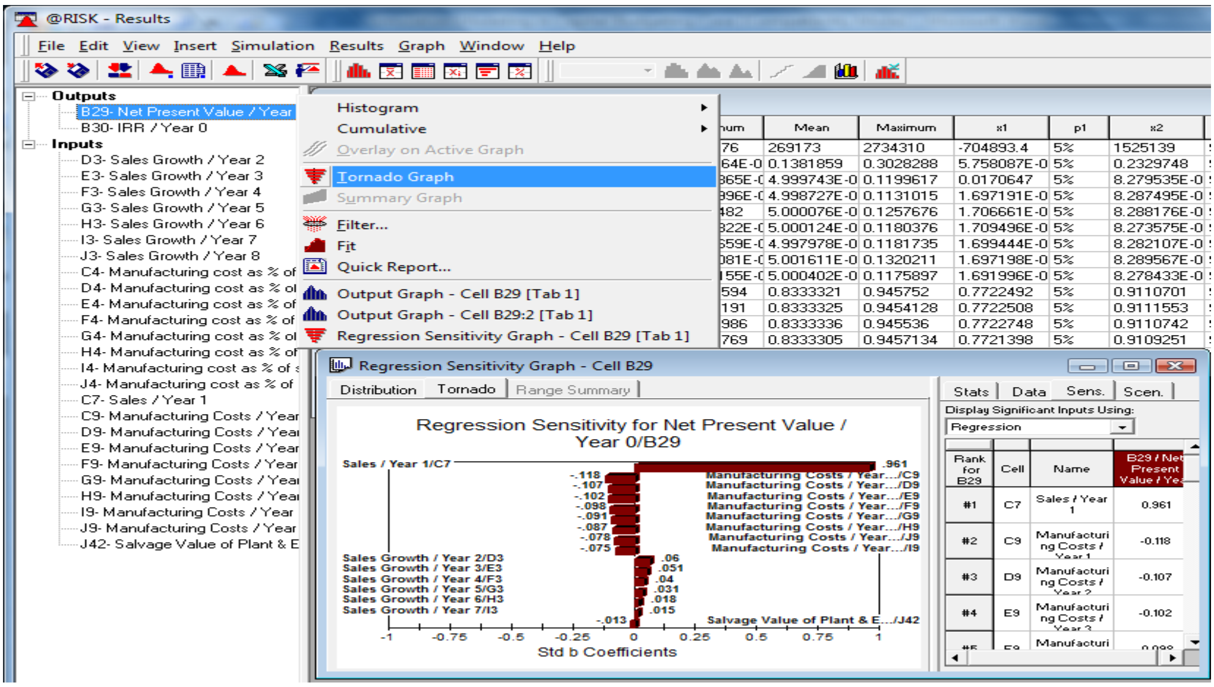


Now go to the right panel and set "Left X" to 0, and "Right X" to 1500000. You will notice that "Left P" becomes 41.33%. This corresponds to the probability that X (here, the NPV) is negative. "Right P" becomes 94.09%. This corresponds to the probability that X is less than 1500000. This means that the probability that X is greater than $1,500,000 is 5.91% =100% - 94.01%.

4.1 Tornado Chart

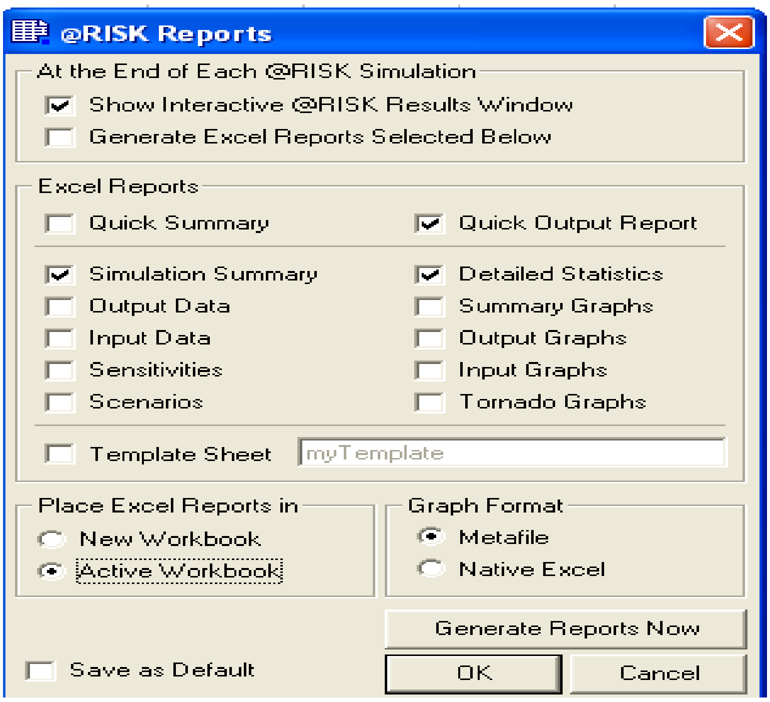
The tornado chart shows the ranking of different input variables in terms of their influence on an output variable. For example, right click B29 – Net Present Value output item on the left panel of the @Risk Results Window. Then click on Tornado Chart. See Screen 10. In the example, sales in year 1 have considerably more bearing on the distribution of the NPV any other uncertain variable. This suggests that, more than anything else, project success hinges on initial sales. In terms of influence on the NPV, initial sales is followed by manufacturing cost as a percentage of sales, sales growth rates, and finally by the salvage value of fixed assets. Also, consistent with the time value of money, manufacturing cost as a percentage of sales in earlier years has more influence on the distribution of NPV than manufacturing cost as a percentage of sales in later years. The same thing is true with the influence on the NPV of sales growth rate in earlier years compared with later years.

Screen 10. Tornado Chart: Project NPV



Simulation results may be reported directly in Excel using *@Risk > Results > Report Setting*, at which point you should see Screen 11. Choose the options you want for the report and click on the *Generate Reports Now* button. @Risk will generate an Excel report that you can print out. You can save the results using *@Risk > File > Save* from the menu bar. The next time you open the Excel file, you will have the option to reload the saved simulation results.

Screen 11. Report Settings



5 Concluding remarks

Traditionally, risk is recognized by performing sensitivity analysis, that is, by examining the impact on performance variables like NPV or IRR of deviations in the values of uncertain variables like sales, sales level, sales growth rates, or unit variable cost. Simulation modeling allows a more focused analysis by incorporating explicit distributions restricting the frequency and magnitude of these deviations. It is also more general in that it allows the evaluation of simultaneous changes in uncertain variables on the distribution of the performance variables. More useful simulation analysis also is made possible by the availability of spreadsheet-based simulation software which allows the analyst to employ distributions which better reflect the dynamics of an uncertain variable, instead of force-fitting more familiar distributions to avoid the analytical complexity of more realistic distributions.

References

1. Benninga, S., 2006, Principles of Finance with Excel, (New York: Oxford University Press).
2. Clemen, R. and Reilly, T., 2001, Making Hard Decisions, (USA: Duxbury).
3. Sheridan Titman and John Martin (2011), “Project Risk Analysis,” Valuation: The Art and Science of Corporate Investment Decisions, 2nd ed., Chapter 3, (Boston, Massachusetts: Pearson/Addison Wesley).
4. Winston, W., Albright, C., and Broadie, M., 2001, Practical Management Science, 2nd ed., (USA: Brooks/Cole).

APPENDIX

Milk4All Project									
	Year 0	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Year 6**	**Year 7**	**Year 8**
Sales Growth			0.05	0.05	0.05	0.05	0.05	0.05	0.05
Manufacturing cost as % of sales		0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83
Rent Increase		0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Sales		4000000	=C7*EXP(D3)	=D7*EXP(E3)	=E7*EXP(F3)	=F7*EXP(G3)	=G7*EXP(H3)	=H7*EXP(I3)	=I7*EXP(J3)
Manufacturing Costs		=0.8*C7	=0.8*D7	=0.8*E7	=0.8*F7	=0.8*G7	=0.8*H7	=0.8*I7	=0.8*J7
Rent		100000	=C10*(1+C5)	=D10*(1+D5)	=E10*(1+E5)	=F10*(1+F5)	=G10*(1+G5)	=H10*(1+H5)	=I10*(1+I5)
Total Operating Expenses		=C9+C10	=D9+D10	=E9+E10	=F9+F10	=G9+G10	=H9+H10	=I9+I10	=J9+J10
EBITDA		=C7-C11	=D7-D11	=E7-E11	=F7-F11	=G7-G11	=H7-H11	=I7-I11	=J7-J11
Depreciation		=C38	=D38	=E38	=F38	=G38	=H38	=I38	=J38
EBIT		=C13-C15	=D13-D15	=E13-E15	=F13-F15	=G13-G15	=H13-H15	=I13-I15	=J13-J15
Tax Rate		0.35	=C17	=D17	=E17	=F17	=G17	=H17	=I17
Tax		=C16*C17	=D16*D17	=E16*E17	=F16*F17	=G16*G17	=H16*H17	=I16*I17	=J16*J17
Net Operating Profit After Taxes		=C16-C18	=D16-D18	=E16-E18	=F16-F18	=G16-G18	=H16-H18	=I16-I18	=J16-J18
Depreciation		=C15	=D15	=E15	=F15	=G15	=H15	=I15	=J15
Invest. in Net Working Capital	=B34	=C34	=D34	=E34	=F34	=G34	=H34	=I34	=J34
Investment In Plant and Equipment	=B37								=-J46
Free Cash Flow	**=B19+B21-B22-B23**	**=C19+C21-C22-C23**	**=D19+D21-D22-D23**	**=E19+E21-E22-E23**	**=F19+F21-F22-F23**	**=G19+G21-G22-G23**	**=H19+H21-H22-H23**	**=I19+I21-I22-I23**	**=J19+J21-J22-J23**
Cumulative FCF	=B25	=B26+C25	=C26+D25	=D26+E25	=E26+F25	=F26+G25	=G26+H25	=H26+I25	=I26+J25
Cost of Capital	0.12								
Net Present Value	**=NPV(B28,C25:J25)+B25**								
IRR	**=IRR(B25:J25)**								
Projected NWC Level	400000	=0.1*D7	=0.1*E7	=0.1*F7	=0.1*G7	=0.1*H7	=0.1*I7	=0.1*J7	=0.1*K7
Investment in NWC	=B33	=C33-B33	=D33-C33	=E33-D33	=F33-E33	=G33-F33	=H33-G33	=I33-H33	=J33-I33
Plant & Equipment	2500000	=B37	=C37	=D37	=E37	=F37	=G37	=H37	=I37
Depreciation		=C37/10	=D37/10	=E37/10	=F37/10	=G37/10	=H37/10	=I37/10	=J37/10
Accumulated Depreciation		=B39+C38	=C39+D38	=D39+E38	=E39+F38	=F39+G38	=G39+H38	=H39+I38	=I39+J38
Ending Book Value of PPE		=C37-C39	=D37-D39	=E37-E39	=F37-F39	=G37-G39	=H37-H39	=I37-I39	=J37-J39
Salvage Value of Plant & Equipment									400000
Ending Book Value									=J40
Capital Gains									=J42-J43
Capital Gains Tax (40%)									=0.4*J44
Net Proceeeds from Sale of PPE									=J43-J45