ACCOUNTING MODELS AND PROBABILISTIC RISK ANALYSIS

Dennis Togo, Anderson School of Management, University of New Mexico, Albuquerque, NM, 87131, 505-277-7106, togo@unm.edu

ABSTRACT

Complex accounting relationships modeled on spreadsheets can be analyzed for risk using spreadsheet add-ins by replacing expected values of key input variables with probability distributions. Performing simulation on the accounting model generates distributions for critical output variables presented with percentile data and equivalent graphs. A profit plan is used to illustrate modeling uncertainty, performing a simulation and assessing risk within the model.

INTRODUCTION

It is common to model key relationships within accounting. For example, an income statement, cost of goods manufactured statement, cash flow statement, and balance sheet are often modeled as a profit plan. Sensitivity analysis and scenario analysis are "what-if" techniques in determining how different input values impact key output values of a modeled relationship. With the ordinary use of spreadsheets, risk analysis is deterministic in that only one value is entered for input variables with their impact on outputs noted also as a singular value. Even when a different value for more than one key input variable is substituted, the model will generate a singular value for output variables. Obtaining sufficient combinations of input variables for a complex model can be challenging in scenario analysis.

Togo [4] recognized the difficulty for spreadsheets to account for the weighting of input values as a hindrance to their use for risk analysis. Without a weighting (probability) assigned to the different values of an input variable, the most-likely, best, or worst case scenarios may be difficult to identify with a deterministic model. Hence, users that rely on skeletal distributions of key output variables may not have a valid representation of the modeled relationship.

ACCOUNTING MODELS WITH UNCERTAINTY

Recent spreadsheet add-ins (e.g., @RISK and Crystal Ball) that perform quantitative simulation facilitate decision-making with their ability to perform risk analysis. Simulation requires key input values of a model to be selected from its underlying probability distribution, which has a range of values and weights assigned to each value. A simulation randomly selects values from the distributions and then computes and stores the selected output values of the model. After completing the specified iterations, results for the output values are displayed as a distribution graph with its mean, minimum and maximum values, and percentiles for targeted values.

Decision-makers view output graphs as a way to better understand risk within the modeled relationship. For example, Togo [4] performed simulation risk analysis for capital budgeting, a budgeted cash flow and a budgeted income statement using @RISK and presented graphical output distributions for NPV, borrowings, and ratios. For NPV, distribution displayed the percentile of outcomes for a negative NPV, the likelihood that NPV will be greater than a targeted amount, and the symmetry of the outcome. For the budgeted cash flow, a graphical distribution for borrowings presented its range and likelihood of occurrence (e.g., 85% of simulated outcomes for borrowings would be covered by a specified amount).

Research in this area has extended to decision support and expert systems. Khataie et al. [2] presented a generic systematical approach for solving supply chain order management problems utilizing the advantages of system dynamics (SD) and mixed-integer programming (MIP) with activity-based costing (ABC) as a harmonizer tool. Their model provided the order fulfillment optimal mix and implementation strategy with real time selling prices. Bogaerd et al. [1] examined text classification algorithms in an accounting setting. The Learning from Positive and Unlabeled (LPU) - algorithm developed was a four stage classification process that classified 90% of the documents accurately into positive, negative or unlabeled.

The educational benefits of modeling uncertainty expressed by students of a cost accounting course include a) greater interest in traditional cost/managerial accounting topics that can be modeled, b) familiarity with a powerful decision aid, and c) increased understanding of risk analysis for accounting models. The following example demonstrates risk analysis for a profit plan with the add-in @RISK [3].

RISK ANALYSIS FOR A PROFIT PLAN

Profit Plan

The profit plan spreadsheet model is presented with a cash flow statement, an income statement, and a balance sheet. The model makes cell references to the expected values of inputs; hence, expected values may be changed for "what-if" type analyses. Beginning balances for the profit plan are noted (*).

Cash Flow Statement	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Year
Beginning cash	$*5,500	$8,000	$8,000	$8,523	$5,500
Cash receipts:					
Prior period receivable	*13,000	24,300	20,250	21,600	79,150
From current sales	56,700	47,250	50,400	53,550	207,900
Cash available	75,200	79,550	78,650	83,673	292,550
Cash disbursements:					
Prior period payable	*14,000	19,488	17,024	18,144	68,656
For current purchases	36,192	31,616	33,696	36,192	137,696
Variable S&A	5,400	4,500	4,800	5,100	19,800
Fixed S&A	14,000	14,000	14,000	14,000	56,000
Disbursements	69,592	69,604	69,520	73,436	282,152
Minimum cash balance	8,000	8,000	8,000	8,000	8,000
Cash needs	77,592	77,604	77,520	81,436	290,152
Excess (deficiency)	(2,392)	1,946	1,130	2,237	2,398
Financing:					
Borrowings	2,392	0	0	0	2,**392**
(Repayments)	0	(1,802)	(590)	0	(2,392)
(Interest paid)	0	(144)	(18)	0	(161)
Net financing	2,392	(1,946)	(607)	0	(161)
Ending cash	$ 8,000	$ 8,000	$ 8,523	$ 10,237	$ 10,237

Income Statement	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Year

Sales	$81,000	$67,500	$72,000	$76,500	$297,000
Cost of goods sold:					
Beginning inventory	*11,520	9,600	10,240	10,880	11,520
Purchases	55,680	48,640	51,840	55,680	211,840
Available	67,200	58,240	62,080	66,560	223,360
Ending inventory	9,600	10,240	10,880	12,160	12,160
Cost of goods sold	57,600	48,000	51,200	54,400	211,200
Gross profit	23,400	19,500	20,800	22,100	85,800
Selling and administrative:					
Variable	5,400	4,500	4,800	5,100	19,800
Fixed	14,000	14,000	14,000	14,000	56,000
Operating income	4,000	1,000	2,000	3,000	**10,000**
Interest expense	72	72	18	0	162
Net income	$3,928	$928	$1,982	$3,000	$9,838

Balance Sheet	Qtr 1	Qtr 2	Qtr 3	Qtr 4
Assets				
Cash	$8,000	$8,000	$8,523	$10,237
Accounts receivable	24,300	20,250	21,600	22,950
Inventory	9,600	10,240	10,880	2,160
Total assets	$41,900	$38,490	$41,003	$45,347
Liabilities & SE				
Accounts payable	$19,488	$17,024	$18,144	$19,488
Notes payable	2,392	590	0	0
Interest payable	72	0	0	0
Paid-in-capital	5,000	5,000	5,000	5,000
Retained earnings	14,948	15,876	17,859	20,859
Total Liabilities &SE	$41,900	$38,490	$41,003	$45,347

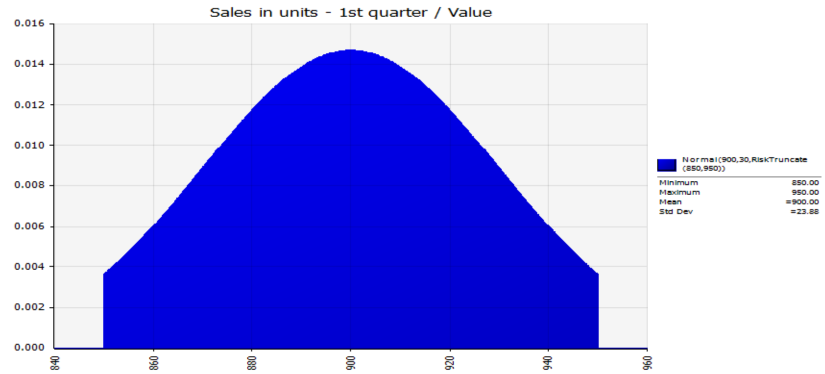
Data for Input Variables

Only three input variables are used to demonstrate how probability distributions model uncertainty. @RISK models **Qtr 1 unit sales** with a normal distribution, **Selling price** with a histogram distribution, and **Invent purchase cost** with a triangular distribution. @RISK distributions are shown next to their expected value. A description of the distributions and their graphs follow the list of input variables.

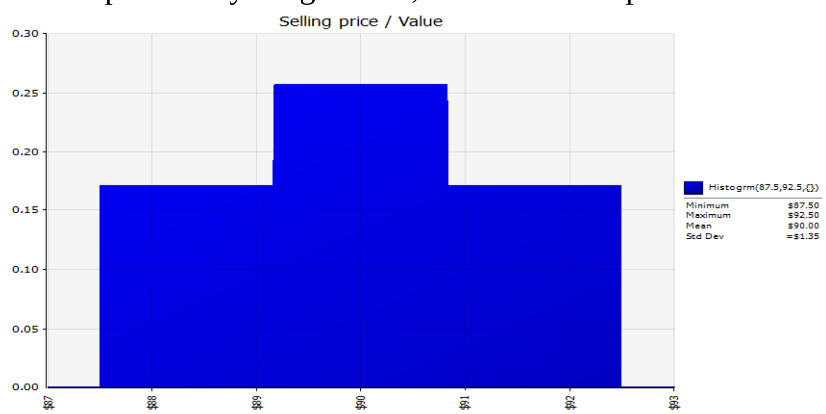
Input Variable	Expected Value	@RISK Probability Distribution
Qtr 1 unit sales	**900**	**RiskNormal(900,30,RiskTruncate(850,950)**
Qtr 2 unit sales	750	RiskNormal(750,30,RiskTruncate(700,800)
Qtr 3 unit sales	800	RiskNormal(800,30,RiskTruncate(750,850)
Qtr 4 unit sales	850	RiskNormal(850,30,RiskTruncate(800,900)
Qtr 1 unit sales of next year	950	RiskNormal(950,30,RiskTruncate(900,1000)
Selling price	**$90.00**	**RiskHistogrm(87.5,92.5,{2,3,2})**
Sales collected in qtr	70%	Held constant at expected value

Invent purchase cost	**$64.00**	**RiskTriang(58.5,66,67.5)**
Ending invent needs	20%	Held constant at expected value
Invent purchases paid in qtr	65%	Held constant at expected value
S&A variable exp per unit	$6.00	Held constant at expected value
S&A fixed exp	$14,000	Held constant at expected value
Minimum cash balance	$8,000	Held constant at expected value
Annual interest rate	12%	Held constant at expected value

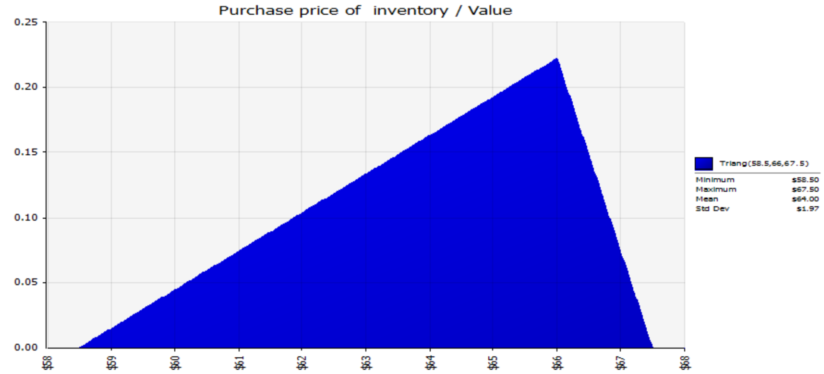
Qtr 1 Unit Sales - RiskNormal(900,30,RiskTruncate(850,950): A normal distribution with a mean (expected value) of 900 units and a standard deviation of 30; however, sampling is restricted to a minimum possible value of 850 and maximum possible value of 950.



Selling Price - RiskHistogrm(87.5,92.5,{2,3,2}): A histogram with a minimum selling price value of $87.50 and a maximum value of $92.50. The range is divided into three equal-length classes having relative probability weights of 2, 3and 2. The expected value is $90.00.



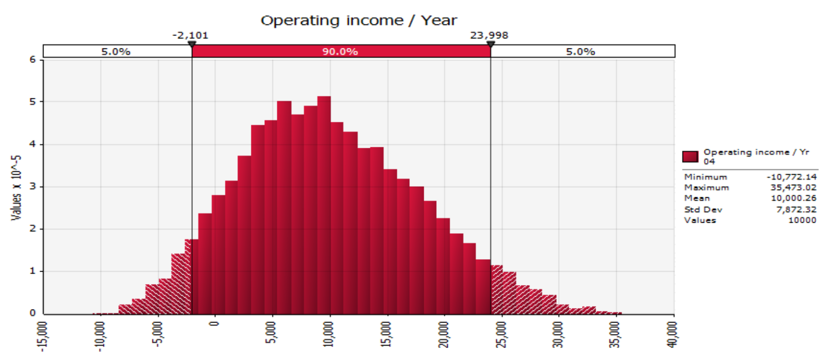
Invent Purchase Cost - RiskTriang(58.5,66,67.5): A triangular distribution with a lower limit purchase cost of $58.50, a most likely value of $66.00, and an upper limit of $67.50. The skewed distribution has an expected value of $64.00.



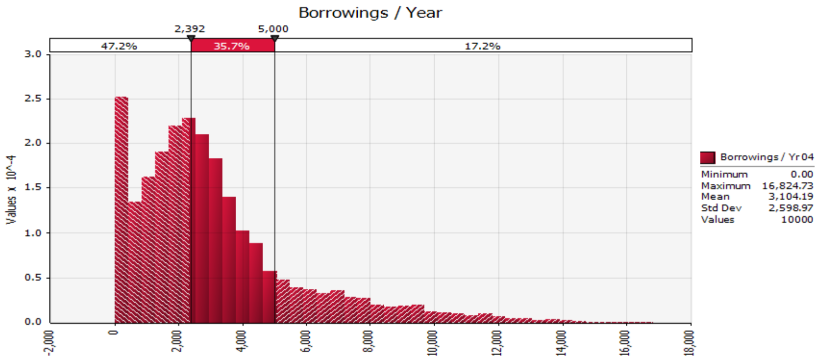
Simulation for Critical Outputs

From the probability distributions modeling uncertainty, a simulation is performed for 10,000 iterations of the profit plan. The graphical results of the simulation for the critical outputs Operating Income and Borrowings are presented below.

Operating Income - the income statement has an expected yearly Operating Income of $10,000 and the simulation mean is also $10,000. The simulation results show a 5% likelihood of having a loss of $2,101and a 5% likelihood of being greater than $23,998. From the simulation data, either the amount for Operating Income or its percentage could be changed to determine the corresponding amount. For example, the graph could show a) the percentile for an operating income of $15,000, or b) the operating income for a 75% cumulative percentile.



Borrowings - the cash flow statement has an expected amount of $2,392 for Borrowings during the year. The simulation results for yearly Borrowings show a 47.2% likelihood at the expected value of $2,392. Although the simulation mean is $3,104, this difference between means is due to Borrowings not having negative outcomes. The simulation results expect Borrowings to have a 52.8% (1-47.2%) of being greater than $2,392. Hence, a manager would want to set up a line of credit that covers a larger percentage of simulated outcomes. The graph shows that Borrowings of $5,000 would cover 82.8% (1-17.2%) of the simulation outcomes.



CONCLUSION

Accountants with the ability to model complex financial relationships can easily use spreadsheet add-ins for risk analysis of managerial decisions. In particular, the ability to model uncertainty, perform quantitative simulation, and graph distributions for critical output variables enhances the analysis of risk within a modeled decision. Graphs for critical outputs of a managerial decision display a range of values with their likelihood of occurrence, which is information not readily available from expected value computations.

REFERENCES

[1] Bogaerd, M. & Aerts, W. Applying machine learning in accounting research. *Expert Systems with Applications.* 2011, 38 (10), 13414-13424.

[2] Khataie, A., Bulgak, A. & Segovia, J. Activity-based costing and management applied in a hybrid decision support system for order management. Decision Support Systems. 2011, 52 (1), 142-156.

[3] Palisade Corporation (2010). @RISK – Advanced Risk Analysis for Spreadsheets. Version 5.7. Newfield, NY.

[4] Togo, Dennis F. Risk analysis for accounting models: a spreadsheet simulation approach. Journal of Accounting Education, 2004, 22 (2), 153-163.