Monthly Cash Budget Under Sales and Collections Uncertainty

Ahmet Tezel and Ginette McManus

This paper develops a monthly cash budget modeled in Excel to illustrate how a spreadsheet simulation analysis can be performed to directly incorporate uncertainty in both sales and collection patterns to determine cash balances. The paper provides a numerical example, formulas as well as assumptions for a cash budget extending from January through December. It also describes how to perform a simulation using the build-in capabilities of Excel RAND function. The cash budget model is run 5000 times to capture the probability distribution of the minimum ending cash balance over that period (end of July). Simulation results support that the mean cash balance in July is considerably less than the positive cash balance obtained in July when no uncertainty in sales and collection patterns are assumed and that the standard deviation of the July cash balance is quite large. In fact, results indicate that there is a 50 percent probability that the July cash balance will be negative. Cash budgeting decision-making is clearly improved by specifying normal probability distributions for each uncertain critical variable such as sales and collection patterns. Excel's build-in capabilities allow students with no programming skills to perform complex and realistic risk analyses of real financial problems.

INTRODUCTION

Cash budget summarizes a firm's expected cash inflows and outflows over a period of time. By using the expected collection patterns and the planned purchases and payments for various expenditures, the cash budget provides the expected cash deficits and surpluses. Forecasted cash balances, however, are very sensitive to changes in sales and collection patterns. By using a personal computer with electronic spreadsheets, what-if analysis is the most common method of evaluating the sensitivity of expected cash balances to changes in sales and collection patterns. However, probability-related methods, such as simulation analysis, give a better overall understanding of uncertainty, particularly in the presence of several sources of uncertainties.

The objective of simulating a cash budget is to describe the distribution and characteristics of the possible resulting values for the cash balance variable. Simulation allows a greater understanding of the cash budget problem by estimating the mean and standard deviation of the cash balances, by constructing the frequency distribution of the cash balances and, by evaluating the probability that the actual cash balance will be greater (or less) than a particular value. Unfortunately, simulation analysis is not widely used mostly because of the unawareness of the ability of electronic spreadsheets to perform simulation.

In this paper, we illustrate a cash budget spreadsheet model developed with the basic Excel package. We describe how to perform a simulation using the inherent capabilities of Excel with the build-in function called RAND. We present the results of a simulation of 5,000 iterations and show that the probability of running out of cash during the year may be quite high even though cash balances remain positive under certainty assumptions.

The main purpose of the paper is to encourage Finance instructors to introduce probability distributions for critical variables using a cash budgeting model as an example and to illustrate the usefulness of Excel itself as a very powerful tool to perform a realistic

St. Joseph's University, Philadelphia, PA 19131.

simulation for determining cash balances. The model and documentation provided in this paper should help students appreciate the importance of directly incorporating uncertainty to enhance financial decision-making.

REVIEW OF THE LITERATURE

There are many published applications of simulations in Finance. Hertz [1964] was the first to report the use of simulation analysis, referred to as risk analysis, in capital budgeting. Norton [1994] describes a simulation model, referred to as a Monte Carlo model, to analyze an acquisition decision.[1] More recently, Benninga [1997] builds financial models in the areas of corporate finance (pro forma financial statements, free cash flows, and leasing to name a few), portfolio theory and insurance, bond duration and immunization, as well as derivatives and implements them with Microsoft Excel. He then uses the Excel's spreadsheets to perform the usual what-if or sensitivity analysis. In some instances, like with the Black-Scholes option pricing model, Benninga [1997] run simulations using VBA (Visual Basic for Applications), Excel's programming language. However, most of the modeling simulations on electronic spreadsheets are found in Management Science books. For example, Winston and Albright [1997] and Ragsdale [1998] formulate spreadsheet models implemented in Excel of a wide variety of business problems from finance, operations, and marketing. They also show how simulation can be used in Excel to analyze several financial decisions including capital budgeting, inventory-ordering, contract bidding and stock trading strategies. We add to this literature by developing a complex but realistic monthly cash budget model and using Excel's build-in simulation capabilities only to analyze the impact of varying both sales and collection experiences on the end-of-the-month cash balances.

CASH BUDGET'S ASSUMPTIONS

Table 1 provides a numerical example for a monthly cash budget modeled in Excel from January (t = 1) through December (t = 12). Table 2 provides the formulas of the model and its assumptions. Sales forecasts, as shown on line 5 of Table 1, are assumed to have a strong seasonality, reaching their maximum amount in May (t = 5). To introduce sales' uncertainty, we assume sales forecast errors to be normally distributed with a zero mean and 6 percent standard deviation of expected sales as follows: @NORMINV(RAND(),0,0.06*Expected Sales). These estimates, along with customers' payment patterns given in lines 8 through 11, are necessary to determine monthly cash collections. Collections from sales are assumed to be 10 percent during the first or current month, 40 percent during the second month and 50 percent during the third month. To simplify the cash budget, no uncollectibles are assumed. To introduce uncertainty with respect to cash collections during this three-month period, standard deviations are assumed to be 1 percent during the first month and 2 percent during the second and third months. If not all receivables are collected during the first three months, the remaining is collected during the fourth month. On the other hand, if the simulated amount during the third month resulted in a total amount collected to be greater than 100 percent, the cash collection during the third month is determined as a residual. Thus, total cash collections received each month are showed on line 20.

Total cash payments made each month are reported on line 38 and show disbursements for purchases on credit (payables), wages, rent and so on (cash costs) as well as capital expenditures. The purchase ratio is assumed to be 65 percent of next month's expected sales. However, purchases during the current month depend upon not just the next month's expected sales but also the current month's sales forecast error. 70 percent of the payments for purchases are made during the first month and 30 percent during the following month. Other cash expenses are paid quarterly and are equal to 20 percent of the quarter's expected sales. Capital expenditures of $17,000 are planned for July.

The net cash change line is obtained by subtracting total cash payments from total cash collections and shows whether a positive (surplus) or negative (deficit) net cash flow is expected to be generated each month. The beginning of the year or January cash balance is assumed to be $8,000. Note that we have not included in the cash budget interest earned on any excess funds and paid on the borrowing, if any. We kept the cash budget model as simple as possible to illustrate the role of sales and collection's

Table 3. Distribution of July Cash Balance (In $'s)

	Collection Percentage Uncertainty	Sales Uncertainty	Sales and Collection Percentage Uncertainty
Mean	6.00	224.00	16.00
Standard Deviation	511.00	943.00	1,079.00
Minimum	(2,267.00)	(2,871.00)	(3,820.00)
Probability <1%	(1,362.00)	(1,945.00)	(2,669.00)
Probability <5%	(890.00)	(1,324.00)	(1,774.00)
Probability <50%	29.00	225.00	30.00
Probability <75%	360.00	850.00	776.00
Probability <95%	790.00	1,791.00	1,759.00
Probability <99%	1,057.00	2,414.00	2,386.00
Maximum	1,837.00	3,552.00	4,049.00

Std. dev. of collection percentages is 1% in first month, 2% in second and 3% in third. Std. dev. of sales is 6%.

uncertainty. Note also that the bottom line ending cash balance shown is a cumulative amount.

SIMULATION RESULTS

When the cash budget model in Table 1 is run one time under sales and collections uncertainty, the minimum ending cash balance is $256 at the end of July (t = 7). Table 1a reports the results of running the cash budget model under certainty and shows a minimum ending cash balance of $215 at the end of July. Thus, if forecasts are accurate, the beginning cash balance of $8,000 appears to be sufficient to cover the expected low cash account balance at the end of July.

Clearly, under uncertainty, sales and collection percentages will differ from those expected, and cash balances, especially in July, will be negative for some of the time. As mentioned previously, a minimum cash balance of $256 for July is obtained if we run once the cash budget model under uncertainty. Of course this cash balance will be different each time we run the cash budget model under sales and collections' uncertainty because normal probability functions will generate different sales and collections each time.

To capture the distribution of cash balances at the end of July, we run the cash budget model 5,000 times. This is accomplished in Excel by preparing a data table for the cash balances. More specifically, in cell A50 (or any blank cell), type @RAND() and fill in the cells from A52 to A5051 with 1, 2, 3, … , 5000. Type in B51 the cell reference of the cash balance at the end of July (I43). Now highlight cells A51 to B5051 and go to Data/Tables and type A50 in the column input cell. When you run the data table, after each run of the model, the cash balance at the end of July is placed in cells B52 to B5051. To sort these cash flows, first copy the values of only cells B52 to B5051 to somewhere in your worksheet (possibly in D52 to D5051), and then sort these cells in an ascending order.[2]

Table 3 presents the results of a simulation run of 5000 iterations for end of July cash balances. The mean cash balance of $16 is less than $215, the cash balance under certainty. Under uncertainty in both sales and collection percentages, the end of July cash balance has a standard deviation of $1,079. The minimum cash balance of -$3,820 is below 3 standard deviation from the mean (-$3,221 = $16 - 3 * $1,079).

To derive the probability distribution of July cash balances, go to the 5,000 cells sorted in ascending order (D52 to D5051) and read off the amounts.[3] For example, the end of July cash balance in cell D3801, which represents 75 percent of the 5,000 cells plus 51, is $776. Therefore, there is a 75 percent probability that the July cash balance will be less than $776. Results in Table 3 indicate that there is almost a 50 percent chance that the July cash balance will be negative. Cash balances need to be raised by $2,669 to reduce the probability of running out of cash in July to less than 1 percent. About $4,000 additional cash is needed to make sure that the company has always a positive cash balance in July.

The distribution of July cash balances in Table 3 indicates that the mean cash balance is $16 and that there is approximately 50 percent chance that the cash balance at the end of July will be less than $16. If the simulation is repeated, we will get a slightly different mean for the distribution of July cash balance. To obtain the accuracy of the estimate, the 95 percent confidence interval from the mean can be calculated by using: Mean± @Normsinv(0.975)*Standard deviation/@SQRT(5000). In this simulation, there is a 95 percent probability that the average July cash balance will be between -$14 and $46.

Students may be given an assignment to study the relative importance of sales and collection uncertainties. For example, if only sales uncertainty existed, the mean and standard deviation of July cash balances are $224 and $943, respectively. If we assume uncertainty in only collection percentages, the mean and standard deviation of July cash balances are $6 and $511, respectively. Clearly, sales and collection uncertainties are not additive.

We emphasize the importance of estimating as accurately as possible the parameters of these distributions. In addition to estimating the expected values for the uncertain variables, standard deviations of the distributions for sales and collection percentages will have to be estimated. Sensitivity analysis with respect to standard deviations is also useful in explaining the trade-off between estimation costs of these parameters and their importance in the model.

SIMULATION WITH ADD-INS

While our cash budget application describes how to run a simulation using the build-in capabilities of Excel, the same risk analysis can be performed using a popular but expensive commercial Excel add-in called @RISK, developed by Palisade Corp. @RISK improves the simulation capabilities of the basic Excel package but is harder to learn and would require additional teaching instructions. It performs the simulation more quickly and easily by providing additional commands that allow the typical steps of the simulation to be executed automatically, particularly statistics gathering and presentation of results. For example, with Excel, we prepared a data table to capture the distribution of the cash balances at the end of July. We also created tables to enhance the cash budget analysis. But with Excel add-inn @RISK, statistics (means and standard deviations) on the cash balances generated by the simulation are automatically kept across the 5000 iterations. @RISK also provides tables or graphs such as histograms of the cash balances. Furthermore, @RISK has a special function, the RISKSIMTABLE function, allowing to run the simulation several times, using a different value for the input variables each time.[4] Note that @RISK is not the only available costly simulation add-in for Excel. A worthy competitor is Crystal Ball, developed by Decisioneering. Crystal Ball has pretty much the same functionality as @RISK. There are also some special-purpose simulation packages like PROMODEL that can simulate complex systems in the manufacturing, service and healthcare industries and a variety of other processes that are being used more increasingly in the business world.

CONCLUSIONS

We showed in this paper that the direct incorporation of uncertainty is easily handled in an Excel spreadsheet by using the build-in RAND function and capturing the simulation results in a data table for a single variable. We use these tools to study the uncertainty of sales and collection percentages in cash budgeting. Both undergraduate and graduate students should know Excel and our examples should help students to make improved financial decisions in the future. With Excel's build-in simulation capabilities, plus powerful Excel add-inns such as @RISK and Crystal Ball, there is little excuse for postponing the introduction of uncertainty into financial decision-making even at the undergraduate level.

ENDNOTES

[1]Some financial planning model packages available commercially, such as *Interactive Financial Planning System*, have build-in capabilities for performing Monte Carlo simulation.

[2]To freeze the July cash balances in the B51.B5051 range in your worksheet, highlight the range B51:B5051 and use the commands: copy/paste special/values only. You can then sort B51:B5051 in an ascending order.

[3]The cumulative frequencies can be obtained by using a frequency function in Excel. For labels, type Values in J51, Frequency in K51, Probability in L51, and Cumulative Probability in M51. Using 9 categories, define the categories by entering the upper limit of each category, except the last category, in the range J52:J59. For example, type -1,500 in cell J52 and increase the amounts by 500 until you get 2,000 in cell J59. Cell J60 will automatically insert values greater than 2000 and you may want to type as a label >2000 in cell J60. Now select K52:K60 and type the array formula: @Frequency(B52:B5051,K52:K59) and press Ctrl-Shift-Enter simultaneously. To generate the probabilities, type K52/5000 in L52 and copy this formula from L52 to L53:L60. To generate the cumulative probabilities, type L52 in M52 and type M52+L53 in M53. Copy this formula in M53 to M54:M60. Another way to obtain cumulative probabilities for a given category is to use the count if function in Excel. For example, @(Countif(B52:B5051,"<0")/5000 gives the probability of July cash balances being less than zero.

[4] Refer to Winston and Albright [1997] p. 692-696 for a simulation of a simplified cash balance/maximum loan model using @RISK.

REFERENCES

Benninga Simon. *Financial Modeling*, Massachusetts Institute of Technology, 1997.

Brigham, Eugene F., and Louis C. Gapenski. *Financial Management: Theory and Practice*, 8th Edition, The Dryden Press, 1997.

Hertz, David B. "Risk Analysis in Capital Budgeting", *Harvard Business Review* 42, (January-February 1964), 96-108.

Norton, R. "A New Tool to Help Managers," *Fortune*, (May 30, 1994), 135-140.

Plane, Donald R., *Management Science: A Spreadsheet Approach*, Boyd & Fraser Publishing Company, 1994.

Ragsdale Cliff T. *Spreadsheet Modeling and Decision Analysis: a Practical Introduction to Management Science*, 2nd Edition, South-Western College Publishing, 1998.

Winston, Wayne L. and S. Christian Albright. *Practical Management Science: Spreadsheet Modeling and Applications*, Wadsworth Publishing Company, 1997.