SPREADSHEET SIMULATION IN ACCOUNTING WITHOUT ADD-INS

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INTRODUCTION

Simulation is widely used in accounting practice to analyze risk. It is employed in managerial accounting practice for (1) financial forecasting and budgeting, (2) replacement and maintenance of machinery/equipment, (3) analyzing capital investment, (4) make or buy decisions, (5) planning and controlling the budgetary process, (6) planning and implementing revisions in accounting systems, (7) inventory analysis and control, and (8) production planning and control (O'leary, 1983). It is also heavily used in auditing practice. For example, parallel simulation is used frequently for controls testing and substantive testing (Turney and Watne, 2003). Realizing the importance of simulation in accounting, when addresses the functional competencies in the AICPA Core Competency Framework for Entry into the Accounting Profession, AICPA states that individuals entering the accounting profession must be able to build appropriate models and simulations using electronic spreadsheets and other software (AICPA, 2009). Developing a simulation model on an electronic spreadsheet has several advantages: (1) the elimination of the need for learning a programming language, (2) the wide spread availability of and familiarity with spreadsheet software, (3) the availability of many built-in statistical functions for generating random numbers and data summarization, (4) the capability of displaying information in detail and in easy-to-read format, not just the final results, and (5) the ease of experiments for different values of the parameters. This paper is organized as follows. At first, it provides a discussion of random number generators in the electronic spreadsheet environment. Next, it demonstrates the use of Microsoft Excel to develop a working simulation model without third-party add-ins.

RANDOM NUMBER GENERATORS

One of the requirements of almost any simulation model is some facility for generating random numbers. Microsoft Excel provides two uniform random number generators in the form of functions: RAND() and RANDBETWEEN(a,b). However, other theoretical distributions – such as normal, exponential, gamma, and Poisson distributions – are encountered more frequently than is the uniform distribution. In many cases, an empirical distribution is used. The inverse transformation method is a general method for transforming a standard uniform deviate into any other distribution, especially, when the distribution is an empirical one. In this section, we briefly discuss procedures for generating random numbers from empirical and frequently used theoretical distributions based on the inverse transformation method. Our emphasis is on procedures that can be coded in a single statement. The procedures for generating random numbers are well discussed in many simulation books. We refer the interested readers to Random Number Generation and Monte Carlo Methods by James Gentle (Gentle, 2004).

Empirical Distribution

Using the inverse transformation method for a general discrete distribution is essentially a table lookup. To generate random numbers from an empirical distribution, we can use either the LOOKUP, VLOOKUP, or HLOOKUP functions provided by Excel. The vector form of LOOKUP function is discussed here. The syntax of the vector form is

=LOOKUP(lookup_value, lookup_vector, result_vector)

The values in the lookup vector must be in ascending order. LOOKUP compares the lookup_value to each cell in the lookup_vector until it finds a cell larger than the lookup_value. It then moves up one cell and returns the content of the corresponding cell in the result_vector as the answer. For example, assume the relative frequency of sales in unit per month for laser printers is as follows:

TABLE 1
Unit Sales of Laser Printers

Unit Sales Per Month	Relative Frequency
350	0.1
450	0.1
550	0.5
650	0.3

To generate monthly unit sales, say, for six months in cells E2 through E7 from the above empirical distribution, at first, convert Table 1 into a cumulative-relative-frequency table as shown in Columns A and B of Table 2. Then, type =LOOKUP(RAND(),$B$2:$B$5, $A$2:$A$5) in cell E2. Finally, position the mouse pointer over the fill handle and drag it to cell E7 to extend the LOOKUP function from cell E2 to the range E3:E7. Suppose the numbers generated by RAND() are 0.22, 0.04, 0.39, 0.78, 0.23, and 0.16, the unit sales generated will be 550, 350, 550, 650, 550, and 450, respectively.

TABLE 2
Illustration of Empirical Random Number Generation

	A	B	C	D	E
1	Unit Sales Per Month (Bin)	Cumulative Relative Frequency		Month	Unit Sales
2	350	0		1	550
3	450	0.1		2	350
4	550	0.2		3	550
5	650	0.7		4	650
6				5	550
7				6	450

Exponential Distribution

The cumulative distribution function (CDF) of an exponentially distributed random variable is
$F(x) = 1 - e^{-\beta x}, x > 0$

where $1/\beta$ equals the mean of the exponential random variable. The inverse of F is then
$F^{-1}(a) = -\ln(1-a)/\beta$

Thus, an exponentially distributed random number can be generated by the simple Excel formula
= -LN(1-RAND())/beta

Because RAND() is uniformly distributed, 1-RAND() is also uniformly distributed, and the above Excel formula can be further simplified as
= -LN(RAND())/beta

The distribution of time that elapses before the occurrence of some event often follows an exponential distribution.

Normal Distribution

The closed-form functional representation of the inverse of the CDF for the normal distribution does not exist. Fortunately, Excel has a built-in function NORMINV(probability,mean,std_dev) which returns the inverse of the normal cumulative distribution for the specified mean and standard deviation. So, to generate a normal random number in Excel, we can use the simple formula

= NORMINV(RAND(), mean, std_dev)

Gamma Distribution

There are two ways of writing (parameterizing) the gamma distribution that are common in the literature. EXCEL uses

$$f(x|\propto,\beta) = \frac{1}{\beta^{\alpha}\Gamma(\alpha)} x^{\alpha-1} e^{-\frac{x}{\beta}} \quad for\ x > 0\ and\ \alpha, \beta > 0$$

Excel provides a built-in function GAMMAINV(probability,alpha,beta) which returns the inverse of the gamma cumulative distribution. Thus, we can use the following formula to generate a gamma distributed random number in Excel.

=GAMMAINV(RAND(),alpha,beta)

Because an exponential distribution with parameter beta is the same as a gamma distribution with parameters alpha and beta where alpha = 1, the GAMMAINV function can also be used to generate an exponentially distributed random variable.

The distribution of time that elapses before the alphath occurrence of some event often follows a gamma distribution. Gamma distribution also provides the most common best fit to lead-time demand for a variety of inventory items (Bagchi et al, 1986).

A CAPITAL BUDGETING EXAMPLE OF SPREADSHEET SIMULATION

A simple capital budgeting problem is listed in Table 4. The net present value (NPV) spreadsheet model for the capital budgeting problem is presented in Table 5. After the formulas are entered into the cells C15, C16 and C17, the range C13:C17 can be copied to the columns on the right to generate additional simulations. For example, to generate additional 50 simulations, we can copy C13:C17 to D13:BA17. Statistics such as total, average, maximum, and minimum can be obtained easily with SUM, AVERAGE, MAX, and MIN functions, respectively. Additional runs for the same values of parameters can be carried out easily by simply pressing the CALC NOW (F9) key. Experiments for different values of the parameters can also be executed easily by entering their values into their respective cells.

Table 4
A Capital Budgeting Problem

	Expected Value	Probability Distribution	
Hurdle rate	10%	Held constant	
Old machine:			
Remaining useful life	5 years	Held constant	
Disposal value, now	$20,000	Held constant	
Disposal value, end of Year 5	$0	Held constant	
Overhaul required, end of Year 2	$10,075	Empirical distribution	
		Cost	Probability
		9,000	0.1
		9,500	0.15
		10,000	0.35
		10,500	0.3
		11,000	0.1
New machine:			
Cost	$56,000	Held constant	
Useful life	5 years	Held constant	
Disposal value, end of Year 5	$0	Held constant	
Annual operating savings	$10,000	Normal distribution with mean 10,000 and standard deviation 1,000	

Table 5
NPV Simulation Model

	A	B	C	D	E	F
1	Hurdle Rate	10%				
2	Project life (years)	5				
3	Overhaul Cost	Cost	Cumulative Probability			
4		$ 9,000	0			
5		9,500	0.1			
6		10,000	0.25			
7		10,500	0.6			
8		11,000	0.9			
9	Annual Operating Savings					
10	Mean	$ 10,000				
11	Standard Deviation	$ 1,000				
12			PV			
13	Cost of new machine		$ (56,000.00)			
14	Disposal value of old machine		$ 20,000.00			
15	Recurring cash operating savings		=-PV($B$1,$B$2,NORMINV(RAND(),$B$10,$B$11))			
16	Overhaul avoided, end of Year 2		=-PV($B$1,2,,LOOKUP(RAND(),$C$4:$C$8,$B$4:$B$8))			
17	Net present value of replacement		=SUM(C13:C15)			

CONCLUSION

Simulation is widely used in accounting practice to analyze risk for a variety of types of problems. Developing and experimenting a simulation model on an electronic spreadsheet not only eliminates the need for learning a programming language and simplifies the model building process but also eases the experiments for different values of the parameters. This paper discusses the procedures for generating random numbers in the electronic spreadsheet environment and demonstrates the use of Microsoft Excel to develop two working simulation models without third-party add-ins. It clearly shows that spread simulation is useful, inexpensive, and easy to learn.

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