Job Cost Estimating By Random Numbers

By William C. Thompson III

The words "random number" usually bring forth images of cards, Las Vegas, illustrations in your Probability and Statistics 101 textbook (I might add — images of the Enterprise and the Klingons are also fair game.) But wait, all of you who are planning a costly project, random numbers will serve you well, too.

For, after all, random numbers are basically a mathematical image or model of the randomness of our real world. Let's examine how a project planner might use random numbers in one aspect of his work. While examining the bids on construction projects which the homeowner made over the past year, he comes to an important conclusion. Each bid made to him, though greatly different as a whole, still consists of variations of the same or similar tasks and materials. Though he can get a good grip on one variable, by the time he takes ten or fifteen more of them at once, the carefully-computed bids aren't much better than the original guesstimates. If there were only some way of restricting the work to each little variable, then cranking it into a machine to figure out how much should be bid.

If the project planner only statistically analyzes all the bids made for all different projects, he will find that the results are almost random.

There is a way to break them all down into the same model. Handle each case as a model; crank out as many trial runs of the model as needed to provide a statistical analysis of each job, or even new jobs! Take one of the bid sheets and instead of each of the guesses, give each item a bit of room to range in. Some of these could use a wider range than others, and a few are fixed. Leave the fixed ones out for now and just add them on at the end.

Now have the computer pick a random value from each range and then use the results as if it actually built it that way. Have the computer "construct" the project as many times as needed and do a statistical analysis of the resulting data.

Now in real life, the values in the center of the range should get picked more often than the outside values, like a normal curve. On the other hand, that may be a bit restrictive — try it both ways: a normal distribution and a random distribution.

Soon the program is up and running with the following results:

Table 1. JOB COST ESTIMATING PROGRAM

```
NUMBER OF TRIALS =?100
RANDOM (1) OR NORMAL(2) DISTRIBUTION?1
```

ITEM NO.	LOWER VALUE	UPPER VALUE	RANGE
1	1200	1300	100
2	200	250	50
3	2300	2345	45
4	2750	3000	250
5	1800	1900	100

```
AVG. PROJECT COST: $ 8519.8
WITH A STANDARD DEVIATION OF:  25.7718
```

ITEM NO.	AVG. COST	STD.DEV.
1	1250.12	9.0167
2	224.934	4.51822
3	2322.42	3.93994
4	2872.38	21.7369
5	1849.94	8.87527

++++ CHANCE OF OVER RUN ++++

TOTAL COST	PROB. OF OVERRUN
$ 8431.4	99.95 %
$ 8453.44	99 %
$ 8469.29	95 %
$ 8493.08	70 %
$ 8519.8	50 %
$ 8546.53	30 %
$ 8570.31	5 %
$ 8586.16	1 %
$ 8608.2	.05 %

Table 2. JOB COST ESTIMATING PROGRAM

```
NUMBER OF TRIALS =?100
RANDOM (1) OR NORMAL(2) DISTRIBUTION?2
```

ITEM NO.	LOWER VALUE	UPPER VALUE	RANGE
1	1200	1300	100
2	200	250	50
3	2300	2345	45
4	2750	3000	250
5	1800	1900	100

```
AVG. PROJECT COST: $ 8522.1
WITH A STANDARD DEVIATION OF:  27.2801
```

ITEM NO.	AVG. COST	STD.DEV.
1	1249.77	9.09024
2	224.987	4.40634
3	2322.35	4.04412
4	2876.27	20.3578
5	1848.71	8.12129

++++ CHANCE OF OVER RUN ++++

TOTAL COST	PROB. OF OVERRUN
$ 8428.53	99.95 %
$ 8451.86	99 %
$ 8468.63	95 %
$ 8493.81	70 %
$ 8522.1	50 %
$ 8550.39	30 %
$ 8575.57	5 %
$ 8592.35	1 %
$ 8615.67	.05 %

Table 3.

```
                JOB COST ESTIMATING PROGRAM

 NUMBER OF TRIALS =?1000
 RANDOM (1) OR NORMAL(2) DISTRIBUTION?1

ITEM     LOWER            UPPER            RANGE
 NO.     VALUE            VALUE
 1        1200             1300             100
 2        200              250              50
 3        2300             2345             45
 4        2750             3000             250
 5        1800             1900             100


AVG. PROJECT COST: $ 8523.61
WITH A STANDARD DEVIATION OF:  24.7341

ITEM NO.      AVG. COST      STD.DEV.
 1         1250.19          8.43583
 2         224.986          4.19953
 3         2322.39          3.75468
 4         2875.91          21.426
 5         1850.13          8.41467


        ++++ CHANCE OF OVER RUN ++++

TOTAL COST               PROB. OF OVERRUN
$ 8438.77                 99.95 %
$ 8459.92                 99 %
$ 8475.13                 95 %
$ 8497.96                 70 %
$ 8523.61                 50 %
$ 8549.26                 30 %
$ 8572.09                 5 %
$ 8587.3                  1 %
$ 8608.45                 .05 %
```

Table 4.

```
                JOB COST ESTIMATING PROGRAM

 NUMBER OF TRIALS =?1000
 RANDOM (1) OR NORMAL(2) DISTRIBUTION?2

ITEM     LOWER            UPPER            RANGE
 NO.     VALUE            VALUE
 1        1200             1300             100
 2        200              250              50
 3        2300             2345             45
 4        2750             3000             250
 5        1800             1900             100


AVG. PROJECT COST: $ 8522.61
WITH A STANDARD DEVIATION OF:  24.4423

ITEM NO.      AVG. COST      STD.DEV.
 1         1250.28          8.36202
 2         225.028          4.30405
 3         2322.29          3.82765
 4         2874.41          20.6594
 5         1850.59          8.24031


        ++++ CHANCE OF OVER RUN ++++

TOTAL COST               PROB. OF OVERRUN
$ 8438.77                 99.95 %
$ 8459.67                 99 %
$ 8474.7                  95 %
$ 8497.26                 70 %
$ 8522.61                 50 %
$ 8547.95                 30 %
$ 8570.51                 5 %
$ 8585.55                 1 %
$ 8606.44                 .05 %
```

Table 5.

```
                    ESTIMATING PROGRAM

 NUMBER OF TRIALS =?10000
 RANDOM (1) OR NORMAL(2) DISTRIBUTION?2

ITEM      LOWER              UPPER              RANGE
 NO.      VALUE              VALUE
 1         1200               1300               100
 2          200                250                50
 3         2300               2345                45
 4         2750               3000               250
 5         1800               1900               100


AVG. PROJECT COST:- $ 8522.5
WITH A STANDARD DEVIATION OF:   24.3572


ITEM NO.       AVG. COST       STD.DEV.
 1           1250.01          8.37312
 2            225.01          4.1619
 3           2322.49          3.78222
 4           2875.01          20.8411
 5           1849.98          8.36827


        ++++ CHANCE OF OVER RUN ++++

TOTAL COST                   PROB. OF OVERRUN
$ 8438.96                     99.95 %
$ 8459.78                     99 %
$ 8474.76                     95 %
$ 8497.24                     70 %
$ 8522.5                      50 %
$ 8547.76                     30 %
$ 8570.24                     5 %
$ 8585.22                     1 %
$ 8606.05                     .05 %
```

REVIEWING THE PROGRAM

Input data are a series of ranges for costs of individual items in a proposed estimate. The microcomputer then simulates construction of the project by selecting a random cost within each range. This is done repeatedly, accumulating a statistical profile of the job. When sufficient iterations have been completed the analysis of the results is finished and results printed out.

This program serves primarily as an example, though quite useful. The techniques illustrated are even more useful. The practice of modeling, simulation and analysis can produce solutions to very complex, otherwise unassailable problems. Over a period of years as various home installation and remodeling projects are put into effect, job cost estimating by microcomputer can result in a saving of project dollars as well as a valuable record upon which to estimate the true value of your property improvements.

PROGRAM LISTING

```
00100 DIM A(100,3),B(100),C00100 DIM A(100,3),B(100),C(100),S(100),D(10,2)
00110 GOSUB 00920
00120 GOSUB 01030
00130 GOSUB 01190
00140 GOSUB 00240
00150 GOSUB 00390
00160 GOSUB 00840
00170 GOSUB 00550
00180 GOSUB 00710
00190 PAGE
00200 STOP
00210 REM ************************************************************
00220 REM    INPUT DATA SUBROUTINE
00230 REM ------------------------------------------------------------
00240 REM  NUMBER OF RANGES
00250 READ N
00260 PRINT TAB(8);"ITEM","LOWER","UPPER","RANGE"
00270 PRINT TAB(8);" NO. ","VALUE","VALUE"
00280 FOR I=1 TO N
00290 REM    LOWER, UPPER VALUE
00300 READ A(I,1),A(I,2)
00310 A(I,3)=A(I,2)-A(I,1)
00320 PRINT TAB(8);I,A(I,1),A(I,2),A(I,3)
00330 NEXT I
00340 PRINT
00350 RETURN
00360 REM ************************************************************
00370 REM    TRIAL RUNS OF PROJECT SUBROUTINE
00380 REM ------------------------------------------------------------
00390 FOR J=1 TO M
00400 B3=B2=0
00410 FOR I=1 TO N
00420 GOSUB 01280
00430 B1=A(I,1)+Z9*A(I,3)
00440 B(I)=B1+B(I)
00450 C(I)=C(I)+B1*B1
00460 B2=B2+B1
00470 B3=B3+B1*B1
00480 NEXT I
00490 B4=B4+B2
00500 B5=B5+B2*B2
00510 NEXT J
00520 RETURN
00530 REM ************************************************************
00540 REM    PRINT SUMMARY STATISTICS OF TRIALS SUBROUTINE
00550 REM ------------------------------------------------------------
00560 V=B4/M
00570 PRINT
00580 PRINT
00590 PRINT TAB(8);"AVG. PROJECT COST: $";V
00600 PRINT TAB(8);"WITH A STANDARD DEVIATION OF: ";S
00610 PRINT
00620 PRINT
00630 PRINT TAB(8);"ITEM NO.     AVG. COST     STD.DEV."
00640 FOR I=1 TO N
00650 PRINT TAB(8);I,B(I)/M,S(I)
00660 NEXT I
00670 RETURN
00680 REM ************************************************************
00690 REM    PRINT PROBABILITIES OF OVERRUN SUBROUTINE
00700 REM ------------------------------------------------------------
00710 PRINT
00720 PRINT
00730 PRINT
00740 PRINT TAB(15);"++++ CHANCE OF OVER RUN ++++"
00750 PRINT
00760 PRINT TAB(8);"TOTAL COST","PROB. OF OVERRUN"
00770 FOR I=1 TO 9
00780 PRINT TAB(8);"$";V+S*D(I,2),D(I,1);"%"
00790 NEXT I
00800 RETURN
00810 REM ************************************************************
00820 REM    CALCULATE STANDARD DEVIATIONS SUBROUTINE
00830 REM ------------------------------------------------------------
00840 FOR I=1 TO N
00850 S(I)=SQR(ABS((C(I)-((B(I)*B(I))/M))/(M-1)))
00860 NEXT I
00870 S=SQR(ABS((B5-((B4*B4)/M))/(M-1)))
00880 RETURN
00890 REM ************************************************************
00900 REM    PRINT HEADING SUBROUTINE
00910 REM ------------------------------------------------------------
00920 PAGE
00930 PRINT
00940 PRINT
00950 PRINT
00960 PRINT TAB(20);"JOB COST ESTIMATING PROGRAM"
00970 PRINT
00980 PRINT
00990 RETURN
01000 REM ************************************************************
01010 REM    INITIALIZE VARIABLES SUBROUTINE
01020 REM ------------------------------------------------------------
01030 FOR I=1 TO 100
01040 B(I)=C(I)=S(I)=A(I,1)=A(I,2)=A(I,3)=0
01050 NEXT I
01060 B1=B2=B3=B4=B5=X8=0
01070 X9=-1
01080 FOR I=1 TO 9
01090 FOR J=1 TO 2
01100 READ D(I,J)
01110 NEXT J
01120 NEXT I
01130 RETURN
01140 DATA 99.95,-3.43,99,-2.575,95,-1.96,70,-1.037,50,0.30,1.037,5,1.96,1.2.575
01150 DATA 0.05,3.43
01160 REM ************************************************************
01170 REM    INPUT PROGRAM PARAMETERS SUBROUTINE
01180 REM ------------------------------------------------------------
01190 PRINT "        NUMBER OF TRIALS =";
01200 INPUT M
01210 PRINT "        RANDOM (1) OR NORMAL(2) DISTRIBUTION";
01220 INPUT NO
01230 PRINT
01240 RETURN
01250 REM ************************************************************
01260 REM    GENERATE NORMALLY DIST. OR RANDOM # 0<=Z9<=1
01270 REM ------------------------------------------------------------
01280 IF NO<>1 THEN 01300
01290 Z9=RND(0)
01300 X=-6
01310 FOR KO=1 TO 12
01320 X=X+RND(0)
01330 NEXT KO
01340 Z9=X/12+.5
01350 RETURN
01360 ************************************************************
01370 REM    PROGRAM HISTORY
01380 REM ------------------------------------------------------------
01390 REM DESIGNED AND WRITTEN BY WM. C. THOMPSON III
01400 REM   APRIL, 1977
01410 REM.....................................................
01420 REM    END OF PROGRAM
01430 REM ##########################################################
01440 REM  THE FOLLOWING IS SAMPLE DATA-INSERT YOUR DATA HERE
01450 DATA 5,1200,1300,200,250,2300,2345,2750,3000,1800,1900
```