Discrete Monte Carlo Simulation Example

Table 7 - Demand Distribution by Demand Categories

Demand	High	Average	Low
36	.05	.10	.15
48	.10	.20	.25
60	.25	.30	.35
72	.30	.25	.15
84	.20	.10	.05
96	.10	.05	.05

Table 8 - Distribution of Demand Type

Type of Demand	Probability	Cumulative Distribution	Random Number Ranges
High	0.30	0.30	00-29
Average	0.45	0.75	30-74
Low	0.25	1.00	75-99

Table 9 - Distribution by Demand Type

	Cum. Dist.			Random Number Ranges		
Demand	High	Avg.	Low	High	Average	Low
36	.05	.10	.15	00-04	00-09	00-14
48	.15	.30	.40	05-14	10-29	15-39
60	.40	.60	.75	15-39	30-59	40-74
72	.70	.85	.90	40-69	60-84	75-89
84	.90	.95	.95	70-89	85-94	90-94
96	1.00	1.00	1.00	90-99	95-99	95-99

```
*******************************************
*    DISCRETE RANDOM VARIABLE SIMULATION  *
*     DSN= DSIM1.SAS                      *
*******************************************;

data dsim1;
  supply = 36;
  seed1=45 ; seed2 = 45;
  do i=1 to 10000;
     demand = 0;  edemand = 0;  esupply = 0;
     x1=int(ranuni(seed1)*100);
     if x1 le 29              then dtype = 'high';
     if x1 ge 30 and x1 le 74 then dtype = 'avg';
     if x1 ge 75              then dtype = 'low';

     x2=int(ranuni(seed2)*100);
     if dtype = 'high' and x2 le  4              then demand = 36;
     if dtype = 'high' and x2 ge  5 and x2 le 14 then demand = 48;
     if dtype = 'high' and x2 ge 15 and x2 le 39 then demand = 60;
     if dtype = 'high' and x2 ge 40 and x2 le 69 then demand = 72;
     if dtype = 'high' and x2 ge 70 and x2 le 89 then demand = 84;
     if dtype = 'high' and x2 ge 90 and x2 le 99 then demand = 96;
     if dtype = 'avg'  and x2 le  9              then demand = 36;
     if dtype = 'avg'  and x2 ge 10 and x2 le 29 then demand = 48;
     if dtype = 'avg'  and x2 ge 30 and x2 le 59 then demand = 60;
     if dtype = 'avg'  and x2 ge 60 and x2 le 84 then demand = 72;
     if dtype = 'avg'  and x2 ge 85 and x2 le 94 then demand = 84;
     if dtype = 'avg'  and x2 ge 95 and x2 le 99 then demand = 96;
     if dtype = 'low'  and x2 le 14              then demand = 36;
     if dtype = 'low'  and x2 ge 15 and x2 le 39 then demand = 48;
     if dtype = 'low'  and x2 ge 40 and x2 le 74 then demand = 60;
     if dtype = 'low'  and x2 ge 75 and x2 le 89 then demand = 72;
     if dtype = 'low'  and x2 ge 90 and x2 le 94 then demand = 84;
     if dtype = 'low'  and x2 ge 95 and x2 le 99 then demand = 96;

     if supply > demand then esupply = supply - demand;
     if demand > supply then edemand = demand - supply;
     sales = supply - esupply;
     revenue = (0.40*sales) ;
     salrev  = (0.10*esupply) ;
     cost    = (0.25*supply) ;
     lostpr  = (0.15*edemand);
     profit = (0.40*sales) + (0.10*esupply) - (0.25*supply) - (0.15*edemand);
     output;
  end;
  *proc print;
   *  id i;
   *  var seed1 x1 dtype seed2 x2 demand supply sales edemand esupply profit;
 proc means;
     var demand supply sales edemand esupply revenue lostpr cost salrev profit;
     title 'POLICY A  SUPPLY = 36';
 run;
```

Table 11 - Evaluation of Policies

Policy	# of Loaves Baked Daily	"Average Daily Profit" Number of Simulations 10	100	500	1,000	10,000
A	36	$1.440	$1.602	$1.468	$1.377	$1.262
B	48	$3.960	$4.552	$4.464	$4.410	$4.334
C	60	$5.940	$6.426	$6.390	$6.357	$6.406
D	72	$6.300	$6.516	$6.772	$6.799	$6.917
E	84	$5.580	$5.418	$5.781	$5.911	$6.111
F	96	$4.320	$3.996	$4.262	$4.446	$4.676

Simulation of an Inventory System with Uncertain Demand and Reorder Lead Time

Simulation becomes a necessity for inventory analysis when two or more model components are subject to uncertainty, such as *product demand* and *reorder lead time*. The objective in this example is to determine the optimal number of products to order from the manufacturer each time an order is placed and when to place an order (that is, the reorder point). The optimal decision is the one that will result in the minimum total inventory cost. With a beginning inventory of 20 units in week 1, the cost parameters for this problem are as follows:

Order Cost, C_o, equals $150 per order of 40 units
Carrying Cost, C_c, equals $1 per unit per week
Shortage Cost, C_s, equals $100 per unit

Demand per week (*x*)	Probability of Demand *p(x)*	Lead Time in Weeks *(y)*	Probability of Lead Time *p(y)*
14	0.2	2	0.6
15	0.4	3	0.3
16	0.2	4	0.1
17	0.1		
18	0.1		

Simulation Experiment with Q (order size) = 40 and R (reorder point) =30

Week	Beginning Inventory	Order Receipt	Inventory Level	R1	Demand (x)	Ending Inventory	R2	Lead Time (y)	C_o	+ C_c	+ C_s	= TC
1	20	0	20	00	14	6	46	2	150	6	0	156
2	6	0	6	49	15	0	80	3	150	0	900	1050
3	0	40	40	41	15	25	61	3	150	25	0	175
4	25	0	25	94	18	7	89	3	150	7	0	157
5	7	40	47	87	17	30	47	2	150	30	0	180
6	30	40	70	33	15	55			0	55	0	55
7	55	80	135	67	16	119			0	119	0	119
8	119	0	119	44	15	104			0	104	0	104
9	104	0	104	63	16	88			0	88	0	88
10	88	0	88	25	15	73			0	73	0	73
						Average weekly inventory cost = $215.70						

```
******************************************
*    DISCRETE RANDOM VARIABLE SIMULATION  *
*                                         *
*     DSN= DSIMINV.SAS                    *
******************************************;

data inv;

do i=1 to 10;

***RESET VARIABLE VALUES***;
week = i;
order = 0;
exdmd = 0;
ddue0=0; ddue1=0; ddue2=0; ddue3=0; ddue4=0;
TC = 0; CO = 0; CC = 0; CS = 0;

if i=1 then beginv=20;
if i gt 1 then beginv = endinv;
if i=1 then ordrec=0;
if i=1 then due0=0;
if i=1 then due1=0;
if i=1 then due2=0;
if i=1 then due3=0;
if i=1 then due4=0;

***ADVANCE ORDER DUE DATES***;
ddue0=due0;  ddue1=due1;
ddue2=due2;  ddue3=due3;  ddue4=due4;
due0=ddue1;  due1=ddue2;
due2=ddue3;  due3=ddue4;  due4=0;

***GENERATE RANDOM NUMBERS***;
q = 40;  r = 30;
[ri = int(ranuni*(45)*100);]
[r2 = int(ranuni*(45)*100);]

if i=1 then r1 = 00;  if i=1 then r2=46;
if i=2 then r1 = 49;  if i=2 then r2=80;
if i=3 then r1 = 41;  if i=3 then r2=61;
if i=4 then r1 = 94;  if i=4 then r2=89;
if i=5 then r1 = 87;  if i=5 then r2=47;
if i=6 then r1 = 33;  if i=6 then r2=.;
if i=7 then r1 = 67;  if i=7 then r2=.;
if i=8 then r1 = 44;  if i=8 then r2=.;
if i=9 then r1 = 63;  if i=9 then r2=.;
if i=10 then r1 = 25;  if i=10 then r2=.;

***DETERMINE RANDOM DEMAND AND LEAD TIME***;

if r1 le 19              then demand = 14;
if r1 le 59 and r1 gt 19 then demand = 15;
if r1 le 79 and r1 gt 59 then demand = 16;
if r1 le 89 and r1 gt 79 then demand = 17;
if r1 le 99 and r1 gt 89 then demand = 18;

if r2 le 59              then ldtime =  2;
if r2 le 89 and r2 gt 59 then ldtime =  3;
if r2 le 99 and r2 gt 89 then ldtime =  4;
if r2 = .                then ldtime = .;

***DETERMINE INVENTORY VALUES***;
ordrec = due0*40;
invlvl = beginv + ordrec;
endinv = invlvl - demand;
if endinv lt 0 then endinv = 0;
if demand > invlvl then exdmd = demand -
invlvl;

***DETERMINE ORDER QUANTITY NEEDED***;
if endinv le 30 then order = 1;
if order=1 and ldtime=2 then due2=due2+1;
if order=1 and ldtime=3 then due3=due3+1;
if order=1 and ldtime=4 then due4=due4+1;

***CALCULATE COSTS***;
if endinv gt 30 then order = 0;
if order=1 then CO = 150;
CC = endinv;
CS = exdmd * 100;
TC = CO + CC + CS;


output;
end;

proc print; var WEEK BEGINV ORDREC INVLVL R1
DEMAND ENDINV ORDER R2 LDTIME CO CC CS TC;
proc means; var TC ;
run;
```

The SAS System

OBS	WEEK	BEGINV	ORDREC	INVLVL	R1	DEMAND	ENDINV	ORDER	R2	LDTIME	CO	CC	CS	TC
1	1	20	0	20	0	14	6	1	46	2	150	6	0	156
2	2	6	0	6	49	15	0	1	80	3	150	0	900	1050
3	3	0	40	40	41	15	25	1	61	3	150	25	0	175
4	4	25	0	25	94	18	7	1	89	3	150	7	0	157
5	5	7	40	47	87	17	30	1	47	2	150	30	0	180
6	6	30	40	70	33	15	55	0	.	.	0	55	0	55
7	7	55	80	135	67	16	119	0	.	.	0	119	0	119
8	8	119	0	119	44	15	104	0	.	.	0	104	0	104
9	9	104	0	104	63	16	88	0	.	.	0	88	0	88
10	10	88	0	88	25	15	73	0	.	.	0	73	0	73

The SAS System

Analysis Variable : TC

N	Mean	Std Dev	Minimum	Maximum
10	215.7000000	296.3331646	55.0000000	1050.00