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ON DETERMINING REORDER POINT AND REORDER QUANTITY IN A PROBABILISTIC INVENTORY MODEL

(A SIMULATION MODEL)

by

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"Opinions Expressed and Positions Taken by Authors are Entirely their Own and do not Necessarily Reflext the Views of the Institute of National Planning".

INTRODUCTION:

In seeking to optimize inventory systems, we may on occasions encounter complex factors that cannot be solved with SIMPLE FORMULAS or Tabular data. Even quite advanced mathematical approaches may turn out to be inadequate or too unwidely. In such situations, the only practical resort available is to use SIMULATION TECHNIQUES, usually with the aid of a computer.

Simulation involves the use of a large number of trial-and-error investigations, seeking to discover the optimal inventory policy. These trials are, of course, not performed in actuality. Such would involve extremely lengthy and costly study. Instead, the experimentation occurs relatively inexpensively and quickly on paper, or on computer circuits, utilizing data and relationships among these data that correspond to the "REAL WORLD" situation under study. The figures SIMULATE THE REAL WORLD and the resulting outcome of expected costs or profits under various simulated conditionsguide management towards formulating an optimal plan or policy concerning the inventory system. The following problem helps us to understand how simulation works.

In this problem we will try to search for best values of reordering point and reording quantity of a consumer product for the sake of minimum cost. In such a situation two extremes are to be avoided: having too many units in store, which results in excessive inventory keeping costs and possibility of deterioration and obsolescence. On the other hand, small inventory size might result in shortage (stock-out) periods and considerable loss of money follows. It is obvious that a balance between those two extremes, based on cost optimization, would be ideal.

PROBLEM:

The illustrative problem is concerned with cost minimization of an inventory keeping system of a consumer product. We will consider the case in which the customer demand varies from week to week. There is also variation in delivery times.

In minimizing costs, three types are considered:

1. Inventory carrying cost
2. Cost of Placing an Order
3. Cost of Shortage

Some other factors are to be considered, such as:

1. Loss in customer good will be suffered when his demand cannot be met in a particular week.
2. Possibility that a customer's requirements can be met from another similar unit.
3. Possibility that the customer will be willing to wait.
4. Means of speeding-up delivery, where a tight inventory situation seems to be developing, such as by means of special handling of shipments .
5. Possible within-season variations or patterns of demand.

PROBLEM DATA:

Since we haven't got actual data, hypothetical values will be considered for purpose of illustration. In designing for the COMPUTER PROGRAM we will give the flexibility of reading the actual data for any given problem.

DATA FOR CUSTOMER DEMAND:

As we have previously decided, we will consider the case of a PROBABILISTIC DEMAND, i.e. the demand data are given using certain DISTRIBUTION PATTERN. A hypothetical pattern may be as follows:

QUANTITY DEMAND. (Units per Week)	FREQ.OF DEMAND (No. of Weeks)	RELATIVE FREQ. (In Percent)	CUMUL.PROBABILITY (In Percent
0	2	4	4
10	4	8	12
20	14	28	40
30	20	40	80
40	8	16	96
50	1	2	98
60	1	2	100
TOTAL	50	100	

TABLE (1)

The original available data are the quantity demanded and the frequency of demand. The actual frequencies are to be converted to relative frequencies. The relative frequencies always add up to 100%.

DATA FOR DELIVERY TIME:

The variation in delivery time and the proposed pattern are shown in the following table:

REQUIRED DEL. TIME (In Weeks)	RELATIVE FREQ. (In Percent)	CUMUL. PROBABILITY (In Percent)
1	60	60
2	30	90
3	9	99
4	1	100
TOTAL	100	

TABLE (II)

COST DATA:

Hypothetical data can be as follows:
1. Inventory carrying charge, per unit per week, L.E. 5
2. Cost of placing an order, per occurence, L.E. 10
3. Cost of shortage, per unit, L.E. 50

TREATMENT OF DIFFERENT FACTORS:

For the purpose of a simplified demonstration we may assume that these factors are negligible and can thus be ignored.

ILLUSTRATION OF RANDOM PHENOMENA:

To start simulating the system week by week, we have to forecast both demand units and delivery time of ordered quantities, if any using the given patterns. While we know from the distribution pattern that there is, for example, a 40% probability of a demand for 30 units in a particular week, and a 28% probability of a demand for 20 units, WE DO NOT KNOW IN ADVANCE WHICH WEEK WILL REPRESENT A PARTICULAR DEMAND. The best thing to do is to CHOOSE THE DEMAND AT RANDOM. This could be accomplished using a TABLE OF RANDOM NUMBERS (SEE TABLE III). We may enter this table at any randomly selected spot, and then proceed in sequence, horizontally or vertically, from row to row or column to column, selecting random numbers.

A Group Of Random Numbers have to be selected to represent demands for several consecutive weeks. Same Procedure is followed to find delivery times.

RANDOM NUMBERS AND DEMAND UNITS:

After selecting a random number, it is matched with the distribution pattern for demand to decide on demand units of a particular week. Let us assume that the first taken random number is 55, and that it is supposed to represent customer demand for first week. Entering the cumulative probability column, we find that 55 is larger than one column value (which is 40) but equal to or smaller than the next column value (which is 80). Since the value of 80 corresponds to a demand of 30 units, we have therefore determined that for week 1 the RANDOMLY FOUND DEMAND IS 30 UNITS. To determine the demand for week 2 the following random number (27)is considered and the same procedure is followed. It can be seen that the demand for second week is 20 units.

RANDOM NUMBERS AND DELIVERY TIMES:

Delivery times can be found in a similar way, but selecting other random numbers, with reference to the cumulative probability column of the DISTRIBUTION PATTERN OF DELIVERY TIMES TABLE.

73	92	46	29	20	10	61	36	74	93
02	07	53	26	19	59	79	95	03	01
56	78	45	72	86	99	05	02	01	06
09	04	02	51	25	12	6	3	57	84
92	96	48	80	96	98	99	05	52	32
86	83	40	76	94	97	54	77	88	00
50	31	21	66	89	00	06	09	54	83
91	95	48	79	39	25	18	09	04	52
82	97	54	27	69	84	48	30	15	07
09	54	33	22	11	05	08	10	61	86
43	21	6	86	99	55	83	97	48	80
46	79	39	75	87	93	45	23	11	61
86	93	51	76	44	28	14	63	37	18
65	38	75	37	74	43	21	10	55	27
13	82	30	21	16	08	60	80	46	29
70	91	01	50	81	90	51	75	43	71
41	70	85	42	21	10	5	58	29	20
60	80	96	48	30	65	38	25	68	90
45	22	17	58	35	23	67	33	72	42
77	38	19	59	29	14	7	59	85	48
24	12	12	12	62	31	71	85	92	02
51	75	35	93	02	57	84	42	77	88
50	31	71	73	85	49	74	87	43	77
38	69	90	45	72	36	18	65	88	94
07	04	08	60	30	15	57	28	70	35
23	17	60	88	44	78	45	22	67	39
19	09	10	11	05	58	79	89	44	22
07	89	50	25	68	40	76	94	47	23
81	30	70	91	51	81	96	04	08	10
55	27	63	31	15	63	87	49	[illegible]	40
76	44	78	95	03	51	25	62	87	43
27	19	65	32	16	14	13	06	03	07
53	76	38	19	9	60	30	65	88	44
28	64	82	97	04	58	29	70	41	20
66	83	90	45	78	95	53	82	41	20
15	14	63	87	99	49	24	18	15	07
59	35	17	08	54	83	41	26	63	37
08	84	04	49	74	37	74	93	52	26
13	56	54	98	99	55	33	16	64	82
47	73	42	27	69	34	17	58	85	42
71	91	01	00	00	50	81	40	70	35
73	30	68	34	17	08	04	02	01	56
26	64	32	16	64	32	66	33	72	92
96	98	49	24	68	34	67	89	00	56
28	14	13	56	34	67	39	69	40	26
13	06	53	26	69	90	95	53	32	72
92	46	79	89	94	03	07	03	57	34
73	36	18	15	57	78	39	75	37	24
62	81	40	20	66	33	22	61	3[illegible]	24
12	62	81	90	01	06	59	85	93	[illegible]
52	82	47	23	11	11	55	77	94	47

TABLE III

SIMULATION APPROACH:

Utilizing the method of determining RANDOM DEMAND and DELIVERY TIMES, based on the demand and delivery patterns given, we may next start to SIMULATE THE INVENTORY SYSTEM operation in a detailed illustration. A WEEK-BY-WEEK REVIEW of the weekly events is traced along the proposed period. In doing this, many logical and mathematical formulas have to be used.

In our analysis we will be mainly interested in two aspects:

SIMULATED WEEKLY ACTIVITY:

After deciding upon the weekly demand, the balance is to be calculated and newly received units are to be added to the master file. An UPDATING PROCESS is to be performed.

SIMULATED COSTS:

Based on transactions, the threetypes of costs are calculated. The cost of inventory keeping is simply calculated by multiplying the number of units (in store) by cost of keeping each unit for a week. If the balance gets down to the REORDER POINT, or below, AN ORDER HAS TO BE PLACED and the costs associated are considered.

In case if anycustomer orders arrive in a STOCK-OUT PERIOD the cost of shortage has also to be considered.

The same procedure is repeated for many weeks, till we are satisfied that ALL PROBABLE CASES HAVE BEEN CONSIDERED. The total costs are added and averaged to obtain AVERAGE SIMULATED COST for the whole period is obtained.

THE SIMULATION RUN has to be repeated so many times for different REORDER POINTS and REORDER QUANTITIES. An optimization process has to be carried out between obtained average simulated costs to obtain THE MINIMUM COST. Reorder Point and Reorder Quantity corresponding to this cost are considered the best conditions.

STEPS FOR MODELING:

The best thing to describe the procedure is to consider an illustrative example. We are going to consider the case of a reorder quantity of 300 units and reorder point of 400 units. This happened to be case number 30 in our simulation run. The reader would better take a glance at the SIMULATION TABLE (TABLE V) before proceeding with the following steps:

1. For the first simulated week, a random number is generated to be used for determining demand in that week, this number was found tobe 55.
2. Entering the table of distribution pattern for demand, corresponding DEMAND UNITS are found to be 30
3. Having started with 300 units, BALANCE UNITS are simply 270
4. Cost of Inventory keeping is obtained by multiplying balance units, which are 270, by the cost of keeping each unit, which is 5, to get final cost which is 1350 L.E.
5. Since balance units haven't got down to the reorder level, no order is to be placed, hence cost of ordering is set equal to zero.
6. A Random Number for DELIVERY TIME is generated, but it is not used since no order is to be placed.

Like this, we have simulated the inventory system for the first week. The same procedure is to be followed for the coming weeks regarding that whenever the balance units get to the reorder point, an order is to be placed and ordering cost of 10 L.E. is to be added to simulated costs. On receiving a customer order during a STOCK-OUT PERIOD, the cost of shortage is obtained by multiplying the number of units by the cost of shortage per unit.

When the simulated period comes to an end, total simulated costs are averaged to get the AVERAGE SIMULATED COSTS for this case. It is found to be 928.365 L.E. This entery is placed opposite the reorder point of 400 units and reorder quantity of 300 units as it is shown in TABLE VI.

The same run is repeated for other reorder points and quantities. As subsequent outcomes are recorded and noted, the search towards the optimum - a minimum cost in this illustration - gradually narrows down.

REMARK: Conditions in our illustration were really favourable and no shortage appeared. In some other cases shortage is likely to take place. Thus a separate case (with 8 reorder quantity and 4 reorder point) is presented to show how shortage is detected and its effect on both simulation table and simulated costs. It is separately shown in TABLE VII

PROGRAMMING FOR THE IBM-1620:

It is obvious that a computer is desperately needed for such a simulation. The amount of logic and mathematical calculations in a single run are tedious enough to be carried out manually. We can imagine how troublesome it would be to do the job for tens of cases.

Another advantage of using the computer is to have a STANDARD PROGRAM APPLICABLE TO ANY PROBABILISTIC INVENTORY SYSTEM. This is essentially intended to help in any ACTUAL SITUATIONS and CASE STUDIES. For these reasons. many flexibilities have been considered such as:

1. The program allows for reading the distribution patterns of both CUSTOMER DEMAND and DELIVERY TIME.
2. The program allows for any variation in demand units, reorder points and reorder quantities.
3. The program allows for reading the elements of cost data.
4. The program allows for simulating any number of weeks up to 104, which are 2 calender years.

OBTAINING RANDOM NUMBERS:

It is better to generate needed random numbers and inject them instantuously in the simulation model. For that purpose a SPECIAL SUBROUTINE FOR RANDOM NUMBER GENERATION* was set up and used in conjunction with the main program.

PROGRAMMING STEPS:

The same steps previoulsy described are herefollowed. The FLOWCHART is hereafter illustrated.

On choosing the subroutine for random numbers generation, a particular chain - code generator was selected to yield the same numbers as those shown in TABLE III. Comparison of this table with simulation reveals that the same numbers appear again in the latter tables.

The program was coded in FORTRAN II
Some of the SIMULATION TABLES are also shown. Summary of Simulation Outcomes for 81 cases is presented in TABLE VI.

RUNNING TIME: 105 MINUTES

* Please refer to "A NEW METHOD FOR RANDOM NUMBERS GENERATION" By Al. W. A. M. EL)SHAFEI.

CONCLUSION:

Simulation is a general tool of analysis capable of being used with inventory system. No generalized system of procedures for simulation has been developed. In each individual instance, when the results of simulation have been tabulated, additional quantitative and managerial analysis and judgement should be applied.

Simulation models can get very much complicated if they involve so many phenomenen with complex interrelations. For example, in our illustration, we have ignored several factors such as: loss in customer demand, Probability of a replacing product, replenishment goods speed delivery, ...etc. If we try to include those in the model we will get a STOCHASTIC MODEL and it needs much more effort and more complicated methods of analysis.

A GUIDE TO FLOW-CHART SYMBOLS

ICC = CUMULATIVE PROBABILITY (CUSTOMER DEMAND)

IDC = QUANTITY DEMANDED (CUSTOMER DEMAND)

ICT = CUMULATIVE PROBABILITY (DELIVERY TIME)

IDT = RSQUIRED DELIVERY TIME

NRC = RANDOM NUMVER FOR CUSTOMER DEMAND

NRT = RANDOM NOMBER FOR DELIVERY TIME

IDS = UNITS DEMANDED

IBS = BALANCE UNITS

IRS = UNITS RECIVED

M1 = LOT SIZE

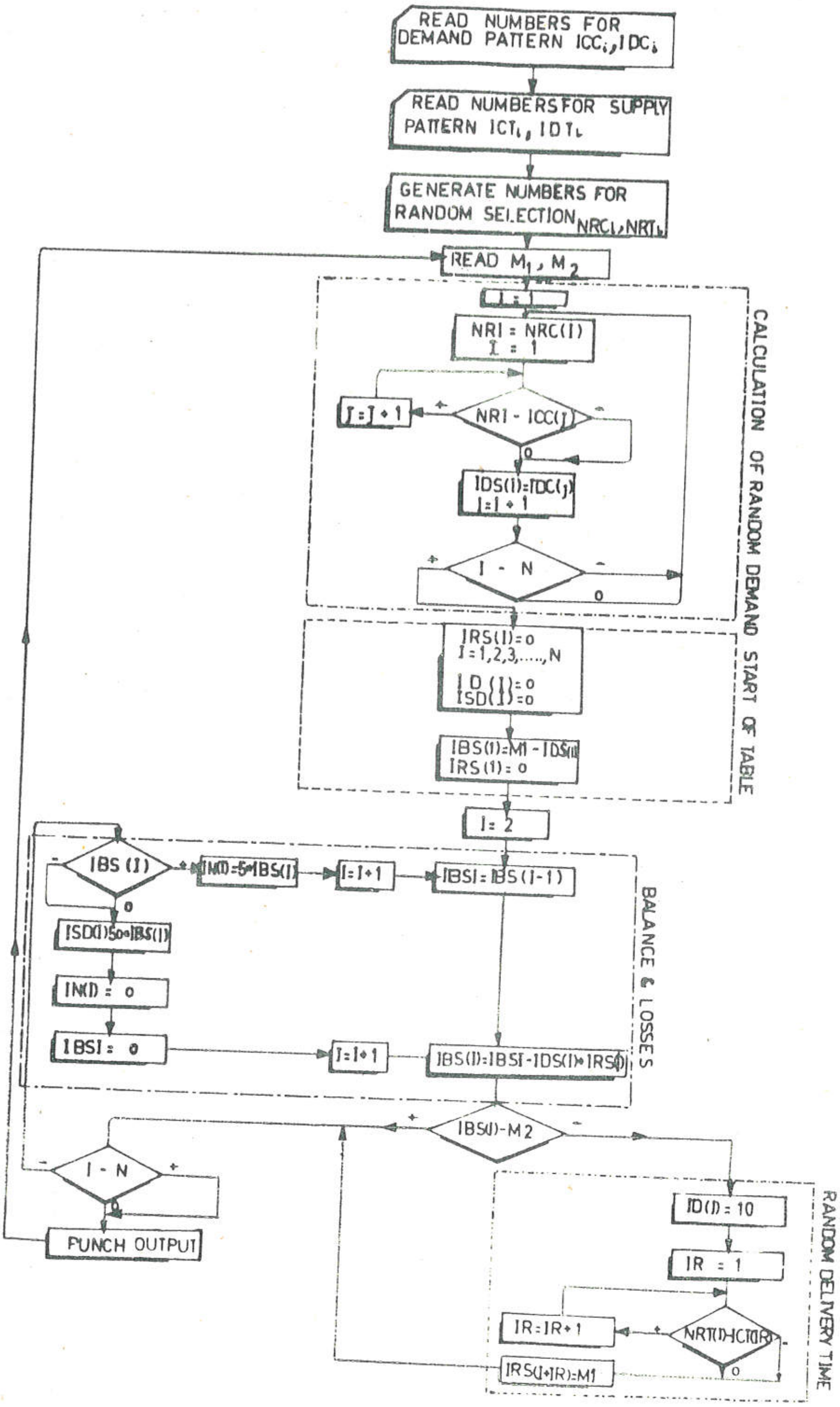
M2 = REORDERING LEVEL

ID = COST OF PLACING AN ORDER

ISD = COST DUE TO SHORTAGE

IN = COST OF INVENTORY KEEPING

IØ = COST OF PLACING AN ORDER


READ NUMBERS FOR DEMAND PATTERN ICC, IDC
READ NUMBERS FOR SUPPLY PATTERN ICT, IDT
GENERATE NUMBERS FOR RANDOM SELECTION NRC, NRT
READ M1, M2
CALCULATION OF RANDOM DEMAND
NRI = NRC(I)
J = 1
NRI - ICC(J)
J = J + 1
IDS(I) = IDC(J)
I = I + 1
I - N
START OF TABLE
IRS(I) = 0
I = 1,2,3,....,N
ID(I) = 0
ISD(I) = 0
IBS(1) = M1 - IDS(1)
IRS(1) = 0
I = 2
BALANCE & LOSSES
IBS(I)
IN(I) = 5*IBS(I)
I = I + 1
IBSI = IBS(I-1)
ISD(I) = 50*IBS(I)
IN(I) = 0
IBSI = 0
IBS(I) = IBSI - IDS(I) + IRS(I)
IBS(I) - M2
I - N
PUNCH OUTPUT
RANDOM DELIVERY TIME
ID(I) = 10
IR = 1
NRT(I) - ICT(IR)
IR = IR + 1
IRS(I+IR) = M1

SIMULATION TABLE FOR CASE NO 1

SIMU-LATED WEEK NUMB.	RANDOM NUMBERS		SIMULATED WEEK ACTIVITY			SIMULATED COSTS		
	FOR CUSTOM. DEMAND	FOR DELIV. TIME	DEMAND UNITS	RECEIPT UNITS	BALANCE UNITS	INVENT-KEEPING	ORDERING	SHORT-AGE
1	55	69	30	0	70	350	10	0
2	27	34	20	0	50	250	10	0
3	63	17	30	100	120	600	0	0
4	31	58	20	0	100	500	10	0
5	15	85	20	100	180	900	0	0
6	63	42	30	0	150	750	0	0
7	87	71	40	0	110	550	0	0
8	49	91	30	0	80	400	10	0
9	80	1	30	0	50	250	10	0
10	40	0	20	100	130	650	0	0
11	76	0	30	100	200	1000	0	0
12	44	50	30	0	170	850	0	0
13	78	81	30	0	140	700	0	0
14	95	40	40	0	100	500	10	0
15	3	70	0	100	200	1000	0	0
16	51	35	30	0	170	850	0	0
17	25	73	20	0	150	750	0	0
18	62	36	30	0	120	600	0	0
19	87	68	40	0	80	400	10	0
20	43	34	30	0	50	250	10	0
21	27	17	20	200	230	1150	0	0
22	19	8	20	0	210	1050	0	0
23	65	4	30	0	180	900	0	0
24	32	2	20	0	160	800	0	0
25	16	1	20	0	140	700	0	0
26	14	56	20	0	120	600	0	0
27	13	28	20	0	100	500	10	0
28	6	64	10	100	190	950	0	0
29								
30								
31								
3								

95	26	40	0	140	700	0	0
53	13	30	0	110	550	0	0
82	6	40	0	70	350	10	0
41	53	30	100	140	700	0	0
20	26	20	0	120	600	0	0
16	69	20	0	100	500	10	0
14	90	20	0	80	400	10	0
63	95	30	100	150	750	0	0
87	53	40	100	210	1050	0	0
99	32	60	0	150	750	0	0
49	72	30	0	120	600	0	0
24	92	20	0	100	500	10	0
18	46	20	0	80	400	10	0
15	79	20	100	160	800	0	0
7	89	10	100	250	1250	0	0
59	94	30	0	220	1100	0	0
35	3	20	0	200	1000	0	0
17	7	20	0	180	900	0	0
8	3	10	0	170	850	0	0
54	57	30	0	140	700	0	0
83	34	40	0	100	500	10	0
41	73	30	100	170	850	0	0
26	36	20	0	150	750	0	0
63	18	30	0	120	600	0	0
37	15	20	0	100	500	10	0
68	57	30	100	170	850	0	0
84	78	40	0	130	650	0	0
98	39	50	0	80	400	10	0
49	75	30	100	150	750	0	0
74	37	30	0	120	600	0	0
37	24	20	0	100	500	10	0
74	62	30	100	170	850	0	0
93	81	40	0	130	650	0	0
52	40	30	0	100	500	10	0
26	20	20	100	180	900	0	0
13	66	20	0	160	800	0	0
56	33	30	0	130	650	0	0
84	22	40	0	90	450	10	0
98	61	50	100	140	700	0	0
99	36	60	0	80	400	10	0
55	24	30	100	150	750	0	0
33	12	20	0	130	650	0	0
16	62	20	0	110	550	0	0
64	81	30	0	80	400	10	0
82	90	40	0	40	200	10	0
47	1	30	100	110	550	0	0
73	6	30	100	180	900	0	0
42	59	30	0	150	750	0	0
27	85	20	0	130	650	0	0
		2870	2900	14390	71950	290	0
		27.596	27.884	138.365	691.826	2.788	0.000

##

AVERAGE SIMULATED COSTS FOR CASE NO. 1# 694.615

TABLE V

SIMULATION TABLE FOR CASE NO 30

-ED K B.	RANDOM NUMBERS FOR CUSTOM. DEMAND	FOR DELIV. TIME	SIMULATED WEEK ACTIVITY DEMAND UNITS	RECEIPT UNITS	BALANCE UNITS	SIMULATED COSTS INVENT-KEEPING	ORDERING	SHORT-AGE
1	55	69	30	0	270	1350	0	0
2	27	34	20	0	250	1250	10	0
3	63	17	30	300	520	2600	0	0
4	31	58	20	0	500	2500	0	0
5	15	85	20	0	480	2400	0	0
6	63	42	30	0	450	2250	0	0
7	87	71	40	0	410	2050	0	0
8	49	91	30	0	380	1900	10	0
9	80	1	30	0	350	1750	10	0
10	40	0	20	300	630	3150	0	0
11	76	0	30	300	900	4500	0	0
12	44	59	30	0	870	4350	0	0
13	78	81	30	0	840	4200	0	0
14	95	40	40	0	800	4000	0	0
15	3	70	0	0	800	4000	0	0
16	51	35	30	0	770	3850	0	0
17	25	73	20	0	750	3750	0	0
18	62	36	30	0	720	3600	0	0
19	87	68	40	0	680	3400	0	0
20	43	34	30	0	650	3250	0	0
21	27	17	20	0	630	3150	0	0
22	19	8	20	0	610	3050	0	0
23	65	4	30	0	580	2900	0	0
24	32	2	20	0	560	2800	0	0
25	16	1	20	0	540	2700	0	0
26	14	56	20	0	520	2600	0	0
27	13	28	20	0	500	2500	0	0
28								
29								
30								

56	95	26	40	300	640	3200	0	0
57	53	13	30	0	610	3050	0	0
58	82	6	40	0	570	2850	0	0
59	41	53	30	0	540	2700	0	0
60	20	26	20	0	520	2600	0	0
61	16	69	20	0	500	2500	0	0
62	14	90	20	0	480	2400	0	0
63	63	95	30	0	450	2250	0	0
64	87	53	40	0	410	2050	0	0
65	99	32	60	0	350	1750	10	0
66	49	72	30	300	620	3100	0	0
67	24	92	20	0	600	3000	0	0
68	18	46	20	0	580	2900	0	0
69	15	79	20	0	560	2800	0	0
70	7	89	10	0	550	2750	0	0
71	59	94	30	0	520	2600	0	0
72	35	3	20	0	500	2500	0	0
73	17	7	20	0	480	2400	0	0
74	8	3	10	0	470	2350	0	0
75	54	57	30	0	440	2200	0	0
76	83	34	40	0	400	2000	10	0
77	41	73	30	300	670	3350	0	0
78	26	36	20	0	650	3250	0	0
79	63	18	30	0	620	3100	0	0
80	37	15	20	0	600	3000	0	0
81	68	57	30	0	570	2850	0	0
82	84	78	40	0	530	2650	0	0
83	98	39	50	0	480	2400	0	0
84	49	75	30	0	450	2250	0	0
85	74	37	30	0	420	2100	0	0
86	37	24	20	0	400	2000	10	0
87	74	62	30	300	670	3350	0	0
88	93	81	40	0	630	3150	0	0
89	52	40	30	0	600	3000	0	0
90	26	20	20	0	580	2900	0	0
91	13	66	20	0	560	2800	0	0
92	56	33	30	0	530	2650	0	0
93	84	22	40	0	490	2450	0	0
94	98	61	50	0	440	2200	0	0
95	99	36	60	0	380	1900	10	0
96	55	24	30	300	650	3250	0	0
97	33	12	20	0	630	3150	0	0
98	16	62	20	0	610	3050	0	0
99	64	81	30	0	580	2900	0	0
00	82	90	40	0	540	2700	0	0
01	47	1	30	0	510	2550	0	0
02	73	6	30	0	480	2400	0	0
[illegible]	[illegible]	59	30	0	450	2250	0	0
04	[illegible]	85	20	0	430	2150	0	0
RAGES			2870	3000	59299	96450	100	0
			27.596	28.846	570.096	927.403	.961	0.000

##

[illegible] SIMULATED COSTS FOR CASE NO. 3[illegible]# 928.365

TABLE VI
SUMMARY OF SIMULATION OUTCOMES

REORD.OT REORD. PT'.	100	200	300	400	500	600	700	800	900
100	694.615	63.461	744.711	745.480	43.269	639.326	81.730	571.923	172.884
200	218.749	563.461	937.980	706.923	43.365	24.038	721.057	956.538	648.846
300	699.615	82.788	495.769	937.692	187.692	485.673	96.057	610.384	831.538
400	199.711	573.173	928.365	495.480	668.365	158.653	533.557	956.634	812.307
500	661.346	92.499	486.153	784.038	259.711	591.346	918.173	649.038	110.384
600	151.826	573.269	29.519	745.480	572.211	206.730	341.249	249.807	547.980
700	599.038	121.442	462.115	14.711	572.307	697.115	312.499	533.557	230.576
800	79.903	544.419	19.903	514.807	716.634	81.826	629.903	225.865	648.962
900	512.692	54.230	510.384	803.365	235.769	543.461	307.692	648.942	177.884

TABLE VII

##

SIMULATION TABLE FOR CASE NO 1

SIMU-LATED WEEK NUMB.	RANDOM NUMBERS		SIMULATED WEEK ACTIVITY			SIMULATED COSTS		
	FOR CUSTOM. DEMAND	FOR DELIV. TIME	DEMAND UNITS	RECEIPT UNITS	BALANCE UNITS	INVENT-KEEPING	ORDERING	SHORT-AGE
1	55	69	3	0	5	25	0	0
2	27	34	2	0	3	15	10	0
3	63	17	3	8	8	40	0	0
4	31	58	2	0	6	30	0	0
5	15	85	2	0	4	20	10	0
6	63	42	3	0	1	5	10	0
7	87	71	4	16	13	65	0	0
8	49	91	3	0	10	50	0	0
9	80	1	3	0	7	35	0	0
10	40	0	2	0	5	25	0	0
11	76	0	3	0	2	10	10	0
12	44	50	3	8	7	35	0	0
13	78	81	3	0	4	20	10	0
14	95	40	4	0	0	0	10	0
15	3	70	0	16	16	80	0	0
16	51	35	3	0	13	65	0	0
17	25	73	2	0	11	55	0	0
18	62	36	3	0	8	40	0	0
19	87	68	4	0	4	20	10	0
20	43	34	3	0	1	5	10	0
21	27	17	2	16	15	75	0	0
22	19	8	2	0	13	65	0	0
23	65	4	3	0	10	50	0	0
24	32	2	2	0	8	40	0	0
25	16	1	2	0	6	30	0	0
26	14	56	2	0	4	20	10	0
27	13	28	2	8	10	50	0	0
2[illegible]								
[illegible]								

58	82	6	4	0	2	10	10	0
59	41	53	3	8	7	35	0	0
60	20	26	2	0	5	25	0	0
61	16	69	2	0	3	15	10	0
62	14	90	2	0	1	5	10	0
63	63	95	3	8	6	30	0	0
64	87	53	4	8	10	50	0	0
65	99	32	6	0	4	20	10	0
66	49	72	3	8	9	45	0	0
67	24	92	2	0	7	35	0	0
68	18	46	2	0	5	25	0	0
69	15	79	2	0	3	15	10	0
70	7	89	1	0	2	10	10	0
71	59	94	3	8	7	35	0	0
72	35	3	2	8	13	65	0	0
73	17	7	2	0	11	55	0	0
74	8	3	1	0	10	50	0	0
75	54	57	3	0	7	35	0	0
76	83	34	4	0	3	15	10	0
77	41	73	3	8	8	40	0	0
78	26	36	2	0	6	30	0	0
79	63	18	3	0	3	15	10	0
80	37	15	2	8	9	45	0	0
81	68	57	3	0	6	30	0	0
82	84	78	4	0	2	10	10	0
83	98	39	5	0	-3	0	10	150
84	49	75	3	16	13	65	0	0
85	74	37	3	0	10	50	0	0
86	37	24	2	0	8	40	0	0
87	74	62	3	0	5	25	0	0
88	93	81	4	0	1	5	10	0
89	52	40	3	0	-2	0	10	100
90	26	20	2	16	14	70	0	0
91	13	66	2	0	12	60	0	0
92	56	33	3	0	9	45	0	0
93	84	22	4	0	5	25	0	0
94	98	61	5	0	0	0	10	0
95	99	36	6	0	-6	0	10	300
96	55	24	3	16	13	65	0	0
97	33	12	2	0	11	55	0	0
98	16	62	2	0	9	45	0	0
99	64	81	3	0	6	30	0	0
100	82	90	4	0	2	10	10	0
101	47	1	3	0	-1	0	10	50
102	73	6	3	16	13	65	0	0
103	42	59	3	0	10	50	0	0
104	27	85	2	0	8	40	0	0
TOTALS			287	272	697	3560	340	750
AVERAGES			2.759	2.615	6.701	34.230	3.269	7.

##

AVERAGE SIMULATED COSTS FOR CASE NO. 1# 44.711