COMPARISON OF PERIODIC REVIEW OPERATING DOCTRINES: A SIMULATION STUDY

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ABSTRACT

This paper contrasts two common operating doctrines for periodic review inventory systems: the "order up to R" rule and the Rr rule, by using both analytical and simulation methods. It concludes that the "order up to R" policy can be considered essentially optimal independently of how review and ordering costs compare with each other.

SCOPE AND PURPOSE

This paper is the outcome of an inquiry into the application of simulation methodology to policy evaluation with respect to an inventory problem.

One operating doctrine for periodic review systems which is used in practice consists in placing an order at each review time if there have been any demands at all in the past period. The time between two successive reviews represents one period of operation for the system. A sufficient quantity is ordered so as to bring the inventory position up to a level R. This operating doctrine is called an "order up to R" doctrine. Models which use an order up to R policy are designated as (R, T) models, where T represents the time-between-reviews.

Another operating doctrine is to make a procurement at a review time only if the inventory position is less than or equal to a certain level r. In such case a sufficient quantity is ordered so as to replenish the stock up to a level R. This operating doctrine is called an Rr rule. Models which use an Rr policy are referred as (R, r, T) models.

It is not equally easy to make numerical computations for each type of operating doctrine. It is relatively easy to make numerical computations manually for (R, T) models, but for (R, r, T) models a computer is required, either because the formulas involved are rather complex (backorders case) or because there are not any explicit formulas (lost sales case) and thus simulation is the only feasible procedure in such situations.

Because of the differences in computational effort required and also because (R, T) models are simple to implement and control, it is of interest to inquire under which circumstances will the "order up to R" policy be essentially optimal.

Hadley and Whitin (1) suggest that when review costs are high relative to ordering costs, an order up to R doctrine should be essentially optimal (Hypothesis I). It is only when ordering costs are high with respect to review costs that an Rr doctrine could be considerably better than an order up to R doctrine (Hypothesis II). These conjectures by Hadley and Whitin were taken as Hypotheses I and II in this paper and tested through simulation methods. The lost sales case is assumed.

Paper Structure

This research paper is divided into four sections. The first reviews the analytical solution for the simplified lost sales model of periodic review system. The second deals with the statement of Hypotheses I and II and contains the test problems and related simulation procedures designed to test these hypotheses. The third is concerned with the verification of the mentioned hypotheses. It develops the analytical solution of the sample

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problems by using the simplified (R, T) model suggested in the first section,where all calculations are easily carried out with a pocket calculator. It then approaches the solution of such sample problems through simulation of an (R, r, T) model. This is accomplished with GASP as a programming language and by using optimal seeking methods. Finally, the last section summarizes the main results.

ANALYTICAL SOLUTION OF SIMPLE (R,T) MODELS (LOST SALES CASE)

The following assumptions are made:

(i) All variables are treated as continuous.
(ii) J = cost of making a review is independent of R and T.
(iii) C = unit cost of the item is constant independent of the quantity ordered.
(iv) Lost sales are incurred only in very small quantities.
(v) The cost of each lost sale is π and it includes the lost profit.
(vi) The procurement lead time may be a random variable or not; it is assumed that the lead times for different orders can be treated as independent random variables.

Let also:

A = cost of placing an order.
I = inventory carrying charge.
L = A + J = total cost of making a review and placing an order.
f (x;t) = density function for demand x in a time interval of length t.
λ = average demand rate.
μ = expected lead time demand.

It can be shown that the average annual cost K is given by:

$$K = \frac{L}{T} + IC[R - \mu - \frac{\lambda T}{2} + \int_R^{\infty}(x-R)\hat{h}(x;T)dx] + \frac{\pi}{T}\int_R^{\infty}(x-R)\hat{h}(x;T)dx \qquad (1)$$

where:

$\frac{L}{T} = \frac{A + J}{T}$ = average annual cost of reviewing and ordering.

$IC[R - \mu - \frac{\lambda T}{2} + \int_R^{\infty}(x-R)\hat{h}(x;T)dx]$ = average annual cost of holding inventory.

$\frac{\pi}{T}\int_R^{\infty}(x-R)\hat{h}(x;T)dx$ = average annual cost of lost sales.

$\int_R^{\infty}(x-R)\hat{h}(x;T)dx$ = expected number of lost sales per period,

and $\hat{h}(x;T) = \int_{\tau_{min}}^{\tau_{max}} f(x;\tau_2 + T)g(\tau_2)d\tau_2$,

where T (lead time) is assumed to be a random variable with density $g(\tau)$; τ_{min} and τ_{max} are the lower and upper limits respectively to the possible range of lead time values, and τ_1, τ_2 are the lead times for orders placed at times t and t + T respectively.

For a given T, the value of R which minimizes K must satisfy

$$\frac{\partial K}{\partial R} = 0 = IC + (IC + \frac{\pi}{T})[\frac{\partial}{\partial R}\int_R^{\infty} x\hat{h}(x;T)dx - \frac{\partial}{\partial R}\int_R^{\infty} R\hat{h}(x;T)dx] = IC + (IC + \frac{\pi}{T})[-\int_R^{\infty}\hat{h}(x;T)dx]$$

Thus R* is a solution to:

$$\int_R^{\infty}\hat{h}(x;T)dx = \frac{ICT}{ICT + \pi} \qquad (2)$$

If $\hat{h}(x;T)$ can be approximated by the normal density function n with parameters μ_1(demand in time τ + T) and σ (variance), i.e., if $\hat{h}(x;T) \approx n(x;\mu_1;\sigma)$, than it can be shown that

$$K = \frac{L}{T} + IC(R - \mu - \frac{\lambda T}{2}) + (IC + \frac{\pi}{T})[\sigma\phi(\frac{R-\mu_1}{\sigma}) + (\mu_1 - R)\Phi(\frac{R-\mu_1}{\sigma})] \qquad (3)$$

where ϕ is the density function of the standardized normal distribution and Φ is the complementary cumulative of ϕ.

A simple way to minimize K is by tabulating K as a function of T, where for each T the optimal R for that T is used. Note that when T is given, R* can be found without a knowledge of the review or ordering costs. (2)

HYPOTHESES, SAMPLE PROBLEMS AND SIMULATION PROCEDURES

Formulation of Hypotheses

The work of Hadley and Whitin already mentioned has suggested the following hypotheses for this research on the lost sales case of periodic review system with stochastic demand:

Hypothesis I . When review costs are high relative to ordering costs, an order up to R doctrine should be essentially optimal.

Hypothesis II. When ordering costs are high with respect to review costs, an Rr doctrine could be considerably better than an order up to R doctrine.

Sample Problems

The test problems given below were devised and solved by using the analytical approach already suggested for simple (R,T) models and also by simulation of an (R,r,T) model. Problem I differs from Problem II in that the review cost and ordering cost are interchanged from one problem to the other. Thus, in Problem I the review cost is ten times the ordering cost, whereas in Problem II the ordering cost is ten times the review cost. Since for an (R,T) model it does not make any difference when review and ordering costs are interchanged, the application of such model yields the same answer to both problems. The reason is that review cost and ordering cost are added in the model, i.e., L = J + A.

Problem I - - (a) A periodic review plan has been suggested for controlling the inventory of a particular item. The plan is to review the number of items in inventory every TBR weeks and to place an order so that the inventory position at the time of order is increased to SCL units. However, management has decided that orders will be placed only if the number of units on hand plus those on order (POS) is less than or equal to R units. Develop a search procedure which will lead to the optimal parameters of the periodic review doctrine. The parameters which can be varied are the time-between-reviews (TBR), the reorder point (R), and the amount up to which the inventory position is returned, i.e., the stock control level SCL. The data for the problem is presented in Table 1, Appendix A. (b) An alternative plan has been suggested, i.e., to control the inventory by using the simple "order to SCL" doctrine. We are to decide which plan will yield the minimum cost.

Problem II - - The same as Problem I, except that cost per order (CPO) and cost per review (CPR) are interchanged (see Table 1, Appendix A).

Simulation Procedures

The objective here is the simulation of an inventory system over a period of six years using simulation language GASP IIA (3) in order to obtain the following statistics: average cost per week, average safety stock, number of orders, and number of lost sales.

The events of the simulation are: (1) a demand for an item (DMAND), (2) the receipt of an order (RECPT), (3) a periodic review of inventory (RVIEW), and (4) the end of the current simulation run (ENDSM). The entities in the simulation are the inventory on hand and the inventory position. In this problem only one event file is necessary. In this file, ATRIB (1) is the time of the event, and JTRIB (1) is the event code. The event code is either 1,2, 3, or 4, depending on whether the event is a demand, a receipt, a review, or the end of simulation. The non-GASP variables associated with this simulation are shown in Table 1, Appendix A.

The Fortran listing of the main program is shown in Figure 1, Appendix B. The main program first reads in the values for the cost of an item, the cost per order, the inventory carrying charge, the cost due to loss in good will and the cost per review. The values for the mean time between demands and the lead time are initialized. New values of the reorder point (R), the stock control level (SCL), and the time between reviews (TBR) are then read. The variables associated with the number of lost sales, total number of orders, total number of reviews, total number of sales, inventory-on-hand, and inventory position are initialized. Then subroutine GASP is called. Subroutine EVNTS transfers control to one of the four user written subroutines: DMAND, RECPT, RVIEW, or ENDSM. Flowcharts of these subroutines are shown in Figures 2,3,4,and 5, Appendix B.

VERIFICATION OF HYPOTHESES

(R,T) Model Solution of Test Problems

The following data (Table 1, Appendix A) refers to Problem I (or II):

- $L = A + J = 33$ ($ per order and review)
- $I = 0.003836$ ($ per $-week)
- $C = 40$ ($ per unit)
- R = stock control level, to be determined
- λ = rate of demand = 5 (units per week)
- τ = lead time = 5 (weeks)
- μ = expected lead time demand = $\lambda\tau$ = 25 (units)
- T = time-between-reviews, to be determined
- π = cost due to loss in good will = 20 ($ per lost sale)

Using the above data and equation (3), the cost expression for Problem I (or II) becomes:

$$K = \frac{33}{T} + 0.15344\left(R - 25 - \frac{5T}{2} + K_1\right) + \frac{20}{T}K_1 \qquad (4)$$

where

$$K_1 = \left\{\sqrt{5(5+T)}\,\phi\left[\frac{R-5(5+T)}{\sqrt{5(5+T)}}\right] + [5(5+T)-R]\,\Phi\left[\frac{R-5(5+T)}{\sqrt{5(5+T)}}\right]\right\} \qquad (5)$$

In expression (4) we can see that:

review and ordering costs = ROC = $\frac{33}{T}$

inventory carrying cost = ICC = $0.15344\left(R - 25 - \frac{5T}{2} + K_1\right)$

lost sales cost = LSC = $\frac{20}{T}K_1$

The optimal values R^* and T^* can now be determined by tabulating K as a function of T, using the R^* value for the given T in computing K. Other methods (e.g. Newton's method or the gradient method) could also be employed. A sample computation is given below.

Calculation for T = 1.0 (week) - -

$T + \tau = 1.0 + 5.0 = 6.0$ (weeks)

The expected demand in time $T + \tau$ is given by:

$\mu_1 = 5 \times 6 = 30$ (units)

The variance of the demand in this time is equal to the mean, i.e.,

$\sigma = \sqrt{30}$ (units)

Thus, from equation (2), R^* is the solution to:

$$\Phi\left(\frac{R-30}{\sqrt{30}}\right) = \frac{ICT}{\pi + ICT} = \frac{0.15344 \times 1.0}{20 + 0.15344 \times 1.0} = 0.00761$$

From the normal tables, it follows that

$$\frac{R^* - 30}{5.47723} = 2.43$$

$$\therefore R^* = 30 + 2.43 \times 5.47723 \approx 43.3$$

Review and Ordering Cost - -

$$ROC = \frac{33}{1} = 33$$

Inventory Carrying Cost - - We first compute K_1 from equation (5):

$$K_1 = \sqrt{30}\,\phi\left(\frac{43.3-30}{\sqrt{30}}\right) + (30-43.3)\,\Phi\left(\frac{43.3-30}{\sqrt{30}}\right) = 0.01409$$

Thus,

$$ICC = 0.15344\ (R - 25 - \frac{5T}{2} + K_1)$$

$$= 0.15344\ (43.3 - 25 - \frac{5}{2} + 0.01409) = 2.42805$$

Lost Sales Cost - -

$$LSC = \frac{20}{T} K_1 = 20 \times 0.01409 = 0.28180$$

Total Cost - -

$$K = ROC + ICC + LSC = 35.70985 \text{ (\$ per week)}$$

The entire procedure is repeated so as to obtain for each T an optimal R for that T. The results are presented in Table 2, Appendix A. From this table it can be seen that the optimal value of T is about 9 weeks. Thus,

$$(R^*, T^*) = (82.7, 9.0) \approx (83, 9.0)$$

Simulation Solution of Test Problems by Using the (R, r, T) Model

The Method of Steepest Ascent (Cauchy) and the simulation procedures explained are used to approach the minimum cost. In order to find how far to move in the gradient direction the Golden Section Method is employed. This method is closely related to what is named the Fibonacci Search Method. The results from the simulation runs of the inventory system with lost sales, using several sets of values for R, SCL and TBR read in by card, are summarized in Table 3, Appendix A.

CONCLUSIONS

(i) Hypothesis I has some support with respect to the near optimality of an (R, T) model when reviewing costs are greater than ordering costs. The (R, T) model solution yields a cost of \$9.62633 when (R*,T*) = (83, 9.0) (Table 2, Appendix A). The solution by simulation of an (R, r, T) model yields a cost of \$15.7161 when (R*, r*, T*) = (38, 83, 3.4) (Table 3, Appendix A). However, we did not find support for the conjecture that an (R, r, T) model and an (R, T) model both yield approximately the same minimum cost (4). The best we could achieve with an (R, r, T) model was a cost of \$15.7161 which is more than sixty per cent greater than the cost obtained with the (R, T) doctrine.

(ii) Hypothesis II is not confirmed by this research. Using an (R, r, T) model, the best cost is \$10.1567 when (R*,r*,T*) = (38, 83, 1.7) (Table 3, Appendix A). This value is not far from that yielded by the (R, T) model, i.e., \$9.62633 (Table 2, Appendix A).

(iii) These results provide a temporary basis for adopting the simple (R, T) model in either case, i.e., independently of how review and ordering costs compare with each other.

(iv) Since the future trend is a relatively lower reviewing cost (due to progress in computerized procedures of reviewing), it would be worthwhile to investigate the range of applicability of an (R, r, T) model and also under what circumstances it could be replaced by an order up to R doctrine. This paper represents a research effort in such direction.

BIBLIOGRAPHY

1. Hadley, G. and Whitin, T.M., Analysis of Inventory Systems, Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1963, p.281.
2. Hadley and Whitin, op.cit., pp 237-42.
3. Pritsker, A.B., and Kiviat, P.J., Simulation with GASP II - A Fortran Based Simulation Language, Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1969.
4. Hadley and Whitin, op. cit., p.281.

APPENDIX A: TABLES

TABLE 1

NON-GASP VARIABLES ASSOCIATED WITH SIMULATION

Variable	DEFINITION	Initial Value
AVIN	Average inventory on hand (units)/wk)	Output
AVSS	Average safety stock	Output
CCHG	Inventory carrying charge ($/$ wk)	0.003836
CPØ	Cost per order ($/order)	3
CPR	Cost per review ($/review)	30
P	Average profit per week	not required
PCØU	Purchase cost of unit ($/unit)	40
PØS	Inventory position	31
R	Reorder point	Read in
SALE	Total number of sales	0
SCL	Stock control level when an order is placed;SCL-POS is the amount ordered	Read in
SLØST	Number of lost sales	0
SPØU	Selling price of unit ($/unit)	65
STØCK	Inventory-on-hand	31
TBR	Time between reviews	Read in
TLEAD	Time between placement and receipt of order (weeks)	5
TØRD	Total number of orders	0
TREV	Total number of reviews	0
ULØSE	Cost due to loss in good-will ($/lost sale)	20
* XL	Mean time between demands (weeks)	0.2

(*) Demand is Poisson-distributed with a mean equal to 5 units per week.

TABLE 2

COMPUTATION OF OPTIMAL VALUES FOR STOCK CONTROL LEVEL (R*) AND TIME-BETWEEN-REVIEWS (T*)

T (wks)	R*(T) (units)	ROC ($/wk)	ICC ($/wk)	LSC ($/wk)	K ($/wk)
1.0	43.3	33.0	2.42805	0.28180	35.70985
2.0	47.8	16.5	2.74192	0.31650	19.55842
6.0	67.7	5.50	4.26779	0.44363	10.21142
8.0	77.6	4.12	5.04173	0.50243	9.66916
9.0	82.7	3.67	5.43975	0.51991	9.62633
10.0	87.7	3.30	5.83092	0.54256	9.67348
12.0	97.7	2.75	6.60953	0.58782	9.94735
15.0	112.6	2.20	7.76347	0.66149	10.62496

TABLE 3

SIMULATION RESULTS (Abridged)

R = Reorder point; SCL = stock-control-level; TBR = time-between-reviews; AORD = Average number of orders; ALOST = Average number of lost sales ; ASALE = Average sales; SS = Safety stock; AVIN = Average inventory .

Execution Number	R	SCL	TBR	AORD	ALOST	ASALE	SS	AVIN	COST
IB58227	18	36	2.0	0.1442	1.7660	3.3301	0.1111	8.1251	52.0032
IB58395	19	36	2.0	0.1827	1.4776	3.6185	0.5536	8.0468	46.3373
IB58395	18	37	2.0	0.1441	1.6987	3.3974	0.0682	8.3539	50.6293
IB58395	18	36	2.1	0.1667	1.5833	3.5128	0.1923	7.8765	47.7054
IB59799	18	36	6.0	0.0833	2.1795	2.9167	0.0000	9.7894	50.3458
IB59799	19	36	8.0	0.0929	2.3558	2.7404	0.0000	8.6698	52.4780
IB60701	18	36	4.0	0.1122	1.9519	3.1442	0.0000	9.0945	48.2741
IB60930	18	36	3.5	0.1346	1.8013	3.2949	0.1463	8.7678	46.4322
IB61018	18	36	2.9	0.1410	1.7788	3.3173	0.0930	8.3255	47.6655
IB61084	18	36	3.8	0.1282	1.8558	3.2404	0.2564	8.7784	46.8313
IB61175	18	36	3.2	0.1250	1.8878	3.2083	0.0000	8.7384	48.8989
IB61252	18	36	3.6	0.1250	1.9006	3.1955	0.1282	8.8517	48.1150
IB61355	18	36	3.4	0.1314	1.7724	3.3237	0.1707	8.6662	46.0224
IB61471	18	36	3.3	0.1346	1.8365	3.2596	0.1667	8.6474	47.5996
IB61600	19	36	3.4	0.1538	1.6218	3.4744	0.4167	8.2534	42.9980
IB61600	18	37	3.4	0.1314	1.6827	3.4135	0.0000	8.7488	44.2402
YA81302	28	42	2.1	0.2308	0.6410	4.4551	1.6761	10.5347	29.4605
YA81302	33	45	1.3	0.3237	0.1667	4.9295	5.5960	13.1607	29.5023
IB67791	24	39	2.6	0.1955	1.1795	3.9167	2.1167	9.7701	37.3140
IB67831	30	43	1.8	0.2724	0.4071	4.6891	3.5542	11.2625	27.4218
IB67891	31	44	1.6	0.2821	0.3558	4.7404	4.2069	12.0336	28.6590
IB67939	29	42	1.9	0.2564	0.5545	4.5417	2.9873	11.0270	29.4208
IB67985	30	43	1.7	0.2660	0.3878	4.7083	2.9146	11.1775	27.9664
IB68085	29	43	1.8	0.2436	0.5224	4.5737	2.9467	11.4342	29.6694
IB68307	31	43	1.8	0.2788	0.3846	4.7115	3.3023	11.1347	26.9726
IB68307	30	44	1.8	0.2436	0.4679	4.6282	3.3200	12.1040	28.6827
IB68307	30	43	1.9	0.2596	0.5000	4.5962	3.5000	11.6202	28.4320
IB69590	30	43	1.1	0.3109	0.2596	4.8365	3.6737	11.3021	35.1715
IB69590	30	43	0.7	0.3397	0.1859	4.9103	4.6538	11.6986	49.4216
IB69615	30	43	1.4	0.2853	0.3910	4.7051	3.6818	11.3726	31.8682
IB69631	30	43	1.5	0.2949	0.3429	4.7532	3.9778	11.5386	29.5188
IB69666	30	43	1.6	0.2821	0.4103	4.6859	3.7816	11.4402	29.6575
IB69710	31	43	1.5	0.3173	0.2724	4.8237	4.3980	11.6518	28.1932
IB69710	30	44	1.5	0.2724	0.3141	4.7821	3.5952	11.8541	28.9384
IB69715	39	83	9.0	0.0641	0.7468	4.3494	1.9500	30.3815	23.1677
IB69715	38	84	9.0	0.0641	0.7179	4.3782	2.1000	30.8794	22.6673
IB69715	38	83	9.1	0.0609	0.8686	4.2276	0.9474	29.8625	25.5141
IB69858	38	83	5.6	0.0801	0.3622	4.7340	3.1600	30.7696	17.6024
IB69858	38	83	3.4	0.0994	0.0641	5.0321	7.3333	32.7873	15.4705
IB69883	38	83	4.2	0.0833	0.3590	4.7372	3.2308	30.6828	19.3615
IB69895	38	83	2.1	0.0994	0.0962	5.0000	6.4000	31.9818	21.4684
IB69926	38	83	2.9	0.1026	0.0224	5.0737	7.0645	32.3334	16.1154
IB69936	38	83	3.8	0.0897	0.1667	4.9295	3.9259	30.8510	16.3296
IB69944	38	83	3.2	0.0994	0.0481	5.0481	8.3000	32.6751	15.7096
IB71391	38	83	3.6	0.0897	0.1058	4.9904	4.3214	30.7662	15.4833
IB71471	38	83	3.5	0.0897	0.1763	4.9199	4.4286	31.3507	17.2719
IB71525	39	83	3.4	0.0994	0.0801	5.0160	7.5667	33.0453	15.8307
IB71525	38	84	3.4	0.0962	0.0641	5.0321	6.5517	32.7952	15.4621
IB71567	38	83	3.3	0.0994	0.0641	5.0321	7.0333	32.5086	15.7161
IB71624	39	83	3.3	0.0994	0.0641	5.0321	7.0333	32.5086	15.7161
IB71624	38	84	3.3	0.0962	0.0673	5.0288	6.1379	32.5861	15.7825

TABLE 3 (continued)

Execution Number	R	SCL	TBR	AORD	ALOST	ASALE	SS	AVIN	COST
IB71662	39	83	3.3	0.0994	0.0641	5.0321	7.0333	32.5086	10.1776
IB71845	40	83	3.3	0.0994	0.0609	5.0353	6.4333	32.2225	10.0695
IB71845	39	84	3.3	0.0994	0.0481	5.0481	7.6667	33.3238	9.9825
IB71845	39	83	3.4	0.0994	0.0801	5.0160	7.5667	33.0453	10.5518
IB72115	39	83	2.0	0.1058	0.0288	5.0673	9.2188	33.5580	10.4128
IB72115	39	83	1.3	0.1090	0.0000	5.0962	11.3235	34.5450	10.9012
IB72154	39	83	2.5	0.0994	0.0705	5.0256	7.7667	32.9393	10.6605
IB72172	39	83	1.7	0.1058	0.0000	5.0962	9.6667	33.8934	10.1567
IB72185	39	83	1.6	0.1058	0.0224	5.0737	9.6667	33.7936	10.7054
IB72199	39	83	1.8	0.1058	0.0032	5.0929	9.9091	33.8088	10.1116
IB72221	39	84	1.7	0.1058	0.0000	5.0962	9.7813	34.3030	10.2197
IB72221	40	83	1.7	0.1090	0.0000	5.0962	10.3636	34.2277	10.3043
IB72237	39	83	1.9	0.1058	0.0256	5.0705	9.2121	33.3317	10.4004

APPENDIX B: MAIN PROGRAM LISTING AND FLOWCHARTS OF SUBROUTINES

FIGURE 1

MAIN PROGRAM LISTING

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      PROGRAM INV(INPUT,OUTPUT)
C*****MAIN PROGRAM FOR A SIMULATION OF AN INVENTORY SYSTEM INVOLVING
C*****LOST SALES.
      DIMENSION NSET(3000),QSET(3000)
      COMMON ID,IM,INIT,JEVNT,JMNIT,MFA,MSTOP,MX,MXC,NCLCT,NHIST.
     1NOQ,NORPT,NOT,NPRMS,NRUN,NRUNS,NSTAT,OUT,ISEED,TNOW,
     2TBEG,TFIN,MXX,NPRNT,NCRDR,NEP,VNQ(4),IMM,MAXQS,MAXNS
      COMMON ATRIB(10),ENQ(4),INN(4),JCELS(5,22),KRANK(4),MAXNQ(4),M
     1FE(4),MLC(4),MLE(4),NCELS(5),NQ(4),PARAM(20,4),QTIME(4),SSUMA
     2(10,5),SUMA(10,5),NAME(6),NPROJ,MON,NDAY,NYR,JCLR,JTRIB(12)
      COMMON XL,POS,STOCK,TLEAD,CPO,CCHG,ULOSE,SLOST,
     1TORD,SALE,SPOU,PCOU,R,SCL,TBR,CPR,TREV
C*****SET VALUES FOR CARD READER AND PRINTER
      NCRDR=5LINPUT
      NPRNT=6LOUTPUT
C*****READ IN VALUES FOR INITIAL CONDITIONS.
      READ(NCRDR,8) SPOU,PCOU,CPO,CCHG,ULOSE,CPR
    8 FORMAT(6F5,2)
      XL=.2
      TLEAD=5
      CCHG=CCHG/52.
   10 READ(NCRDR,8) R,SCL,TBR
      IF(SCL) 20,20,30
   30 SLOST=0.
      TORD=0.
      TREV=0.
      SALE=0.
      STOCK=31.
      POS=31.
      CALL GASP(INSET,QSET)
      GO TO 10
   20 CALL EXIT
      END
```

FIGURE 2

SUBROUTINE DMAND

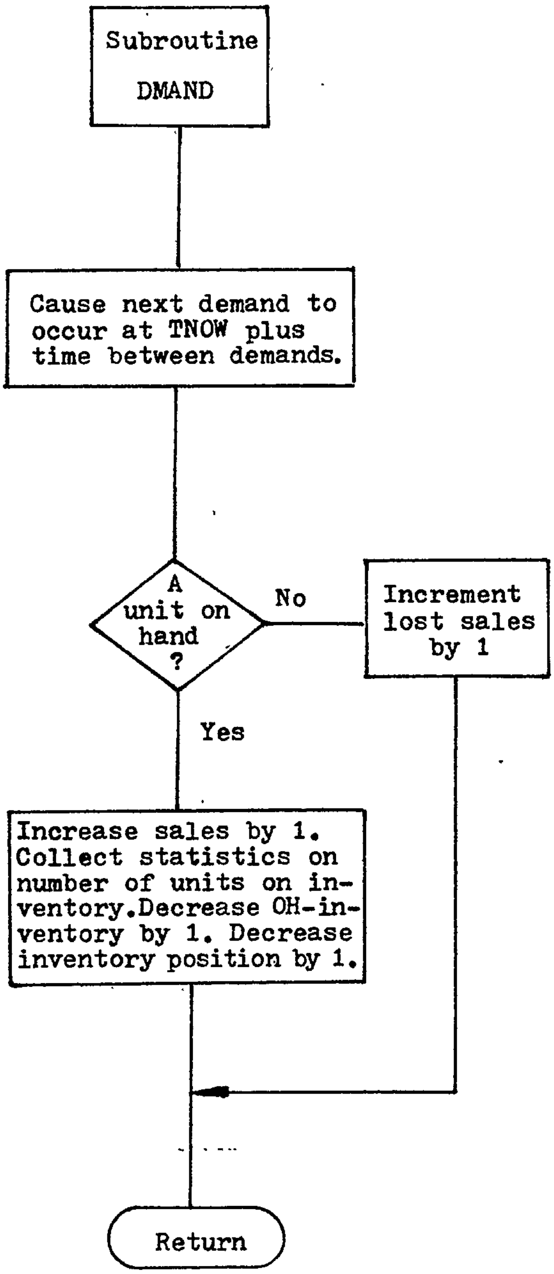

FIGURE 3

SUBROUTINE RVIEW

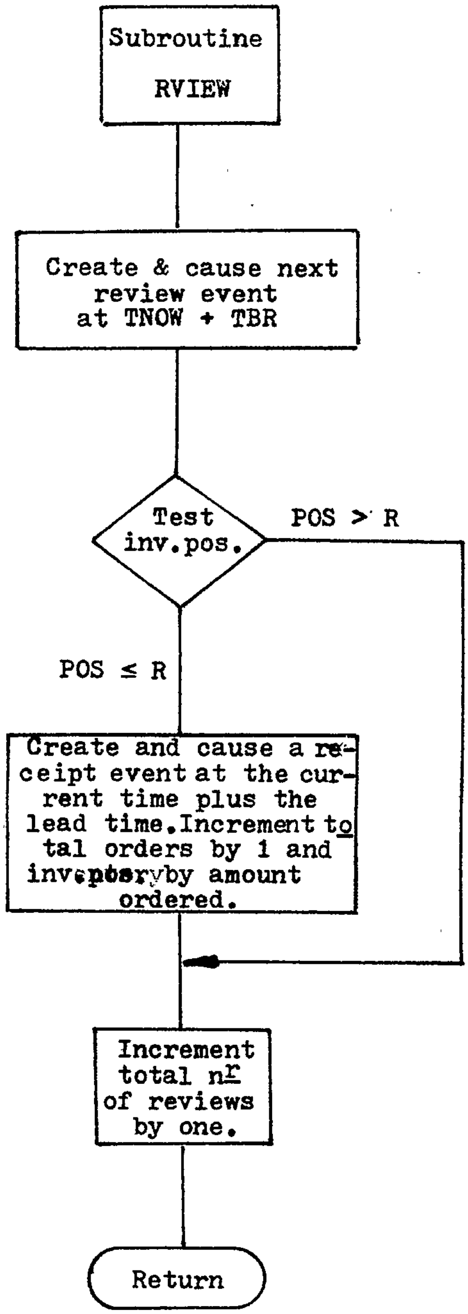

FIGURE 4

SUBROUTINE RECPT

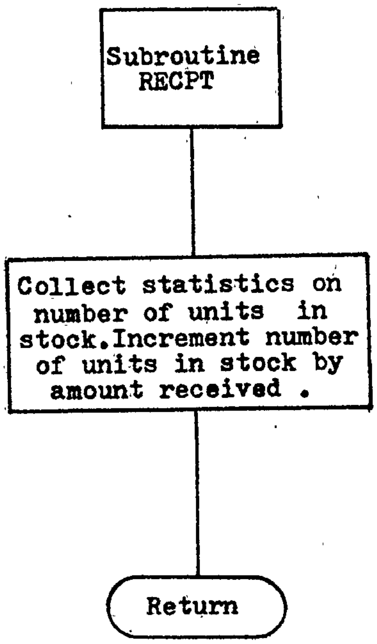

FIGURE 5

SUBROUTINE ENDSM