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An Inventory Modelling Approach to a Problem of Tourism Involving Discrete Transportation Cost

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ABSTRACT

A mathematical model in connection with tourism is investigated. Some travel agency arranges for the tourists and sends them in transport vehicles to the tour organisers in required numbers. Here the discrete transportation cost is considered explicitly. Tourists are supposed to come to the travel agency at a finite rate. The agency transports them to the tour organisers also at uniform rate. An accurate and rapid algorithm is presented to obtain the optimal cost and cycle time. Numerical examples are discussed to illustrate the solution procedure. Sensitivity analysis is also carried out.

KEY WORDS: *Hospitality cost, Transportation cost, Set-up cost.*

INTRODUCTION

Inventory modelling is an important part of Operations Research, which can be used in a variety of problems. To make it applicable in different real life situations it becomes necessary to make some modifications in the original model of Harris-Wilson[1]. This earliest formula, known as simple lot-size formula, was developed by Ford Harris in 1915. R.H. Wilson also derived this formula independently at the same time. And so it is commonly known as Harris-Wilson formula. This is a very elementary model involving many assumptions. It is not possible to apply this formula to all situations in its original form. Such assumptions match very little with real life situations. Therefore, many researchers in this field have come up with a number of relaxations of these restrictive assumptions.

An excellent review of the inventory system was given by Whitin[2] in his book. The research paper of Arrow, Harris and Marschak[3] marks the beginning of the modern analysis of inventory systems. The general system proposed by these authors was analysed by Dvoretzky, Keifer and Wolforentz[4]. Several researchers have studied a number of inventory models in many interesting and realistic situations. A description of these models can be found in Naddor[5]. Later on many other models with infinite replenishment rate and with varying rates of demand were developed by a number of researchers. Some of them are Silver and Meal[6], Donaldson[7], Datta and Pal[8], Gupta and Vrat[9], Mandal and Phaujdar[10] and Baker and Urban[11]. Goswami and Chaudhuri[12] have studied a model with shortage and linear trend in demand. Gupta and Jauhari[13] have analysed a model discrete in time.

The models solved initially did not include the transportation cost explicitly. Perhaps it might have been included in some other cost. Many later generalisations also followed the same pattern. However, the purchaser is generally obliged to pay for transportation charges along with other normal charges. Transportation and inventory costs interact and so it is desirable to have a joint transport inventory model for study.

Many researchers in this field have analysed the situation by considering the transportation cost while determining the optimal lot-size. Baumol and Vinod[14] were perhaps first to study an inventory theoretic model of freight transport, taking per unit transportation cost. Das[15] followed with a different set of assumptions. Buffa and Reynolds[16] extended the model further to include explicitly the stock-out cost and freight discount. Langley[17] considered different types of freight cost. Larson[18] considered a model for economic transport quantity with freight discount. Russell's[19] model includes unit freight cost, which decreases with increasing lot-size. Gupta[20] has studied a model which is more realistic, where a fixed cost for a transport mode is incurred irrespective of its occupancy, whether full or partial. Transportation cost happens to be a discrete function of the lot-size.

In this paper we consider the application of the inventory model to a problem of tourism involving a travel agency, which arranges for the tourists to be transported to the tour organisers. The entire batch is not transported instantly, but there is a uniform rate of shipment. Transportation mode and the transportation cost are same as considered by Gupta[20] in his model. Though the generalisation makes the problem a bit complex, yet we have developed an algorithm for finding the optimal quantities that minimize the total operating cost of the model.

ASSUMPTIONS AND NOTATIONS

The following assumptions and notations layout the structure of the model under consideration:-

ASSUMPTIONS

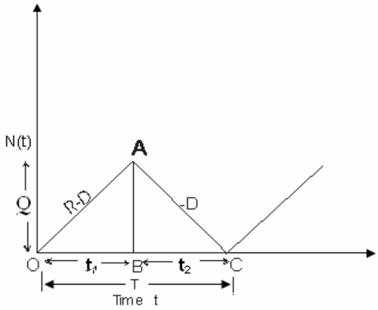
1. Demand rate is uniform and constant.
2. Tourist intake rate to the agency is finite.
3. Set-up cost is constant and does not include the transportation cost.
4. The transportation cost is constant for a vehicle load whether it is fully occupied or not and it is to be borne by the tour organisers.

NOTATIONS:

1. Demand rate : D tourists per unit time
2. Tourist intake rate : R tourists per unit time
3. Hospitality cost : C_1 per tourist per unit time
4. Transportation cost : C_2 per vehicle load
5. Set-up cost : C_3 per set-up
6. Capacity of the transport vehicle : K
7. Batch-size : q
8. Number of transport vehicles : M
9. Lowest integer greater than or equal to x : $\lceil x \rceil$

Model Development

The diagram shows the number of tourists N (t) present in the system at any time t.



Tourists start arriving at the agency at a finite rate R. At the same time they are being transported to the tour organisers with a uniform and constant rate D. After time t = t_1, when the number of tourists in the system becomes Q, intake is stopped. Then remaining tourists present in the system are transported to the tour organisers till the end of the cycle time t = T, when N (t) = 0. Then the cycle repeats itself.

EXPLANATION OF FIGURE-1

Figure-1 represents the variation of the three different costs: The hospitality cost f_1 (q) is directly proportional to the batch-size q. The transportation cost f_2 (q) decreases as the batch-size q increases till it (q) is less than or equal to MK (the total capacity of the specified number of vehicles). As soon as it crosses this capacity, there is a sudden jump in the transportation cost. This cost starts decreasing again till the batch-size becomes (M+1) K, and so on. The set-up cost f_3 (q) is inversely proportional to the batch-size q.

COST CALCULATION

Hospitality cost = $\frac{C_1 Q(t_1 + t_2)}{2}$

Transportation cost for a load of M vehicles = MC_2

Set-up cost = C_3

From basic concept of inventory, we have

$$t_1 = \frac{Q}{R-D} \quad and \quad t_2 = \frac{Q}{D}$$

Also the cycle time is

$$T = t_1 + t_2$$

$$= \frac{Q}{D\left(1-\frac{D}{R}\right)} \qquad \text{-- (1)}$$

Also batch-size q = DT

$$or \quad q\left(1-\frac{D}{R}\right) = Q \qquad \text{-- (2)}$$

The total average cost per unit time is

$$C(Q,T) = \frac{1}{T}\left[\frac{C_1 QT}{2} + MC_2 + C_3\right] \qquad \text{-- (3)}$$

By using equation (2) the total average cost per unit time is

$$C = f(q) = \frac{C_1\left(1-\frac{D}{R}\right)q}{2} + \frac{MC_2 D}{q} + \frac{C_3 D}{q} \qquad \text{------------------------------------ (4)}$$

$$= f_1(q) + f_2(q) + f_3(q)$$

For minimum value of cost C, we must have

$$\frac{dC}{dq} = 0 \quad and \quad \frac{d^2C}{dq^2} > 0$$

$$\frac{dC}{dq} = 0 \quad gives$$

$$\frac{C_1}{2}\left(1-\frac{D}{R}\right) - \frac{(MC_2 + C_3)D}{q^2} = 0$$

$$or\ q = \sqrt{\frac{2\left(MC_2 + C_3\right)D}{C_1\left(1 - \frac{D}{R}\right)}} \qquad \text{---} (5)$$

Also, at this value of q

$$\frac{d^2C}{dq^2} = \frac{2\left(MC_2 + C_3\right)D}{q^3} > 0$$

Therefore the optimal cost C* is given by the relation

$$C* = \frac{C_1}{2}\sqrt{\frac{2\left(MC_2 + C_3\right)D\left(1 - \frac{D}{R}\right)}{C_1}} + \sqrt{\frac{\left(MC_2 + C_3\right)DC_1\left(1 - \frac{D}{R}\right)}{2}}$$

$$= \sqrt{2C_1\left(MC_2 + C_3\right)D\left(1 - \frac{D}{R}\right)} \qquad \text{---} (6)$$

Optimal cycle time T* is given by the relation

$$T* = \sqrt{\frac{2\left(MC_2 + C_3\right)}{C_1D\left(1 - \frac{D}{R}\right)}}$$

For optimality of the total cost of the model, we analyse the transportation cost $\frac{MC_2D}{q}$ in relation with set-up and hospitality costs of the system. Transportation cost varies with the value of q. For optimum batch-size, we observe the following points:

1. As shown in the Figure -1, cost $\frac{MC_2D}{q}$ takes sudden jump upwards, as q becomes slightly greater than MK, then it decreases till q becomes (M+1) K, and so on.

Thus, the points of minimum transportation cost exist at q=MK, M=1, 2, 3

2. The cost $\frac{C_1\left(1 - \frac{D}{R}\right)q}{2} + \frac{C_3D}{q}$ is minimum at

$$q = q_0 = \sqrt{\frac{2C_3D}{C_1\left(1 - \frac{D}{R}\right)}}$$

As the value of q deviates from this optimum value, the cost $\frac{C_1\left(1 - \frac{D}{R}\right)q}{2} + \frac{C_3D}{q}$ continuously increases.

From the above noted points, we arrive at the following conclusion:

The average total cost C= f (q) increases for values of q less than q_{M^*-1} {=(M*-1) K} as well as for values of q greater than q_{M^*} {= M*K}, where $M^* = \lceil q_0/K \rceil$.

Thus the minimum average total cost f (q) lies either between the points q_{M^*-1} and q_{M^*} or at one of them.

The value of q for optimal cost, between q_{M^*-1} and q_{M^*} can be calculated from the relation.

$$q = \sqrt{\frac{2\left(M^* C_2 + C_3\right)D}{C_1\left(1 - \frac{D}{R}\right)}}$$

If q ≤ M*K, then calculate f (q_{M^*-1}), f (q_{M^*}) and f (q). The smallest of these three is the optimal cost for the corresponding value of q.

If q > M*K, then f (q_{M^*-1}) and f (q_{M^*}) are compared and the smaller one is the optimal cost and the corresponding value of q is also optimal batch-size. This helps in developing the following algorithm.

ALGORITHM

Step-1: Calculate the optimal batch-size q_0, when transportation cost is not included using the formula

$$q_0 = \sqrt{\frac{2C_3D}{C_1\left(1 - \frac{D}{R}\right)}}$$

Step-2: Calculate the number of vehicles M* to carry q_0, by the relation

$M^* = \lceil q_0/K \rceil$.

Step-3: Calculate

$$q = \sqrt{\frac{2\left(M^* C_2 + C_3\right)D}{C_1\left(1 - \frac{D}{R}\right)}}$$

If q ≤ M*K, go to Step - 4 and if q > M*K, go to Step-5.

Step-4: Compare f (q_{M^*-1}), f (q_{M^*}) and f (q). The least of these three values gives the optimal cost and the corresponding value of batch-size is the optimal batch-size.

Step-5: Compare f (q_{M^*-1}) and f (q_{M^*}). The lesser of the two is the optimal cost and corresponding batch-size is the optimal batch-size.

ILLUSTRATIVE EXAMPLES

Example 1.

Assume C_1 = 2 Rs, C_2= 25 Rs, C_3 = 10 Rs, D = 400 units, R = 800 units, K = 80 units.

Step-1 : Calculate q_0

$$q_0 = \sqrt{\frac{2C_3D}{C_1\left(1 - \frac{D}{R}\right)}} = \sqrt{\frac{2 \times 10 \times 400}{2 \times \left(1 - \frac{400}{800}\right)}} = 89.4427$$

Step-2 : Calculate M*

$$\begin{aligned} M^* &= \lceil q_0/K \rceil \\ &= \lceil 89.4427/80 \rceil \\ &= 2 \end{aligned}$$

Step-3 : Calculate q

$$q=\sqrt{\frac{2\left(M^{*}C_2+C_3\right)D}{C_1\left(1-\frac{D}{R}\right)}} \qquad = \sqrt{\frac{2\times\left(2\times 25+10\right)\times 400}{2\times\left(1-\frac{400}{800}\right)}}$$

$$= 219.089$$

> 160

$q > M^*K$

Step-5: Since $q > M^*K$, calculate $f(q_{M^*-1})$ and $f(q_{M^*})$, i.e., calculate f (80) and f (160).

$$f\left(q_{M^*-1}\right) = \frac{C_1\left(1-\frac{D}{R}\right)q_{M^*-1}}{2} + \frac{\left\{\left(M^{*}-1\right)C_2+C_3\right\}D}{q_{M^*-1}}$$

$$f(80) = \frac{2\times\left(1-\frac{400}{800}\right)\times 80}{2} + \frac{\left\{\left(2-1\right)\times 25+10\right\}\times 400}{80} \qquad = 215$$

$$f\left(q_{M^*}\right) = \frac{C_1\left(1-\frac{D}{R}\right)q_{M^*}}{2} + \frac{\left(M^{*}C_2+C_3\right)D}{q_{M^*}}$$

$$f(160) = \frac{2\times\left(1-\frac{400}{800}\right)\times 160}{2} + \frac{\left(2\times 25+10\right)\times 400}{160} \qquad = 230$$

Here f (80) < f (160) and so f (80) = 215 is the optimal cost and the optimal batch-size is 80.

Example 2.

Assume $C_1 = 6$ Rs, $C_2 = 25$ Rs, $C_3 = 10$ Rs, D = 400 units, R = 800 units, K = 50 units.

Step-1: Calculate q_0

$$q_0 = \sqrt{\frac{2C_3D}{C_1\left(1-\frac{D}{R}\right)}} \qquad = \sqrt{\frac{2\times 10\times 400}{6\times\left(1-\frac{400}{800}\right)}} \quad = 51.6398$$

Step-2: Calculate M*

$$M^* = \lceil q_0/K \rceil$$
$$= \lceil 51.6398/50 \rceil$$
$$= 2$$

Step-3: Calculate q

$$q=\sqrt{\frac{2\left(M^{*}C_2+C_3\right)D}{C_1\left(1-\frac{D}{R}\right)}} \qquad = \sqrt{\frac{2\times\left(2\times 25+10\right)\times 400}{6\times\left(1-\frac{400}{800}\right)}}$$

$$= 126.4911$$

> 100

$q > M^*K$

Step-5: Since $q > M^*K$, calculate $f(q_{M^*-1})$ and $f(q_{M^*})$, i.e., calculate f (50) and f (100).

$$f\left(q_{\text{M*-1}}\right) = \frac{C_1\left(1 - \frac{D}{R}\right) q_{\text{M*-1}}}{2} + \frac{\left\{\left(M^* - 1\right)C_2 + C_3\right\}D}{q_{\text{M*-1}}}$$

$$f(50) = \frac{6 \times \left(1 - \frac{400}{800}\right) \times 50}{2} + \frac{\left\{(2-1) \times 25 + 10\right\} \times 400}{50}$$

$$= 355$$

$$f\left(q_{\text{M*}}\right) = \frac{C_1\left(1 - \frac{D}{R}\right) q_{\text{M*}}}{2} + \frac{\left(M^* C_2 + C_3\right)D}{q_{\text{M*}}}$$

$$f(100) = \frac{6 \times \left(1 - \frac{400}{800}\right) \times 100}{2} + \frac{(2 \times 25 + 10) \times 400}{100}$$

$$= 390$$

Here f (50) < f (100) and so f (50) = 355 is the optimal cost and the optimal batch-size is 50.

Example 3.

Assume $C_1 = 2$ Rs, $C_2 = 3$ Rs, $C_3 = 10$ Rs, D = 275 units, R = 4000 units, K = 25 units.

Step-1 : Calculate q_0

$$q_0 = \sqrt{\frac{2C_3D}{C_1\left(1 - \frac{D}{R}\right)}} = \sqrt{\frac{2 \times 10 \times 275}{2 \times \left(1 - \frac{275}{4000}\right)}}$$

$$= 54.3417$$

Step-2: Calculate M*

$$M^* = \lceil q_0/K \rceil$$
$$= \lceil 54.3417/25 \rceil$$
$$= 3$$

Step-3 : Calculate q

$$q = \sqrt{\frac{2\left(M^* C_2 + C_3\right)D}{C_1\left(1 - \frac{D}{R}\right)}} = \sqrt{\frac{2 \times (3 \times 3 + 10) \times 275}{2 \times \left(1 - \frac{275}{4000}\right)}}$$

$$= 74.9049$$

$$< 75$$

$$q < M^*K$$

Step-4: Since q < M*K, calculate f (q), f ($q_{\text{M*-1}}$) and f ($q_{\text{M*}}$), i.e., calculate f (74.9049) , f (50) and f (75).

$$f(q) = \frac{C_1\left(1-\frac{D}{R}\right)q}{2} + \frac{\left(M^*C_2 + C_3\right)D}{q}$$

$$f(74.9049) = \frac{2\times\left(1-\frac{275}{4000}\right)\times 74.9049}{2} + \frac{\left(3\times 3+10\right)\times 275}{74.9049}$$

$$= 139.5103$$

$$f\left(q_{M^*\text{-}1}\right) = \frac{C_1\left(1-\frac{D}{R}\right)q_{M^*\text{-}1}}{2} + \frac{\left\{\left(M^*-1\right)C_2 + C_3\right\}D}{q_{M^*\text{-}1}}$$

$$f(50) = \frac{2\times\left(1-\frac{275}{4000}\right)\times 50}{2} + \frac{\left\{\left(3-1\right)\times 3+10\right\}\times 275}{50}$$

$$= 134.5625$$

$$f\left(q_{M^*}\right) = \frac{C_1\left(1-\frac{D}{R}\right)q_{M^*}}{2} + \frac{\left(M^*C_2 + C_3\right)D}{q_{M^*}}$$

$$f(75) = \frac{2\times\left(1-\frac{275}{4000}\right)\times 75}{2} + \frac{\left(3\times 3+10\right)\times 275}{75}$$

$$= 139.5104$$

Here f (50) < f (75) and f (50) < f (74.9049) so f (50) = 134.5625 is the optimal cost and the optimal batch-size is 50.

Example 4.

Assume $C_1 = 2$ Rs, $C_2 = 3$ Rs, $C_3 = 10$ Rs, D = 60 units, R = 300 units, K = 25 units.

Step-1 : Calculate q_0

$$q_0 = \sqrt{\frac{2C_3D}{C_1\left(1-\frac{D}{R}\right)}} = \sqrt{\frac{2\times 10\times 60}{2\times\left(1-\frac{60}{300}\right)}}$$

$$= 27.3861$$

Step-2: Calculate M*

$$M^* = \lceil q_0/K \rceil$$

$$= \lceil 27.3861/25 \rceil$$

$$= 2$$

Step-3: Calculate q

$$q = \sqrt{\frac{2\left(M^*C_2 + C_3\right)D}{C_1\left(1-\frac{D}{R}\right)}}$$

$$= \sqrt{\frac{2\times\left(2\times 3+10\right)\times 60}{2\times\left(1-\frac{60}{300}\right)}}$$

$= 34.6410$

< 50

$q < M^{*}K$

Step-4: Since $q < M^{*}K$, calculate f (q), f ($q_{M^{*}-1}$) and f ($q_{M^{*}}$), i.e., calculate f (34.6410) , f (25) and f (50).

$$f\left(q\right) = \frac{C_1\left(1-\frac{D}{R}\right)q}{2} + \frac{\left(M^{*}C_2 + C_3\right)D}{q}$$

$$f\left(34.6410\right) = \frac{2\times\left(1-\frac{60}{300}\right)\times 34.6410}{2} + \frac{\left(2\times 3+10\right)\times 60}{34.6410}$$

$= 55.4256$

$$f\left(q_{M^{*}-1}\right) = \frac{C_1\left(1-\frac{D}{R}\right)q_{M^{*}-1}}{2} + \frac{\left\{\left(M^{*}-1\right)C_2 + C_3\right\}D}{q_{M^{*}-1}}$$

$$f\left(25\right) = \frac{2\times\left(1-\frac{60}{300}\right)\times 25}{2} + \frac{\left\{\left(2-1\right)\times 3+10\right\}\times 60}{25}$$

$= 51.2000$

$$f\left(q_{M^{*}}\right) = \frac{C_1\left(1-\frac{D}{R}\right)q_{M^{*}}}{2} + \frac{\left(M^{*}C_2 + C_3\right)D}{q_{M^{*}}}$$

$$f\left(50\right) = \frac{2\times\left(1-\frac{60}{30}\right)\times 50}{2} + \frac{\left(2\times 3+10\right)\times 60}{50}$$

$= 59.2000$

Here f (25) < f (50) and f (25) < f (34.6410) so f (25) = 51.2000 is the optimal cost and the optimal batch-size is 25.

CONCLUSION

Transportation cost in many practical situations is fixed for finite capacity of transportation mode. When a vehicle is engaged, a fixed cost is incurred whether its capacity is fully utilized or partially utilized. The model in which one does not consider transportation cost explicitly, considers that the cost of transportation is included in set-up cost or in hospitality cost, when it is fixed or variable respectively. We have considered a tourism problem, which explicitly involves transportation cost, but the algorithm proposed is simple and saves much of the time and efforts involved in calculations. Sensitivity analysis shows variation in the optimal cost and optimal batch-size with respect to changes in different parameters of the problem. This analysis is given in the Table-1. From this Table the following observations are made: With the increase in the hospitality cost C_1, the batch-size decreases but the optimal cost increases; With the increase in the transportation cost C_2 per vehicle load, the batch-size and the optimal cost increase simultaneously.

Similarly, the increase in set-up cost C_3 also increases both the batch-size and optimal cost simultaneously. When the tourist intake rate R is increased, the optimal cost increases but the batch-size decreases. When the capacity K of the vehicle is increased, the optimal cost decreases. When the demand rate D of tourists increases, both the batch-size and the optimal cost increase simultaneously. The effect of simultaneous increase in demand rate and tourist intake rate is to enhance the batch-size as well as the optimal cost.

REFERENCES

1. F.W. Harris. (1915): What quantity to make at once? The Library of Factory Management, Vol. 5, Operations and Costs, pp. 47-52. A.W. Shaw Company, Chicago
2. T.M. Whitin. (1953): The Theory of Inventory Management. Princeton, N.J.; Princeton University Press
3. K.J. Arrow, T. Harris and J. Marschak. (1951): Optimal inventory policy. Econometrica, XIX, 252-272
    A. Dvoretzky, J. Keifer and J. Wolforentz. (1952): The inventory problem; I, Case of known distribution of demand; II, Case of unknown distribution of demand. Econometrica, XX, 187-222 and 456-466
4. E. Naddor. (1966): Inventory Systems. Wiley, New York
5. E.A. Silver and H.C. Meal. (1969): A simple modification of the EOQ for the case of varying demand rate. Prod. Invent. Mgmt. 10, 52-65 E.A. Silver and H.C. Meal. (1973): A heuristic for selecting lot-size quantities for the case of deterministic time varying demand rate and discrete opportunities for replenishment. Prod. Invent. Mgmt. 16, 64-74
6. W.A. Donaldson. (1977): Inventory replenishment policy for a linear trend in demand-an analytical solution. Opl. Res. Q. 28, 663-670
7. T.K. Datta and A.K. Pal. (1988): Order level inventory system with power demand pattern for items with variable rate of deterioration. Indian J. Pure Appl. Math. 19, 1043-1053
8. R. Gupta and P. Vrat. (1986): Inventory model for stock dependent consumption rate. Opsearch. 23, 19-24
9. B.N. Mandal and S. Phaujdar. (1989): A note on an inventory model with stock dependent consumption rate. Op search. 26, 43-46.
10. T.L. Urban. (1992): An inventory model with an inventory-level-dependent demand rate and relaxed terminal conditions. J. Opl. Res. Soc. 43, No.7, 721-724
    A. Goswami and K.S. Chaudhuri. (1991): An EOQ model for deteriorating items with shortages and a linear trend in demand. J. Opl. Res. Soc. 42, No. 12, 1105-1110
11. P.N. Gupta and Rajendra Jauhari. (1993): Optimum ordering interval for constant decay rate of inventory discrete in time. Ganita Sandesh. 7, No. 1, 12-15
12. W.J. Baumol and H.D. Vinod. (1970): An inventory theoretic model of freight transport demand. Mgmt. Sci. 16, 413-421
13. C. Das. (1974): Choice of transport service: An inventory theoretic approach. Logist. Transport. Rev. 10, 181-187
14. F.P. Buffa and J.I. Reynolds. (1977): The inventory- transport model with sensitivity analysis by indifference curves. Transport. J. 16, 83-90
15. C.J. Langley Jr. (1981): The inclusion of transportation costs in inventory models: Some considerations. J. Bus. Logst. 2,106-125
16. P.D. Larson. (1988): The economic transportation quantity. Transport J. Winter, 43-48
17. R.M. Russell. (1989): Optimal purchase and transportation cost lot-sizing for a single item. DSI. Proc. Annual Meeting, pp. 1109-1111
18. O.K. Gupta. (1992): A lot-size model with discrete transportation costs. Computers and Engng. Vol. 22. No. 4, pp. 397-402