BULGARIAN ACADEMY OF SCIENCES

CYBERNETICS AND INFORMATION TECHNOLOGIES • Volume **11**, No 1

Sofia • 2011

A Programme Implementation of Several Inventory Control Algorithms

Vladimir Monov, Tasho Tashev

Institute of Information and Communication Technologies, 1113 Sofia
E-mails: vmonov@iit.bas.bg ttashev@iit.bas.bg

Abstract: *The paper presents several inventory control algorithms developed on the basis of widespread mathematical models of inventory systems. The algorithms have been implemented as software modules in the programme environment of the MATLAB system. Their functionality and basic characteristics are described and illustrated by numerical examples.*

Keywords: *Inventory control, stock management, storehouses.*

I. Introduction

The problem of inventory control in a store system involves a variety of activities aimed at a successful management of stocks of goods which are held in the system for future use or sale. This problem arises in many areas of the business including companies in production and commercial branches such as manufacturers, wholesalers and retailers. Inventory control problems also play a central role in the modern supply chain management where the main objective is the overall control of material flows from suppliers of raw materials to final customers.

Maintaining inventories is necessary in order to meet the demand of stocks for a given period of time which may be either finite or infinite. In the literature, there are lists of recognized and well studied reasons either for, or against keeping stocks in a store system. Briefly, these reasons can be summarized as follows [1, 2, 4].

- Reasons for holding stocks.

It is economical to purchase relatively large quantities in order to get volume discounts which inevitably leads to accumulation of stocks. Also, the demand and supply can vary significantly in time and this is another motive to maintain certain levels of stored items in order to guarantee operation of the system. Fluctuations in the price and in particular, the anticipated rise in prices can as well serve as an incentive for holding stocks. It is also clear that higher inventory levels should generally be held if there is a substantial period of time (lead time) between placing an order for replenishment of the inventory and the actual delivery of stocks.

- Reasons against holding stocks.

One of the main arguments against keeping large amount of stocks is based on the costs for procurement and storage of the items. In practice, it is usually assumed that these costs are proportional to the quantity of stocks held in the system. Another strong motive for not holding inventories comes from the possibility for alternative uses of funds. It may turn out to be more economically to keep stock levels down and to invest funds in alternative purposes. Yet another reason against holding stocks follows from the fact that keeping large quantities requires more complicated management and information services, increased costs for renting storage area, security and insurance costs etc.

The above two groups of reasons essentially motivate contradicting interests which suggest that the main objective of inventory control is often to find a balance between conflicting goals [1]. However, achieving such a balance in practice is not a trivial task even in the simplest cases of small store systems. In this context, the modern inventory theory offers a variety of economical and mathematical models of inventory systems together with a number of methods and approaches aimed at achieving an optimal inventory policy. The main steps in applying a scientific inventory management are outlined in [3] as follows.

1. Formulate a mathematical model describing the behavior of the inventory system.

2. Seek an optimal inventory policy with respect to this model.

3. Use a computerized information processing system to maintain a record of the current inventory levels.

4. Using this record of current inventory levels, apply the optimal inventory policy to signal when and how much to replenish inventory.

There are great differences between the mathematical models of existing inventory systems which are mainly determined by the size, structure and complexity of these systems, the type of items which they store, the costs associated with their operation, the characteristics of demand and replenishment processes in the system. With respect to the structure and complexity, there are single- and multi-echelon systems with different levels of interactions and either independent or coordinated ordering of items [1]. Despite the complex structure, a study of the operation process usually begins with a simple mathematical model including a single stocking point in the system with a single source of replenishment [2]. Concerning the process of demand for items, the mathematical inventory models are divided into two large categories – deterministic and stochastic models. In the former case, the rate of demand for products stocked by the system is considered to be known with certainty and it can be either a constant quantity (deterministic static model) or a known function of time (deterministic dynamic model). In the latter case, the rate of demand is a random variable whose probability density function can be either constant in time (stochastic static model) or time-varying (stochastic dynamic model) [5].

Given the mathematical inventory model, one usually seeks for an inventory policy that will make profits as large as possible or costs as small as possible. By expressing the profits or costs in an appropriate optimization criterion, the optimal inventory policy is determined from the solution of an optimization problem of profit maximization or cost minimization. Various components of the profit or cost that are included in the criterion should be clearly identified together with the period of time over which the optimization is carried out.

Regardless of the physical nature of the stored goods, the application of an optimal inventory control must give answers to the following two basic questions:

- How much of a given item to order for replenishment of the inventory.
- At which moment to place an order for replenishment.

As it is pointed out in [2], every decision which is made in controlling inventories in any organization is one way or another related with the above two questions.

In this paper, we present a programme implementation of seven inventory control algorithms suitable for different and frequently used mathematical models of inventory systems. The algorithms have been developed in the course of a project supported by the National innovation fund as a part of an experimental programme system for production scheduling and inventory control in small and medium enterprises. In the next section of the paper, we briefly characterize the main parameters of the inventory models under consideration and in Section 3, we give a concise description of the algorithms. The software implementation and illustrative examples are presented in Section 4. Section 5 contains some concluding remarks.

II. Parameters of the inventory models

Several basic mathematical models of inventory systems have been used in the development of appropriate inventory control algorithms. The models are well known in the literature [1-5] and can be characterized by the following parameters: rate of demand for items, production rate of the supplier, procurement lead time, safety stock and the various costs associated with systems operation. These parameters represent input data for our inventory control algorithms and can be briefly described as follows.

II. 1. Rate of demand for items

The demand for an item is the amount of stock of this item which is withdrawn from inventory in order to meet the needs of inventory clients. We shall denote by λ the rate of demand determined as the demand per year. In most of the presented algorithms, the demand is treated as a deterministic continuous process and it is assumed that λ is a constant quantity independent of time. When multiple items are stored in the system, λ_i denotes the rate of demand for item i. One of the algorithms provides a solution to the control problem in an inventory system with stochastic demand. In this case the demand is considered to be a random variable with normal distribution and λ denotes the average demand per year. The demand during the procurement lead time is characterized by its mean value (mathematical expectation) μ and standard deviation σ.

II. 2. Production rate of the supplier

When the ordered quantity of stocks can not be supplied in the inventory system as a single lot, the order is accomplished in batches which are delivered to the inventory along with some period of time. Typically, this takes place when the supplier is a factory or production company which needs certain time to produce the ordered goods. In this case an important parameter is the production rate of the supplier denoted by θ. A necessary condition for operation of the inventory system is that the production rate of the supplier θ must be greater than the rate of demand λ.

II. 3. Procurement lead time

Practically, in any inventory system there is a period of time between the placement of an order to replenish inventory and the actual receipt of the ordered stocks. This period of time, denoted by τ, is known as procurement lead time and it can depend on the time for production and/or shipping of the ordered goods, the time to fill and send the order to the supplier, etc. In the inventory models considered here, it is assumed that the value of τ is constant and independent on the ordered quantity. The amount of a stock available in the system at the time of arrival of procurement is known as safety stock and it is denoted by *s*. In inventory systems with permitted shortages and backorders, *s* may take on negative values corresponding to the backordered demands.

II. 4. Costs associated with systems operation

There are four types of operation costs which are important in determining the optimal inventory control.

II. 4.1. Costs of ordering the units stored in the system

The costs of ordering an amount of Q units are represented by the cost function $c(Q)$ where

(1) $$c(Q) = A + CQ$$

if $Q > 0$ and $c(Q) = 0$ if $Q = 0$. In (1), C is the cost of a unit of stock which is assumed to be independent on the amount of units ordered. The value of C generally includes production costs, transportation costs, part of the receiving costs, part of the inspection costs, etc. for a unit of stock. Thus the term CQ represents costs which are proportional to the amount of the order. The parameter A in (1) represents fixed costs of an order and it may include processing costs in the purchasing and accounting departments, communication costs, labour costs, etc.

II. 4.2. Costs of holding the items in inventory (storage costs)

These costs represent all the expenses associated with the storage of items in the inventory and they may include costs of funds tied up in inventory, costs of keeping the storehouse such as light, heat and air condition, insurance and security taxes. This type of costs is estimated by a parameter denoted by I and called carrying charge [2]. The physical dimension of I is cost per unit time per monetary unit invested in inventory.

II. 4.3. Costs associated with demands occurring when the system is out of stock (shortage costs)

The costs incurred when there is a demand and the system is out of stock generally are two types – backorder costs and costs of lost sales. In the first case the unsatisfied demands are back-ordered until a replenishment of the inventory takes place and then all backorders are met before any other demands. In the second case a demand which occurs when the system is out of stock is lost, i.e., it is not met at all. We consider only inventory models with allowed backorders where the cost of a backorder has the form

(2) $$\pi(t) = \pi + \hat{\pi}\, t$$

where π is the fixed cost of a backorder, $\hat{\pi}$ is a proportionality coefficient and t is the length of time for which the backorder exists. The dimension of $\hat{\pi}$ is cost per unit of backordered stock per year. Thus each backordered unit of stock has a fixed cost and a variable cost which is linear in time.

II. 4.4. Costs of operating the data and control procedures in the inventory system

These costs may include various components associated with implementation and exploitation of a computerized information system, costs of making demand predictions, accounting costs etc. According to [2], such costs are independent on the quantity of ordered stocks and the reorder point and usually, do not affect the computation of parameters of an optimal inventory control. Thus, this type of costs are not included in the inventory models under consideration and in the optimization criteria of our algorithms.

The most important output parameters of the inventory control algorithms are the quantity of an order Q and the reorder point r. The first of this parameters determines how much units of a given item should be ordered for replenishment of the inventory while the reorder point specifies the inventory level at which the order should be placed.

III. Inventory control algorithms

The algorithms presented in this section are developed on the basis of inventory system models widely known as lot size-reorder point models and characterized by a single stocking point and a single source of supply [1, 2]. Although relatively simple, these models are well suited to many practical systems and, on the other hand, a variety of inventory control problems are encountered within this framework. The algorithms can be divided into three groups: inventory control in systems with deterministic demand and independent ordering, deterministic demand and coordinated ordering and inventory control in systems with stochastic demand.

III.1. Inventory control with deterministic demand and independent ordering

The algorithms in this group are characterized by the following main assumptions:

1) the demand is deterministic with a rate of demand that is constant and independent on time;

2) different items can be controlled independently;

3) the inventory system will continue to operate within a sufficiently long period of time and the objective of inventory control is minimization of the average annual costs in the system.

In view of the second assumption, the algorithms provide solutions of the respective inventory control problems for a single item stored in the system. This group consists of three algorithms corresponding to the following distinct inventory control problems.

III.1.1. Inventory control in a store system without stockouts

The algorithm computes optimal parameters for inventory control of a given item on the basis of the well known Economic Order Quantity model [1-3]. The model is characterized by the additional assumptions that no shortages are permitted and that the entire quantity ordered is delivered as a single package, i.e. an order is never split into separate batches. Input data of the algorithm are:

- rate of demand λ for the item;
- procurement lead time τ which is constant and independent on the quantity ordered;
- cost of a unit of stock C which is independent on the amount of units ordered;
- fixed cost of an order A;
- inventory holding costs I.

The algorithm computes optimal values of the inventory control parameters which minimize the cost function

(3) $$R = \frac{\lambda}{Q} A + IC\left(\frac{Q}{2} + s\right).$$

Output data of the algorithm are:

- optimal quantity of an order Q_{opt};
- optimal time of an operating cycle in the system T_{opt};
- optimal reorder point r_{opt};
- optimal average annual costs in the system R_{opt}.

III.1.2. Inventory control in a store system with permitted shortages and backorders

The inventory model is characterized by the assumption that it is permissible for the system to be out of stock when a demand occurs. In this case the demands when the system is out of stock are backordered and these demands are met first when an order arrives. As in the previous case, it is assumed that the entire quantity ordered is delivered as a single package, i.e. an order is never split into separate batches. Input data of the algorithm are:

- rate of demand λ for the item;
- procurement lead time τ which is constant and independent on the quantity ordered;
- cost of a unit of stock C which is independent on the amount of units ordered;
- fixed cost of an order A;
- inventory holding costs I;
- fixed cost of a backordered unit of stock π;
- variable cost of a backordered unit of stock $\hat{\pi}$.

The algorithm solves the problem of finding optimal values of the inventory control parameters which minimize the cost function

$$R = \frac{\lambda}{Q} A + IC \frac{(Q-s)^2}{2Q} + \frac{1}{Q}(\pi\lambda s + \frac{1}{2}\hat{\pi} s^2) . \tag{4}$$

If the optimization problem has an optimal solution, the algorithm yields the following output data:

- optimal quantity of an order Q_{opt} ;
- optimal time of an operating cycle in the system T_{opt};
- optimal reorder point r_{opt};
- optimal average annual costs in the system R_{opt}.

Depending on the input data, the optimization problem may have no optimal solution and in this case the algorithm terminates with an appropriate warning.

III.1.3. Inventory control in a factory warehouse with finite production rate.

The algorithm solves the problem of inventory control in a typical factory warehouse where the item is produced at the factory in batches and stored in the factory warehouse. The inventory model is characterized by the assumptions that an order is supplied to the warehouse in batches during some period of time (production time) and that no shortages are permitted in the warehouse. A necessary condition for operation of the system is that the factory production rate must be greater than the rate of demand for the item. Input data of the algorithm are:

- rate of demand λ for the item;
- procurement lead time τ which is the time between submission of an order to the factory and the receipt of the first batch of the ordered stock;
- cost of a unit of stock C which is independent on the amount of units ordered;
- fixed cost of an order A;
- inventory holding costs I;
- production rate of the factory ψ.

The algorithm computes optimal values of the inventory control parameters which minimize the cost function

(5) $$R = \frac{\lambda}{Q}A + IC\left(\frac{Q}{2}\left(1 - \frac{\lambda}{\psi}\right) + s\right).$$

Output data of the algorithm are:

- optimal quantity of an order Q_{opt};
- optimal time of an operating cycle in the system T_{opt};
- optimal reorder point r_{opt};
- optimal average annual costs in the system R_{opt}.

III.2. Inventory control with deterministic demand and coordinated ordering

The algorithms in this group are characterized by the following main assumptions:

1. Multiple items are stored in the system and the demand for each item is deterministic with a rate of demand that is constant and independent on time.
2. There are common constraints concerning all items which require coordinated ordering of stocks for the items.
3. No shortages are allowed and the entire quantity ordered for each item is supplied as a single lot, i.e., orders are not split into separate batches.
4. The inventory system will continue to operate within a sufficiently long period of time and the objective of inventory control is minimization of the sum of average annual costs for all items subject to a given constraint.

This group consists of three algorithms corresponding to three different constraints.

III.2.1. Inventory control in a store system with multiple items and a constraint on the overall storage area or volume

The algorithm finds optimal values of the order quantity and the reorder point for each item such that to minimize the sum of costs for all items subject to a given limit of the storage area or storage volume of the warehouse. Input data of the algorithm are:

- number of items *n* stored in the system;
- overall storage area/volume *f*;
-area/volume taken by a unit of stock of the *i*-th item f_i, i=1, 2, …, n;
- rate of demand for the *i*-th item λ_i, i=1, 2, …, n;
- procurement lead time for the *i*-th item τ_i, i=1, 2, …, n;
- cost of a unit of stock for the *i*-th item C_i, i=1, 2, …, n;
- fixed cost of an order for the *i*-th item A_i, i=1, 2, …, n;
- inventory holding costs for the *i*-th item I_i, i=1, 2, …, n.

The algorithm computes optimal values of the inventory control parameters for each item such that to minimize the cost function

(6) $$R = \sum_{j=1}^{n}\left(\frac{\lambda_j}{Q_j}A_j + I_j C_j \frac{Q_j}{2}\right)$$

subject to the constraint

$$\sum_{j=1}^{n} f_j Q_j = f_1 Q_1 + \ldots + f_n Q_n \le f . \tag{7}$$

Output data of the algorithm are:

- optimal quantity of an order for the i-th item Q_i^{opt}, $i = 1, 2, \ldots, n$;
- optimal time of an operating cycle for the i-th item T_i^{opt}, $i = 1, 2, \ldots, n$;
- optimal reorder point for the i-th item r_i^{opt}, $i = 1, 2, \ldots, n$;
- optimal average annual costs in the system R_{opt}.

III.2.2. Inventory control in a store system with multiple items and a constraint on the amount of money investment in inventory

The algorithm finds optimal values of the order quantity and the reorder point for each item such that to minimize a cost function in the form (6) subject to the constraint

$$\sum_{j=1}^{n} C_j Q_j = C_1 Q_1 + \ldots + C_n Q_n \le D, \tag{8}$$

where D is a given limit of the amount of money invested in inventory. Input data of the algorithm are the same as in algorithm III.2.1 with the only difference that f is formally replaced by D and the costs C_i are used in (8) instead of parameters f_i. Output data of both algorithms are the same.

III.2.3. Inventory control in a store system with multiple items and a constraint on the maximal number of orders placed per year

The algorithm finds optimal values of the order quantity and the reorder point for each item such that to minimize the sum of costs for all items subject to a given limit of the number of orders placed per year. The inventory model is characterized by the assumption that there is no fixed cost per order, i.e., $A_i = 0$, $i = 1, 2, \ldots, n$. Input data of the algorithm are:

- number of items n stored in the system;
- maximal number of orders placed per year h;
- rate of demand for the i-th item λ_i, $i = 1, 2, \ldots, n$;
- procurement lead time for the i-th item τ_i, $i = 1, 2, \ldots, n$;
- cost of a unit of stock for the i-th item C_i, $i = 1, 2, \ldots, n$;
- inventory holding costs for the i-th item I_i, $i = 1, 2, \ldots, n$.

The algorithm computes optimal values of the inventory control parameters for each item such that to minimize the cost function

$$R = \sum_{j=1}^{n} I_j C_j \frac{Q_j}{2} \tag{9}$$

subject to the constraint

$$\sum_{j=1}^{n} \frac{\lambda_j}{Q_j} \le h . \tag{10}$$

Output data of the algorithm are the same as in algorithms III.2.1 and III.2.2.

III.3. Inventory control in a store system in terms of a random demand with normal distribution

There are various probabilistic models of inventory systems with stochastic demand which mainly differ by the degree of approximation and assumptions made in developing a particular model [2, 3]. We present here a simplified algorithm for inventory control based on the usual lot size-reorder point model with the assumption that the demand is a random variable with normal distribution. In contrast to the preceding algorithms, the objective of inventory control is not optimization of a cost or profit function. Instead of this, the algorithm computes the quantity of an order and the reorder point depending on a desirable probability that a stockout will not occur in the system. Input data of the algorithm are:

- average annual demand λ;
- mean value of the demand during the procurement lead time μ;
- standard deviation of the demand during the procurement lead time σ;
- cost of a unit of stock C which is independent on the amount of units ordered;
- fixed cost of an order A;
- inventory holding costs I;
- desirable probability $F(z)$ to have no stockout in the system;
- value of the argument z corresponding to $F(z)$.

It should be noted that the probability $F(z)$ is specified by the user and the value of z corresponding to $F(z)$ can be taken from the table with values of the probability distribution function of a random variable with normal distribution. Output data of the algorithm are the order quantity Q and the reorder point r such that a stockout in the system will not occur with probability equal to $F(z)$.

IV. Programme implementation and illustrative examples

The inventory control algorithms described in the previous section have been coded in the language of the well known programme system for technical and scientific computations MATLAB. The programme implementation of algorithms in this particular development environment is motivated by the rich computational and graphical capabilities of the MATLAB system as well as by its user friendly interface allowing for an interactive and easy access to systems resources.

By using the language and desktop tools of MATLAB, each one of the inventory control algorithms III.1.1-III.1.3, III.2.1-III.2.3 and III.3 is programmed as an independent software module (m-function) with its own input and output data. The following basic principles are adopted in the development of all modules.

- Entering of the input data is carried out interactively from a standard keyboard and the obtained results are automatically displayed on the screen after the end of computations.
- Each module performs tests for correctness of the input data and a possibility for re-entering of incorrectly entered parameters is provided.
- During operation each module displays appropriate messages on the screen

concerning the status of computations for the particular inventory control problem which is being solved.

- After the end of computations, an option is provided in each module allowing the user to save the input data and the obtained results in a user file for a subsequent treatment and analysis.

In addition to the software modules implementing the inventory control algorithms, a simple interface module is developed which enables the user to make their choice among the available inventory control tasks and to start the respective software module. The opening window of this interface module is shown in Fig. 1.

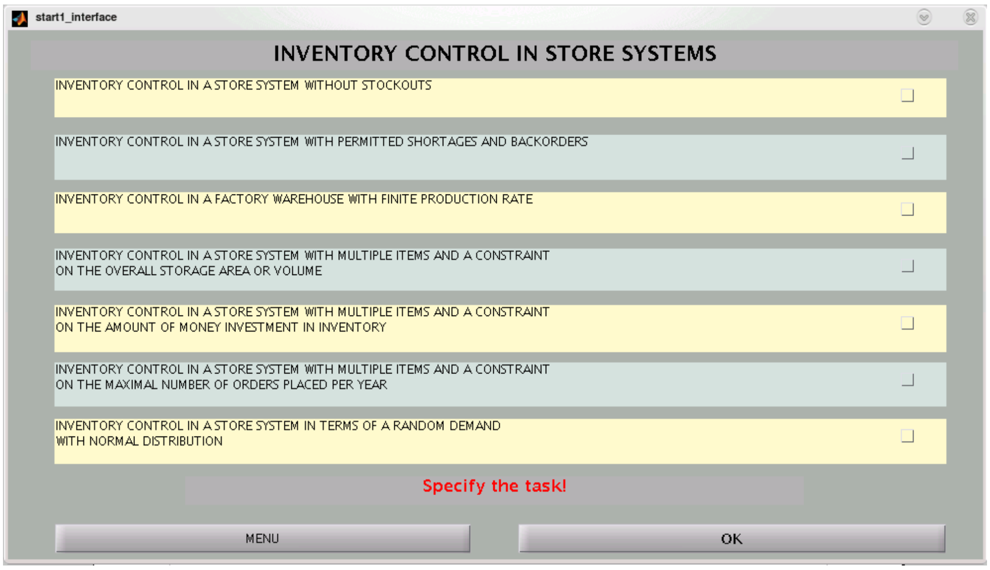

Fig. 1

From this window each software module can be run by checking the corresponding box on the right hand side of the window and then clicking on the button OK.

We shall illustrate the work of algorithms and their programme implementation by two numerical examples of particular inventory control problems.

The first example demonstrates the solution of an inventory control problem in a store system with permitted shortages and backorders. The items stored in the system are controlled independently and the numerical data for a given item are as follows. The rate of demand is $\lambda = 1000$ units of stock per year, the cost of a unit purchased is $C = 25$ lv. and the fixed cost of an order is 40 lv. The procurement lead time is two months, i.e., $\tau = 0.16$ and the inventory holding costs are characterized by a carrying charge $I = 0.2$. Shortages and backorders for this item are permitted with fixed and variable costs of a backordered unit of stock given by $\pi = 0.5$ lv. and $\hat{\pi} = 5$ lv. per year, respectively. The cost function associated with the storage of this item is given by (4) and it is necessary to find optimal values of the quantity of an order and the reorder point such that to minimize the value of (4).

In order to solve this problem the appropriate software module is selected by checking the second box in the right hand side of the window shown in Fig. 1. By clicking on the button OK, the module is run and it starts an interactive procedure of entering the input data. Fig. 2 shows the window with entered numerical values of all input parameters.

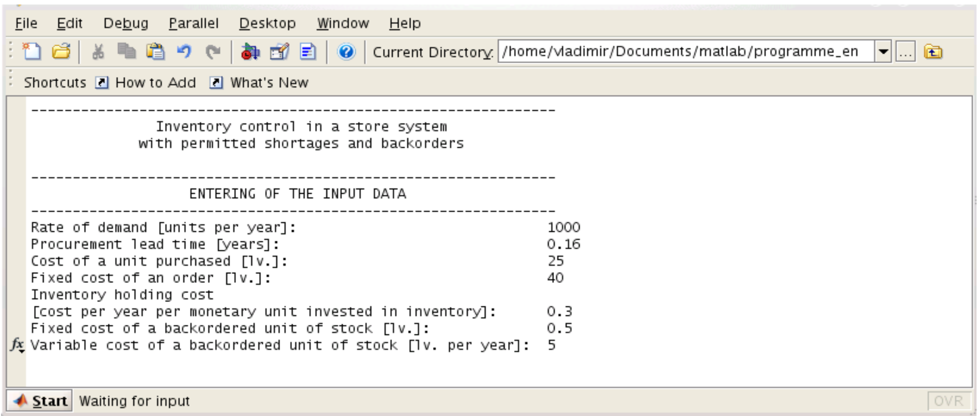

Fig. 2

With the above numerical data, the module solves the optimization problem of minimizing the cost function (4) and after completing the computations, the results are displayed on the screen as it is shown in Fig. 3.

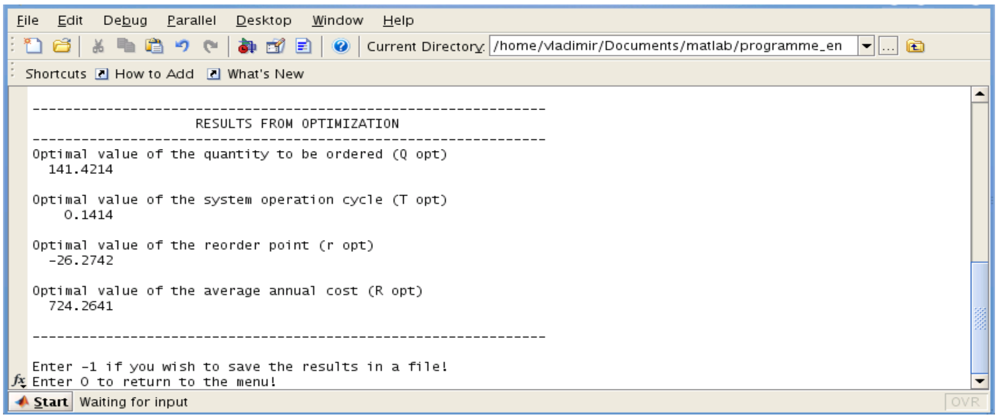

Fig. 3

The negative optimal value of the reorder point in Fig. 3 shows that, in an optimal mode of operation, a shortage of the controlled item occurs within the operation cycle of the system. Also, in integer values, the optimal quantity of an order is 141 units and an order for replenishment of the inventory is placed when the amount of backordered demands reaches 26 units.

The second example illustrates the solution of an inventory control problem in a store system with multiple items and a constraint on the overall storage area.

The number of items stored in the system is n = 3 and the overall storage area is f = 100 m^2. The areas taken by a unit of stock of each item are given by f_1 = 0.4 m^2, f_2 = 0.75 m^2 and f_3 = 0.3 m^2, respectively. The rates of demands for the three items are $\lambda_1 = 1000$, $\lambda_2 = 500$ and $\lambda_3 = 2000$ units per year and the procurement lead times are respectively given by $\tau_1 = 0.5$, $\tau_2 = 0.75$ and $\tau_3 = 0.25$. The costs of a unit purchased of each item are C_1 = 20 lv., C_2 = 100 lv., C_3 = 50 lv. and the fixed costs of an order for the respective items are A_1 = 50 lv., A_2 = 75 lv. and A_3 = 100 lv. The holding costs are the same for all items, i.e. $I_1 = I_2 = I_3 = 0.20$. It is necessary to find optimal values of the order quantity and the reorder point for each item such that to minimize the cost function (6) subject to the constraint (7).

In order to solve this problem the appropriate software module is selected by checking the forth box in the right hand side of the window shown in Fig. 1. The module is run with the button OK and after entering the input data the optimization problem is solved and the results are displayed on the screen. The input data and the optimal solutions obtained for each item are also saved in a user file which is given in an Appendix at the end of the paper.

V. Conclusion

Problems of inventory control arise in many areas of the economy and industry where the management of material flows plays a crucial role. The algorithms presented here provide solutions to some basic inventory control problems and can be used to facilitate the stock management in small and medium enterprises operating in relatively predictable conditions with respect to the demand of stored items and supply of materials. In a future perspective, a library of inventory control algorithms and software modules can be developed on the basis of more elaborate mathematical inventory models and by including new algorithms taking into account the dynamics and stochastic nature of processes in an inventory system.

R e f e r e n c e s

1. A x s a t e r, S., Inventory Control. 2nd Edition. Springer, 2006.
2. H a d l e y, G., T. M. W h i t i n, Analysis of Inventory Systems. Englewood Cliffs, New Jersey, Prentice-Hall Inc., 1963.
3. H i l l i e r, F. S., G. I. L i e b e r m a n, Introduction to Operations Research. 8th Edition., McGraw-Hill, 2004.
4. S c r a f, H. E., A Survey of Analytic Techniques in Inventory Theory. – In: Multistage Inventory Models and Techniques, E. Scraf, D. M. Gilford, M. W. Shelly (Eds). Stanford University Press 1963.
5. T a h a, H. A. Operations Research: An Introduction. 7th Edition. Prentice Hall, 2002.

A p p e n d i x

Input data and optimal parameters for inventory control in a store system with multiple items and a constraint on the overall storage area

27/04/11
15:14:22

```
---------------------------------------------------------------
  Inventory control in a store system with multiple items and
    a constraint on the overall storage area or volume
-------------------------------------------------------------
                 SYSTEM INPUT DATA
---------------------------------------------------------------
Number of items stored in the system:
   3.000000
Overall storage area/volume [sq.m./cu.m.]:
   100.000000
---------------------------------------------------------------
          INPUT DATA FOR ITEM 1/3
------------------------------------------------------------
Area/volume taken by a unit of stock [sq.m./cu.m.]:
   0.400000

Rate of demand [units per year]:
   1000.000000

Procurement lead time [years]:
   0.500000

Cost of a unit purchased [lv.]:
   20.000000

Fixed cost of an order [lv.]:
   50.000000

Inventory holding cost
[cost per year per monetary unit invested in inventory]:
   0.250000
------------------------------------------------------------
        OPTIMAL RESULTS FOR ITEM  1/3
------------------------------------------------------------
Optimal value of the quantity to be ordered (Q opt)
   75.272743

Optimal value of the system operation cycle (T opt)
   0.075273

Optimal value of the reorder point (r opt)
   48.363539
------------------------------------------------------------
          INPUT DATA FOR ITEM 2/3
------------------------------------------------------------
Area/volume taken by a unit of stock [sq.m./cu.m.]:
   0.750000

Rate of demand [units per year]:
   500.000000
```

Procurement lead time [years]:
0.750000

Cost of a unit purchased [lv.]:
100.000000

Fixed cost of an order [lv.]:
75.000000

Inventory holding cost
[cost per year per monetary unit invested in inventory]:
0.250000

OPTIMAL RESULTS FOR ITEM 2/3

Optimal value of the quantity to be ordered (Q opt)
39.236424

Optimal value of the system operation cycle (T opt)
0.078473

Optimal value of the reorder point (r opt)
21.872180

INPUT DATA FOR ITEM 3/3

Area/volume taken by a unit of stock [sq.m./cu.m.]:
0.300000

Rate of demand [units per year]:
2000.000000

Procurement lead time [years]:
0.250000

Cost of a unit purchased [lv.]:
50.000000

Fixed cost of an order [lv.]:
100.000000

Inventory holding cost
[cost per year per monetary unit invested in inventory]:
0.250000

OPTIMAL RESULTS FOR ITEM 3/3

Optimal value of the quantity to be ordered (Q opt)
134.880184

Optimal value of the system operation cycle (T opt)
0.067440

Optimal value of the reorder point (r opt)
95.359448

OPTIMAL VALUE OF THE SYSTEM AVERAGE ANNUAL COST (R opt)
4624.431461
