Synopsis

Submitted on the topic

Optimal Ordering policy for inventory system in Demand Declining Market

By

Nidhi Raykundaliya

Under the Guidance

Dr. Nita H. Shah

Department of Mathematics

Gujarat University, Ahmedabad

India
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1. INTRODUCTION:

“Inventory” for many small business owners is one of the more visible and tangible aspects of doing business. Raw materials, goods in process and finished goods all represent various forms of inventory. Each type represents money tied up until the inventory leaves the company as purchased products.

Likewise, merchandise stocks in a retail store contribute to profits only when their sale puts money into the cash register. In a literal sense, inventory refers to the stocks of anything necessary to do business. These stocks represent a large portion of the business investment and must be well managed in order to either maximize profits or minimized the cost. In fact, many small businesses cannot absorb the types of losses arising from poor inventory management. Unless inventories are controlled, they are unreliable, inefficient and costly.

Inventory is at the heart of cash flow and working capital management. As a major investment, inventory serves many purposes, such as:

• Ensuring the customer’s order shipped is complete and on time
• Providing a buffer against supply chain uncertainty and unpredictability
• Decoupling manufacturing operations
• Assuring an uninterrupted supply of seasonal products
• Taking advantage of sales promotional tools.

As inventory management is most important factor for any type of business, the three basic problems related to inventory management are as follows:

(1) What items should be kept in stock?
(2) When orders should be placed?
(3) How much should be ordered?

Type of Inventories on the basis of their use:-

1. **Decoupling Inventory** – When various manufacturing process operates successively then failure of any one can interrupt whole production. To overcome this stocking point of the inventory takes place between adjacent stages.
   - Raw material and component parts.
   - Work in process Inventory.
   - Finished goods Inventory.
   - Spare parts Inventory.
   - Consumables. e.g. Oil, stationary, cleaners.

2. **Lot size Inventory** – This inventory exists when there is more production and less immediate demand. Amount of inventory depend upon storage, space limitation, economical shipment quantity, investment, resources etc.

3. **Safety – Buffer Stock** – This stock is created to meet any uncertainties of demand. This helps to meet any unpredictable shortage or emergency.

4. **Pipeline (or Transit) Inventories** – This inventory is required for shipment of inventory items from production units to distribution centers and further to customers.

5. **Seasonal Inventory** - This inventory is created to meet demand which is caused due to seasonal variation in demand.

6. **Anticipation Inventory** – This inventory is simply maintained to make sure that no customer remains disappointed by not getting the desired item at any instant of time.
2. Basic Concepts and Terminology

Following are the basic concepts and terminology associated with an inventory system.

- **Demand:** Demand is not predefined but using past experience/ data one can defined demand pattern of the customer.
  
  Demand is defined as number of units required per unit time.
  
  Demand is either fixed or static for a period of time or it can vary (dynamic) from one period to another therefore it is divided in two parts deterministic demand or probabilistic demand. When number of unit required over a period of time is known with certainty then demand is said to be of deterministic pattern. In probabilistic demand requirements are not known in advance with certainty but can be described by some probability distribution using past data.

- **Lead Time:** The time gap between placing an order and its actual reception is called lead time. Again it can be deterministic and probabilistic. It has got two types of components as administrative lead - time from initiation of procurement action until the placing of an order, and the delivery lead time from placing of an order until the delivery of the ordered material.

- **Planning Horizon:** This is defined as time period over which a particular inventory level is maintained. This can be finite or infinite depending on nature of the demand.

- **EOQ (Economic Order Quantity):** EOQ is size of order which gives minimum total inventory cost.
• **Order Cycle:** The time and process involved from the placement of an order to the receipt of the shipment. The orders may be placed on the basis of the following two types:

1. **Continuous Review:** In this review, a fixed re-order level is set for each item and inventory level is supervised continuously. A fixed order quantity is ordered when stock fall down to a specific level. Any variation in demand is allowed by changing time between orders.

2. **Periodic Review:** In this system, the inventory levels are reviewed at equal intervals of time. Orders of variable size are placed at regular intervals of time. Variation in demand can be satisfied by changing order size.

• **Deterioration:** Deterioration is defined as decay, evaporation, obsolescence, loss of utility or marginal value of the commodity that results into the reduction of usefulness from the original condition. It may happen due to the following reasons.

• The items may have a fixed life and may be of no use if stored after the life period, e.g., medicines, photo films, bulbs, etc.

• Deterioration can take place due to unsatisfactory, poor or inadequate storage conditions, e.g., dairy products.

• Deterioration can also result from poor handling in the store, e.g., fruits and vegetables, crockery items.

Different cost related to find total cost / profit of inventory system are as follows:
• **Ordering Cost:** This cost is associated with the ordering of raw material for the production purposes/ finished goods for stocking in the inventory system. It includes advertisement cost, stationary, postage, telephone charges, telegrams, rents etc.

• **Purchase cost:** This is referred as cost price charged by supplier to retailer for one unit of item. It plays an important role when some discount on purchase price per unit to be paid on purchasing some specific units.

• **Inventory Carrying (Holding) cost:** Holding cost is money spent to keep and maintain a stock of goods in storage.

  The most obvious holding costs include rent for the required space; equipment maintenance, materials, and labor to operate the space; insurance; security; interest on money invested in the inventory and space, and other direct expenses.

  Some stored goods become obsolete before they are sold, reducing their contribution to revenue while having no effect on their holding cost. Some goods are damaged by handling, weather, or other mechanisms.

• **Shortage cost:** Shortage costs are incurred when an item is out of stock; also called stock out costs.

  Moreover, the shortage cost can be calculated (in second case) as sales plus the customer goodwill or the lost contribution margin.
• **Opportunity Cost:** The gain or profit from an alternative offer, e.g., investment decision that is forgone in favor of another. Holding cost also includes the opportunity cost of reduced responsiveness to customers’ changing requirements, slowed introduction of improved items, and the inventory's value and direct expenses, since that money could be used for other purposes.

• **Inflation:** inflation is a general and progressive increase in prices; “in inflation everything gets more valuable except money”

  It may arise due to less supply and more demand which is known as ‘demand – pull inflation’. Inflation also results due to increase in cost of some critical input, such as steel or petroleum, which then triggers off a gradual rise in overall cost which is known as ‘cost - push inflation’. When inflation increases, it results into the decline in the purchasing power of money.

• **Present Value:** The discounted value of future cash – flows is known as present value of that particular future cash – flow. For example, present value of $ 1000 expected two years from today is $ 826.45, if the discounting rate is 10 %, i.e. $1000 / (1+0.10)^2$

• **Discounting Rate:** The interest rate used in calculating the present value of future cash – flows is known as discounting rate. The interest rate is often considered to be the inflation rate. The procedure for calculating the present value of future cash – flows by applying appropriate rate of discounting rate is known as discounting. This approach is also known as Discounted – cash – flow (DCF) approach. This is based on the concept of time value of money which
differentiates between dollars offered today and one expected at some point of
time in future.

- **Declining demand:** If the demand of an industry is declining then either the
growth is negative or its economic growth is not happening broadly. There are
many reasons for a declining industry: consumer demand may be steadily
evaporating, the depletion of a natural resource may be occurring, or there may
be the emergent substitutes because of technological innovation.

3. **Literature Survey:**

   The most of the inventory models are developed under the assumption
that demand is linear i.e. the demand changes uniformly over the time. But in real
life situation the demand of the products like fashion goods, air-seats, seasonal
paddy grains decreases with time. So as extensions of that models many
researchers have studied influence of varying demand such as time dependent
demand or cycle time and retailer price sensitive demand. Silver and Meal (1969)
gave heuristic solution for time varying demand pattern. Donaldson (1977)
developed a mathematical model to compute optimal order quantity when
demand is changing linearly over finite horizon and shortages are not allowed.
However, this procedure was computationally complex. Ritchie (1980, 1984, and
1985) derived simple procedure to find exact solution. Mitra et al. (1984)
formulated a simple procedure for adjusting the economic order quantity model
for the case of increasing / decreasing linear trend in demand.
After that ordering policy for deterioration items were considered. Deterioration is defined as decay, spoilage, evaporation and loss of utility or loss of marginal value of commodity that decreases usefulness from the original one. Medicines, chemicals, food-stuff, fashion goods, vegetables and fruits are example of deteriorating commodities. Deterioration is either constant over time or weibull distributed (dependent on time). First Dave and Patel (1981) derived an inventory model for deteriorating items with time – proportional linear demand. Hollier and Mak (1983) formulated ordering policies for deteriorating items under the assumption that the demand decreases exponentially with time. Sachan (1984) extended Dave and Patel’s model by allowing shortages. The review articles by Nahmias (1982), Raafat (1991), Shah and Shah (2000) and Goyal and Giri (2001) up to date reference of the literature published on deteriorating gave inventory models.

In business transactions, an inventory represented a capital investment and it has to compete with other assets for a firm. The higher inflation has changed the financial scenario of countries like United State, India and Russia. So it is necessary to incorporate the effects of inflation on the inventory system. Buzacott(1975) studied the inventory decisions under an inflationary condition in classical economic order quantity. Misra (1979-a, 1979-b) derived a cash-discounted model using inflation and time value of money. Chandra and Bahner (1985) analyzed the effects of inflation and time value of money on optimal ordering policies. Datta and Pal (1991) developed a model to study the effects of inflation and time value of money when demand changes uniformly over finite

Supplier trade credit is a key concern for many enterprises, with clear impact on finance and accounting. As a promotional tool supplier offering trade credit to settle the account of the retailer is a common practice prevailing in the market. This helps the retailer to retain the revenue in an interest bearing account and earn some interest. The retailer pays no interest during this allowable grace period by the supplier to settle the account, but if the payment is not made at the specified time then the interest will charged. The classical Wilson’s economic ordering quantity (EOQ) model is derived under the assumption that the retailer settles the account immediately for the goods received in inventory. Brigham (1995) defined “net 30” which means a supplier allows 30-days time period to settle the total amount owed to him. The supplier does not charge any interest for the amount if it is paid within the allowable permissible delay period. The permissible tread credit reduces the retailer’s total cost, i.e. it is considered as a sales promotion tool for the supplier to attract new customers. However, the strategy of granting credit terms adds not only an additional cost to the supplier but also default risk to the supplier (Teng et al. (2005)). Goyal (1985) developed an EOQ model under the condition of permissible delay in payments. He ignored the difference between the selling price and purchase cost, and concluded that the cycle time and order quantity increases marginally under the permissible delay in payments. Dave (1985) corrected the Goyal’s model by assuming the fact that the selling price is higher
than its purchase price. Shah (1993a) and Jaggi and aggarwal (1995) formulated a mathematical model when units in inventory are subject to constant deterioration and tread credit is offered to the retailer by the supplier. Shah (1993b, 1993c) derived probabilistic inventory model under the assumption of permissible delay in payments. Hwang and Shinn (1997) formulated the optimal pricing and ordering policies for the retailer under the scenario of allowable trade credit. Liao et al. (2000) developed an inventory model under same scenario when demand is stock-dependent. Most of the above stated articles ignored the difference between unit sale price and unit purchase cost, ending to the similar conclusions as those of Goyal (1985). Jamal et al. (1997, 2000) and Sarker et al. (2000) considered the difference between the unit sale price and n unit purchase cost and established that the retailer should settle the account somewhat sooner as the unit selling price increases relative to the unit cost. Teng (2002) provided an alternative conclusion that the well-established retailer should place order of smaller size to avail of the permissible delay more frequently. The most of the above stated study is done under the assumption of the constant and known deterministic demand. Chang et al. (2003) modeled the scenario when supplier offers trade credit to the buyer if the order quantity is greater than or equal to a pre-determined quantity. Ouyang et al. (2006) allowed partial shortages and credit period to settle the dues against the purchases. Chang et al. (2006) derived optimal ordering and pricing policies for deteriorating inventory problem when partial backlogging and trade credits are offered. Chung and Huang (2003) determined optimal ordering policy under conditions of allowable shortages and
permissible delay in payments. Ouyang et al. (2009) considered partial trade credit linked to order quantity in deteriorating inventory model.

There are many research articles available on inventory system in supply chain independently and derived inventory policy which is either beneficial to vendor or buyer. But often views of different players of inventory policy are different and may not be accepted by others. Some researcher developed an integrated policy when decision is to be made which is favorable to all the players. Goyal and Gupta et al. (1989) and Sarmah (2006), discussed the importance of coordination between vendor and buyer in the supply chain management. Due to globalization, the vendor and buyer agree to do business by collaborating in order to survive. The shrinking resources, shortened product life cycle, customer’s satisfaction, quicker and effective sales and service also forced the players of the business to work jointly. Based on mutual trust, the cooperation includes the sharing of information, resources and profit which are building blocks of an effective supply chain network. The closed cooperation will not only increase the joint profit but also will enable a quicker response to customer demand. Clark and Scarf (1960) discussed serial multi echelon structured to derive the optimal policy. Banerjee (1986) developed a joint economic lot-size model for a single vendor, single buyer under the assumption that the replenishment rate of the vendor is finite. Goyel (1988) extended Banerjee’s model by relaxing the assumption of the lot-for-lot production. Ha and Kim (1997) analyzed the integrated vendor-buyer inventory system using
graphical method. Li et al. (1996) developed a lot-for-lot joint policy when demand is price sensitive.


As another promotional tool quantity discount pricing strategy is advantageous to attract the buyer to accept the joint decision. In integrated study following three scenarios are discussed where the negotiation factor is used. This is incorporated to distribute the extra profit sharing between the two players:

Scenario1: Inventory system without considering vendor- buyer integration
Scenario2: Inventory system with vendor- buyer integration
Scenario3: Inventory system with vendor- buyer integration using extra profit sharing factor.

Monahan (1984) analyzed an optimal quantity discount policy that maximizes the vendor’s profit but at the buyer’s end there was an additional cost. Lal and Staelin (1984) formulated a fixed order quantity model when discount is offered to benefit the buyer. Lee and Rosenblatt (1986) generalized Monahan’s model to study the vendor’s ordering and discount-price policy. Kim and Hwang (1988) developed an incremental discount-pricing schedule with multiple buyers and
single price break. Chakravarty and Martin (1988) developed an integrated strategy to compute the discount price and cycle time for any desired negotiation factor. Weng and Wong (1993) formulated a general all-unit quantity discount model to determine optimal sale price and cycle time. Weng (1995) developed the vendor’s quantity discount to reduce the vendor’s operating cost and boost up the buyer’s demand when end-user demand is price-sensitive. Li et al (1996) formulated a lot-for-lot discount policy with price-sensitive demand. Wee (1998) developed a lot-for-lot discount pricing policy when units in inventory are subject to deterioration at a constant rate. As cited in Yang (2004), operating an integrated supply chain required (a) reengineering systems, (b) a long term and mutual benefit partnership between upstream and downstream, (c) complete knowledge of all players, (d) an accessible instant any data in the whole system, such as point-of-sale market and inventory information, through global market, (e) producing and ordering the required items just in time for their consumption to minimize the integrated total cost, (f) a global optimization instead of local optimization, (g) matching supply and demand, and etc. Yang (2004) developed an integrated optimal strategy mode for deteriorating item with quantity discount when demand is price-sensitive.

Recession prevailing since beginning of 2009 is the result of reduction in the demand of products in the global market. Recession can also be associated with falling prices known as deflation due to lack of demand of products. Again, it could be the result of inflation or a combination of increasing prices and stagnant economic growth in the west. IT industries, financial sectors, real estate owners,
car industry, investment banking and other industries as well are confronting heavy loss due to the fall down of global economy. Federation of Indian Chambers of Commerce and Industry (FICCI) found that when industry face the global recession, inventories industries like garment, gems, textiles, chemicals and jewellery had cut production by 10 per cent to 50 per cent. Although the next two years or more are expected to lead in a difficult phase for the national economy, there are silver linings still amid the dark clouds looming on the horizon. But it is necessary to know two things before loading up. First, the financials must be in order, including a healthy balance sheet, cash, and little debt. Second, pick the right fights — in other words, craft a recession strategy. Therefore we get motivation for dealing with declining market condition and using this concept and above literature study, we develop our research.

4. Outline of the thesis

The proposed thesis has been divided into eight chapters on the basis of the structure of the different models which are as under:

Chapter – 1: Introduction

Chapter– 2: Inventory model with deteriorating items with exponential decreasing demand.

Chapter– 3: Deteriorating Inventory Models using DCF approach for Demand Declining Market under the scenario of trade credit.
Chapter 4: Deteriorating Inventory Models for Demand Declining Market using trade credit strategy.

Chapter 5: Ordering policies for Weibull distributed deterioration Under Trade Credit In Declining Market

Chapter 6: Integrated Vendor-Buyer deteriorating inventory model in declining market when the trade credit and quantity discount are offered

Chapter 7: Integrated Vendor-Buyer inventory model in declining market when the two level trade credit policy is offered.

Chapter 8: EOQ models for single vendor and multiple buyers without deterioration and with constant deterioration rate.

Chapter 1 gives an overall introduction of different inventory models proposed in following chapters in the light of different assumptions.

Chapter 2 discusses a basic inventory model with weibull distributed deterioration rate when demand is decreasing exponentially and shortages are allowed.

Chapter 3 deals with a Deteriorating Inventory Model for Demand Declining Market using different components which are related to selling price.

Section 3.1 The effects of deterioration rate, inflation and decreasing demand rate and decision variable on objective function are studied for obtaining optimal ordering policy.

Section 3.2 is an extension of above mentioned model of sec 3.1 in which approach of trade credit and backlogging of the units are used in discounted cash flow.
Chapter 4 deals with a Deteriorating Inventory Model for Demand Declining Market using the strategy of trade credit period.

Section 4.1 An EOQ model for deteriorating items under supplier credit period when demand decreasing by time.

Section 4.2 we extend our model discussed in section 4.1 using declining demand which is dependent on cycle time and retailer’s price for deteriorating items under supplier credit period.

Chapter 5 Deals with a time dependent Deteriorating Inventory Model for Demand Declining Market associated with discounted cash flow and supplier credit period.

Section 5.1 here we study effect of decision variable in the optimal solution for weibull distributed deterioration using different type of deterioration discount on selling price this model assumes that demand rate is deterministic and constant, lead time is zero and replenishment rate is infinite and instantaneous.

Section 5.2 The mathematical model is developed for wiebull deterioration of items in inventory in declining market in which demand is decreasing by time when the supplier offers his retailers a progressive credit period to settle the accounts against the dues. with the assumption that if retailer settle account after first credit period then retailer suppose to pay interest at some rate say (IC_1), if he settles account after second credit period then he is suppose to pay interest on the remaining amount at the rate of say (IC_2) (IC_2 > IC_1). Moreover it is assumed that as soon as retailer gets revenue from sale it is deposited in some interest bearing account.

Section 5.3 proposes a model is extension of derived model in section 4.2 using the assumption that declining demand is time and price sensitive.
Chapter 6 A collaborative inventory system consisting of single vendor and single buyer is developed to maximize the total profit of the supply chain. The model is developed for prevailing scenario of declining demand due to recession. However, the optimal solution for the supply chain may not be beneficial to both the players. To ensure mutual benefit, a negotiation factor is incorporated to share the profit between the players according to their contributions. To attract the buyer for the joint decision, the vendor used different strategy.

Section 6.1 model is developed for collaborative inventory system in which vendor offers different trade credit to buyers for settlement of accounts due against purchases. The units in inventory are subject to constant deterioration and replenishment rate is proportional to demand rate.

Section 6.2 This article deals with formulation of optimal ordering and pricing policy with vendor-buyer integration when units in inventory deteriorate at a constant rate. A quantity discount pricing strategy is developed to attract the buyer to accept the joint decision. A negotiation factor is incorporated to share profit between the vendor and the buyer.

Chapter 7 discussed the Co-ordinate inventory models with two-level credit policy vendor-buyer and buyer-customer in supply chain management where Customer’s demand is sensitive with respect to time and buyer’s price. The concept of a price negotiation scheme is used in declining market

Chapter 8 An integrated inventory policy for single vendor and multiple buyers is developed. The demand function is decrease with respect to time.
**Section 8.1** An inventory system is developed for single – vendor and N buyers with the assumption that the inventory system deals with a single item, the demand of an item is decreasing by time \( t \). Shortages of an item at any stage are not allowed and the replenishment rate is instantaneous. i.e. lead – time is zero.

**Section 8.2** Is an extension of above section 8.1 with the same assumption. The effects of deterioration rate and decreasing demand rate on decision variable and objective function are studied for the inventory system for single – vendor multiple buyers.

**LIST IF PAPERS PUBLISHED, ACCEPTED FOR PUBLICATION OR PRESENTED.**

- **List of papers presented.**

- **List of papers published.**


6. “Optimal pricing and ordering policy for deteriorating inventory under trade credit in demand declining market”, China review, 2009,


8. Optimal inventory policies for weibull deterioration under trade credit in declining market. JBRMR

- List of papers communicated

1. A Collaborative Vendor-Buyer deteriorating inventory system in declining market when trade credit is offered, JIMS_268

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