5-1983

Inventory Control for a Small Business

Matthew H. Skomal

INVENTORY CONTROL FOR A SMALL BUSINESS

by

Matthew H. Skomal

Bachelor of Business Administration,

University of San Diego, 1980

An Independent Study

Submitted to the Graduate Faculty of

The University of North Dakota

in partial fulfillment of the requirements

for the degree of

Master of Business Administration

The University of North Dakota Graduate Center

May
1983

APPROVAL PAGE

This independent study submitted by Matthew H. Skomal in partial fulfillment of the requirements for the Degree of Master of Business Administration from the University of North Dakota is hereby approved by the Faculty Advisor under whom the work has been done. This independent study meets the standards for appearance and conforms to the style and format requirements of the Graduate School of the University of North Dakota.

Paul J. Nowak, D.B.A.
Faculty Advisor

PERMISSION

Title INVENTORY CONTROL FOR A SMALL BUSINESS

Department School of Business and Public Administration

Degree Master of Business Administration

In presenting this independent study in partial fulfillment of the requirements for a graduate degree from the University of North Dakota, I agree that the Library of this University will make it freely available for inspection. I further agree that permission for extensive copying for scholarly purposes may be granted by the professor who supervised my work or, in his absence, by the Chairman of the Department. It is understood that any copying or publication or other use of this independent study or part thereof for financial gain shall not be allowed without my written permission. It is also understood that due recognition shall be given to me and to the University of North Dakota in any scholarly use which may be made of any material in my independent study.

Matthew H. Skomal

Matthew H. Skomal

August 30, 1983

TABLE OF CONTENTS

ABSTRACT

This paper is an examination of several inventory related problems faced by many small businesses. Specifically the problems addressed are: 1) How can the manager of a small business easily and efficiently track his inventory items in order to determine their individual inventory turnovers? 2) How should the manager judge these individual inventory turnovers? How can he judge the performance of a particular item? 3) How many of a given item should be stocked or ordered at a given time? How should safety stocks be determined?

Chapter Two addresses each of these questions giving several alternate solutions developed from the literature pertaining to the subject. These methods are then applied to a particular case in Chapter Three. The case under consideration is a small bookstore located in Minot, North Dakota.

This study concludes that the best solution to the inventory problems of the bookstore is a simple manual system. The tracking of items is accompkished via a combination of color coding and tear-tags, the judging of turnovers is based upon breakeven levels, and the ordering of merchandise is based upon a fixed time period model.

CHAPTER ONE - INTRODUCTION

Introduction

This paper is a study of the inventory control problems facing many small businessmen. The problems to be discussed are defined, and various solutions presented. The paper addresses these problems with alternative solutions applicable to many small businesses. An application of these solutions is presented in Chapter Three, where the various alternatives are evaluated in relation to the problem of one particular small business.

This paper is divided into four chapters and an appendix. Chapter One presents an overall introduction to the paper, a problem statement, a justification of the study, a discussion of the scope to the study, a listing of assumptions and limitations of the study, a presentation of the methodology used to analyze and explore the problem, and a brief summary of the chapter.

Chapter Two deals primarily with a review of the literature pertinent to inventory control for a small business. It begins with an introduction and an overview of the chapter, followed by the actual review of the literature. This section will present various alternative solutions to the problems stated in Chapter One and discuss their relative merits and faults.

Chapter Three presents the methodology and an analysis used to answer the questions addressed in this paper. The questions are evaluated by use of the case method; the situation of a single small business is discussed and alternative solutions evaluated in relation to this firm. The chapter begins with an overview of the firm's situation and inventory problems, and an overview of the chapter itself. The methodology discussed is designed to solve the firm's inventory problems. This methodology is the result of examining the various alternatives presented in Chapter Two in the light of the particular case under scrutiny. Again this chapter will be summarized.

Chapter Four deals with the implications and conclusions drawn in this study. The paper is summarized in an introduction, then the implications and conclusions presented. This section will deal with the problems of implementation, and suggest other areas needing inquiry. Finally the chapter is summarized.

The appendices will list data and background information as required for clarification. In addition it will contain the methodology developed, for the firm addressed in Chapter Three, in checklist form to facilitate the implementation of the solution by the firm's owner.

Problem Statement

This paper addresses the problem of improving the productivity of inventory for the small business. In order to achieve

this goal this study will develop a methodology to 1) aid in the control and monitoring of the firm's inventory, 2) help in the evaluation of the productivity of individual items, and 3) aid in the ordering of the correct quantities of merchandise. Specifically the questions to be answered are: 1) How can items be tracked easily and efficiently and their individual inventory turnovers be determined? 2) How do we evaluate these turnovers, what is adequate, poor, good? 3) How many of an item should be stocked or ordered, how should stocks be determined?

Justification of the Study

The proper management of inventory has become a complicated task for most small businesses. The increasing harshness of our economic climate and the large number of competitors in most fields make it essential that a firm seek to maximize the productivity of its inventory. Current conditions, the high cost of capital, competition, and rising costs combine to complicate this task for the manager.

This study provides a theoretical and practical framework for the analysis of inventory problems by the small business manager. This study is justified as an application of current theories to current situations. Furthermore this study is justified as an aid to managers of small firms in the proper control of their inventories. The study is designed to present alternative methodologies which, if currently applied will systematically improve the productivity of a

firm's inventory and give the manager greater control over his resources. Finally, this study is justified as an academic contribution toward the improvement of understanding about the inventory problems facing today's small businesses.

Scope of the Study

This study will develop a methodology to track individual inventory items, determine their annual turnovers, evaluate these turnovers, and aid in the ordering of stock while maintaining specifeid safety levels. This study is concerned with the ordering and performance evaluation of various staple items. The problem or merchandise selection is not directly confronted, nor is the problem of merchandise storage and transportation. The results of this study are intended as a guide to the manager, not as a "total" solution. The judgement of the individual manager is expected to prevail in situations where the models in use are deemed inadequate.

This study concerns itself only with the inventory problems facing small businesses. The methodology developed assumes that the firms cannot justify expensive automated systems, that in the case of these small firms such a system is not cost-effective. The inventory stocking methods evaluated are common, proven methods, not special purpose methods such as "just in time" inventory control. This study limits itself to methods which can be implemented

with hand calculations, not those requiring automated systems.

Limitations of the Study

This study assumes that the inventory problems a firm faces occur in a relatively stable environment, i.e. there are no major changes in business operations of the firm over the short run, eg. a change in the type of goods from staples to seasonal, or the acquisition of a computer for inventory control. The products of the firms examined are assumed to be staples, with relatively little seasonal variation. The models discussed may have to be slightly altered in their applications for products which are highly seasonal. In addition, consideration has been given to the concept that a simple straightforward procedure, which will not require large amounts of time or capital to implement, is desirable.

The models developed in this study have been designed for use in the short term and will need to be periodically updated as profitability, demand, turnover, or other variables change.

Some of the major decisions about inventory control will require the experience and knowledge of the management of the given firm. For example, once a product has been identified as having a low turnover management will have to decide whether to promote the product more thoroughly, change its price, or replace it.

Methodology of the Study

The alternative solutions to the problems discussed have been obtained through a review of the literature dealing with inventory control, retail merchandise control, and retail buying. The final selection of a particular methodology is based upon a case study. The various alternative solutions presented in Chapter Two are evaluated in relation to the needs of a particular firm, thus emphasizing some of the relative merits and faults of alternative solutions.

Summary of Chapter One

Chapter One presented an overview of the subject matter of this paper, the objectives of the study, and an overview of the entire paper. A problem statement was presented stating that the questions to be specifically addressed included: 1) How to track items in order to easily determine their individual turnovers? 2) How to judge these turnovers? 3) How many of a particular item should be stocked, and how should safety stocks be determined?

Chapter One also presented a justification of the study, a statement of the scope of the study, a listing of the assumptions and limitations of the study, and a review of the methodology used to solve the stated problem. Finally, a summary of the chapter was presented.

CHAPTER TWO - REVIEW OF THE LITERATURE

Introduction

A summary of the literature reviewed will be presented in the order of the subject addressed. First, literature pertaining to the question, how can the manager of a small business track items and thus determine their respective turnovers? Second, the question of how to judge these turnovers will be addressed. Finally, literature concerning the quantity of items to carry and order will be discussed. The advantages and disadvantages of each alternative will be discussed as they are presented.

Question One

How can items be tracked easily and efficiently and their individual turnovers determined? There are five alternative methods for accomplishing this objective described in this paper.

Alternative One

The first method considered is the use of color coding, the Small Business Administration recommends this method as a technique to assure good stock rotation. Basically, as each item of merchandise arrives it is tagged with a

colored price tag, each color representing the month or quarter in which the merchandise was placed upon the shelf. The advantage of this system is that at a glance merchandise which is not selling can be identified, this can flag the item in the manager's mind as requiring more attention. One disadvantage of this method is that it can become unwieldy if too many colors are in use, as in the situation where a different color is used for each month. Care must be taken to prevent the repetition of a color already in use to prevent confusion. In addition, only so much information can be signified by the use of simple colors, book numbers, stock identifications, quantity last ordered, etc. must be found from other records. Finally, this system does not identify exactly how long an item has been on the shelf, only an approximation. When a quarterly system is in use, the time an item has spent upon the shelf as indicated by its colored tag could vary up to three months.[1]

Alternative Two

Another method to consider is the use of bin tickets. This method entails determining the minimum quantities of each item required to be on hand. These quantities are the amount of the item required to prevent running out of stock from the time an order is placed to the time stock is received.

---

[1]Small Business Administration, "Retail Buying Function," Business Basics, (1953), p. 31.

In addition a reorder quantity is calculated for each item. These two quantities are written on the bin ticket which is in turn placed on the shelf area reserved for the item in question. The advantage of this system is that at a glance a manager or salesperson can determine if the item is sufficiently stocked, and calculating the amount of the item sold during a given time period is merely a matter of comparing the amount of stock on hand vs. the amount on hand at the last order. This system is primarily designed for use with small packaged items, such as screws, bolts, etc. The system assumes that the same quantity of item is to be reordered each time whenever stock reaches the reorder point. This means that a close watch must be kept over all times to determine when they have reached their reorder point. This type of perpetual inventory system may be difficult to implement in stores with large inventories of many small items, or a small labor force. Another disadvantage of this system is that care must be taken to insure that customers are not rearranging the inventory displays, thus giving the salesperson an incorrect perception of how many items are remaining in stock. This method requires that all similar items be grouped together in a specified location for quick analysis.[2]

Alternative Three

A third solution to the question of how to track the

---

[2]Dwayne Laws, Starting and Managing a Small Retail Hardware Store, (Washington, D.C.: Small Business Administration, 1965), p. 54.

performance of individual items is the use of a point of sale terminal and computer based inventory system. Such a system automatically updates inventory records with each sale, and flags a product when it reaches its reorder point, in addition the individual turnovers of each item are continuously computed. The item in question is either reordered when a minimum quantity is reached, or at some specific point in time. This system is the easiest of those mentioned to implement and use. It can be also used to keep track of other items deemed important by the manager such as checking customers credit, or forming inventory level reports.

The main disadvantage of the point of sale terminal is the high cost of acquiring such a system. Such a system can run into several thousand dollars, and may not be justified if the inventory to be tracked could be adequately controlled by manual methods. This system would be impractical for the small one man operation, but would generate a cost savings to the company large enough to benefit from labor savings.[3]

Alternative Four

Another alternative is to use some of the ideas from the POS terminal system in a manual system. The easiest way to accomplish this is to use a tear-tag system. Such a

---

[3]Donald Sanders, Computers in Business, (New York: McGraw Hill Book Company, 1979), p.379.

system is relatively simple to implement and can be quite effective. As each item arrives it is tagged with a two part tag which can be torn in half. The top half of the tag stays attached to the item and has the name of the store and the price of the item printed on it. The lower half of the tear-tag is imprinted with the item number, price, and date the item was put on the shelf. When the item is sold the second half of the tag is torn off at the register and retained. At a later time, usually once a day, the manager can determine which items have been sold on that day. Using this information and previous inventory records and invoices he can determine the individual inventory turnovers of each item. Thus if previous records indicate that an average inventory of $100 was on the shelf for the last year, and sales of the item for the year were $300, the item's inventory turnover for the year would be three times. ($300/$100) This method gives the manager the advantage of a semi-perpetual inventory system, a good method for determining inventory turnovers, and the ability to be flexible in using his time since the manager can put off counting tear-tags for a short period of time if necessary. As with the point of sale terminal system the manager can keep close track of the inventory levels of each item, all that is necessary is that he count the tags for each item sold and subtract those amounts from his initial inventory.

Alternative Five

A fifth alternative to consider is similar to the tear-tag method previously described. Instead of attaching a tag to each item, a receipt is written up at the cash register for each transaction. The receipt should contain such items as the customer's name and address, the item sold and its price, and any other information the manager feels would be worthwhile to collect. This system has the added advantage over the tear-tag system of providing the manager with a list of his customers and their home addresses, thus providing a mailing list for use in future advertising. The calculation of turnovers is done the same way as before with the tear-tags, sales are compared to previous records. The main disadvantage of this method is that it may slow service times at the cash register, and that some customers may object to giving out their names and addresses.

Summary of Alternatives Presented

The five alternatives presented will all aid the manager in tracking the sales of inventory items and determining their turnovers, yet not all five are equally efficient, nor are they mutually exclusive. It is possible to combine methods in such a way as to gain benefits not possible with one method alone.

The use of color coding has the distinct advantage of allowing the manager to spot problem items by merely glancing at his shelves. The presence of items on the shelf

with old tags indicates possible problems to the manager, without his having to refer to inventory records or other sources. The disadvantage of color coding is that the calculation of inventory turnovers is not exact, and they are in effect estimates.

The use of bin-tickets is especially useful for items such as screws, nails, or small bulk items. However, the management of shelf space becomes extremely important under this alternative and may not be applicable for packaged goods.

A point of sale terminal is excellent under most circumstances, if its high cost can be justified. Sometimes it is just more practical to keep track of inventory levels using manual methods.

The use of tear-tags or a written receipt is excellent for most small operations. The manager can calculate his current inventory levels quickly and efficiently, as well as gather other marketing information. By combining this method with the use of a color-coding system the manager can gain the advantage of being able to quickly spot possible trouble items, and after referencing his records he can determine if a problem really does exist. After determining the individual inventory turnovers of his stock the manager must determine whether or not they are satisfactory, this is the next problem to be discussed.

Question Two

How are the individual inventory turnovers to be judged?

The most practical method of judging the individual turnover of an item is to compare its turnover to the turnover of similar items. The Small Business Administration advocates comparing the turnover of questionable items to those of similar items which are known to be profitable. This establishes a goal to strive for, inventory levels can be increased or reduced to meet this goal.[4] A better method is to calculate the average gross profit for a given class of items, eg. all paperback books in a given cost range. This average gross profit should then be compared to the average holding and carrying costs per book. Where gross profit is determined to be equal to the costs of holding and ordering is the breakeven point in terms of turnover for the average item. Thus once this figure is known it can be used as a rule of thumb to indicate to the manager when an item is performing questionably. This second method has the advantage of giving a set cutoff point to the manager, rather than a goal to be striven for. For example: if the average gross profit per item is $1.00, the average holding cost per item per month is .20, and the average ordering cost has been .30, the equation to determine breakeven in terms of months is: 1.00 = .30 + .20x. In this example x = 3.5.

---

[4]Small Business Administration, "Retail Merchandise Management," Business Basics, (1953). p.29.

Thus this set of items must turnover its entire inventory at least once every 3.5 months, or 3.2 times per year just to breakeven. This turnover would become the minimum acceptable inventory turnover for this class of items. This leaves the final question to be considered, how many of a given item should the manager carry or order at one time?

Question Three

How many items should be carried at one time? How many of a particular item should be ordered? What is an adequate safety stock? These questions are all related to one another, and will be examined together.

Alternative One

One way to answer these questions was presented in the Small Business Administration self-instructional booklets, Retail Merchandise Management - 1953, and The Buying Function - 1953. These publications advocate determining inventory levels based on targeting a specific gross profit per sq. ft. of selling space. First, the gross profit per sq. ft. of selling space. First, the gross profit per sq. ft. of selling space is calculated for several of the items considered most profitable and some of the items considered least profitable. This establishes a range of gross profit/ sq. ft. figures and allows the manager to select a target figure. At this point the question is raised, what is the minimum acceptable gross profit for a given item? This is

answered by calculating the total expenses of the firm per square foot and subtracting this figure from gross profit/ sq. ft. This figure calculated is the net profit per sq. ft. Each item of normal merchandise should have a positive net profit/sq. ft. Thus the minimum gross profit/sq. ft. is large enough to yield a positive net profit/sq. ft. and the target gross profit/sq. ft. is selected from a range of figures of profitable items. A distinction between normal merchandise and "loss leaders" must be drawn at this point. Some items in every retail inventory are carried because the customer expects to find them at the establishement. Often these items yield no profit at all, but must be carried anyway to maintain customer traffic. These "loss leaders" need not conform to the requirement that they have a positive net profit/sq. ft.[5]

Items which have unsatisfactory gross profit/sq. ft. figures must be evaluated and appropriate action taken. Basically the retailer has three alternatives 1) he can promote the item more efficiently, 2) he can reduce the amount of inventory carried of the item, thus reducing the square footage occupied by the item, or 3) he can replace the item with a more profitable one.[6]

Calculating the gross profit/sq. ft. for items which are small with proportionately higher costs than the majority of the merchandise will not be sufficient to

---

[5]Ibid., p.13.

[6]Ibid.

to determine inventory levels. A good example of this type of merchandise is jewelry. The total amount of space allocated for jewelry as a group can be determined by using the gross profit/sq. ft., but the appropriate amount of each item carried is better determined by calculating the gross profit per investment in average inventory. This profit/investment must be closely watched to bring it as close as possible that of other merchandise. This is done by calculating the profit/investment of several normal items of merchandise, i.e. some high profit and some average profit items. This establishes a range from which the target profit/investment is selcted. The minimum required profit/investment is calculated by subtracting the expenses/ investment from gross profit/investment to obtain net profit/investment. It is important to note that the investment figure used in these calculations is the average investment in inventory. The required net profit/investment must be equal to the opportunity costs of the investment, or the amount the retailer would have to pay in interest on a loan for this amount.[7]

These methods discussed cover the questions of how much space should be allocated to a given item, and as a result the relative amounts of inventory for each item carried at one time. This system answers tht question of how many of an item should be ordered at one time by using the open-to-buy method.

---

[7]Ibid., p.23.

The open-to-buy method determines the appropriate amount of an item to order by calculating the amount of an item likely to be sold during the review period and during the lead time and ordering an appropriate amount based on safety stock requirements and current inventory.[8]

X - The expected number of unit sales during the inventory review period.
+Y - The expected unit sales during lead time, the time from the placing of an order to the delivery of the item.
-Z - Units already on order, or from previous backorders.
-S - Current inventory above safety stock, safety stock defined as the amount kept in stock for emergencies such as delays.

Open-To-Buy Quantity - This is the amount of the item which should be ordered.

These methods have several advantages, 1) they present a systematic framework for improving the overall profitability of an inventory. Second, they determine an appropriate amount of shelf space for each item. These methods are easily applied and implemented, and finally they give a basis for comparison between items.

The major disadvantage of this methodology is that the determination of target gross profit/sq. ft., gross profit/investment, and adequate safety stocks are somewhat subjective. The establishing of a relevant range and subsequent choosing of a target will likely yield satisfactory results, but not necessarily optimum results. In addition the determination of order quantities will vary according to the subjective decisions.

---

[8]Small Business Administration, "Retail Buying Function," p. 15.

A second methodology that can be used to answer the question of how many items should be carried, ordered, or maintained as safety stock, involves the use of economic order quantities, (EOQ's).

Alternative Two

The EOQ is the number of orders or order quantity that will result in the lowest total cost of ordering and holding a given item. Ordering costs include the cost of placing an order, shipping and handling, salaries of personnel involved, etc. Holding costs include the cost of capital tied up in inventory, storage costs, insurance, depreciation, obsolesence, etc. The quantity that balances these costs has the minimum total cost of acquisition and holding. See figure 1.

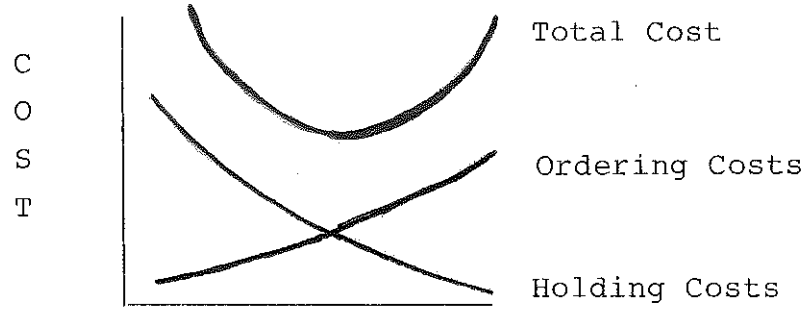

Figure 1

The algebraic formula for the EOQ is: $EOQ_{opt} = \sqrt{\frac{2DS}{H}}$, D= annual demand, S= ordering costs, and H= holding costs. This model assumes that 1) demand for the product is uniform and constant through the period, 2) lead time is constant, 3) price per unit is constant, 4) inventory holding costs are based on average inventory levels, 5) ordering and

setup costs are constant, and 6) all demands for the product will be satisfied (no backorders).[9]

Most of these assumptions can be approximated, by most small retail businesses, except for the assumption of constant demand. Thus in order to compensate for this uncertainty a set amount of safety stock must be carried. When using this model a new order of the economic order quantity is placed when stock levels reach the reorder point. This reorder point is: $R = \bar{d}L + z\sigma_L$, where $\bar{d}$ = average daily demand, L = lead time in days, z = number of standard deviations for a specified confidence level, and σ_L = standard deviation of usage during lead time. Thus the only time there is a risk of running out of stock is during the lead time.

In order to find the given amount of safety stock ($z\sigma_L$) for a specified item it is necessary to state the desired service level, that is the level of demand that is to be satisfied out of stock on hand. In addition it is necessary to calculate the standard deviation during lead time, σ_L, and the EOQ.

Thus if the manager of a store has a policy of wanting to fill the customer's demand from products off the shelf 95% of the time, his specified level of confidence is 95%. From this prior calculations concerning the item in question he has determined that its demand has a standard deviation

---

[9] Jerome H. Fuchs, Computerized Inventory Control Systems, (Englewood Cliffs, New Jersey: Prentice-Hall, Inc. 1978), p. 39.

during lead time of 10, and an economic order quantity of 100.

First, he has to calculate the expected number of units short from a normalized table where the mean is equal to 0, and the standard deviation is equal to one. In order to calculate this value of E(z) he puts the appropriate values into the equation:

$$E(9) = \frac{(1-P)Q}{\sigma_L}$$

- E(z) - expected number of units short from a normalized table.
- (1-P) - unsatisfied demand. P-confidence level.
- Q - Economic Order Quantity
- σ_L - standard deviation of demand during lead time.

For our example:

$$E(z) = \frac{(1-.95)\ (100)}{10} = .5$$

From table 1 in the appendix at E(z) = .5, $z \cong -.20$.

Second, the manager must calculate the reorder point. If the average daily demand is 10 units, a lead time is seven days, he can calculate the reorder point using the equation:

$$R=\bar{d}L + z\sigma_L$$

- $\bar{d}$ - average daily demand
- L - lead time (time between ordering and delivery).
- $z\sigma_L$ - safety stock, value z from normalized table.

For our example:

Reorder point = 10(7) + (-.2)(10) = 68. Thus when stock gets down to 68 units, the manager should order 100 additional units. In addition he has the assurance that

95% of the time when a customer requires this product he will have it on hand.[10]

There are several advantages to using this inventory system, first the optimum number of units to carry, order, and maintain in safety stock are calculated. In addition the calculation of safety stock involves set confidence limits, rather than just a subjective quantity.

The major disadvantage of this system is that each item must be ordered when it reaches its reorder point. In terms of a retail store this would mean that if one or two items reached their reorder points, they would have to be ordered at that time. Depending on how many items happened to reach their reorder point at the same time ordering costs would fluctuate greatly. Thus under a system like this ordering costs are likely to be considerably higher than in a system where orders for all items are made at specific intervals. In addition the calculation of ordering costs to be used in the EOQ equation, could only be an approximation and thus lessen the savings and value of the EOQ model. Note: the EOQ model assumes constant ordering costs, this would not hold true for a retail store using this method.

Alternative Three

A third method of solving the questions relating to the amount of inventory carried, the amount ordered, and the

---

[10]Richard B. Chase and Nicholas J. Aquilano, Production and Operations Managment, (Homewood, IL: Richard D. Irwin, Inc. 1981). pp. 476-482.

amount of safety stock required is the use of a fixed time period model.

Fixed time period models generate order quantities that vary from order to order depending on changing usage rates. These models are frequently used by vendors who make periodic calls upon their customers at set intervals, other firms use these models because of they facilitate planning, eg. managers can plan ahead exactly when they are going to have to order.[11]

The fixed time period models are similar to the open-to- buy system, the quantity ordered is a function of the demand over the review cycle (T), the demand over the lead time (L), current inventory on hand plus on order (I), and safety stock ($z\sigma_{T+L}$). Since only a periodic count of the merchandise is made safety stocks must take into consideration not only the lead time for a particular item, but the time between review periods as well. It is possible that the day after a shipment arrives it is sold out because of some spike in demand for the item, eg. a lectureer comes to the local university for a lecture and recommends a particular book, or a teacher requires it as a text for a class. The fact that stocks have been depleted may not be discovered until the next review period, therefore when safety stocks are calculated the review period as well as the lead time is considered.

---

[11] Ibid. p. 482-485.

The first step necessary to use the fixed time period model is to determine the average demand for a period, day or week, etc. This is represented by the symbol $\bar{d}$. In addition the standard deviation for this demand must be calculated, σ_d. For example the demand for a given item is 1.25/week, and σ_d is 1.125.

Second the standard deviation of the demand must be converted into the standard deviation of the review period plus lead time. Since each week's σ_d is independent the σ_{T+L} is equal to the square root of the sum of the variances for each week. Thus the equation:

$$\sigma_{T+L} = \sqrt{\qquad \sigma_{di}^2}$$

In our example since the review period is 4 weeks, and the lead time 2 weeks, this equation would be written as:

$$\sigma_{T+L} = \sqrt{(4+2)(1.125)^2} = 2.76$$

Step three in this procedure is to calculate the expected number of units short from a normalized table. This is similar to the way safety stocks were calculated for the EOQ models.

$$E(z) = \frac{D_t(1-P)}{\sigma_{T+L}}$$

D_t - is the demand during the review Period.
P - is the specified service level, for this example we want to be 95% sure demand is satisfied from stock on hand.

Thus $E(z) = \frac{5(1-.95)}{2.76} = .0906$, the comparable z value for

this E(z) is found to be approximately .96 by interpolation from Table 1 in the appendix.

Step four is to determine the quantity to order. The equation for this calculation is:

$Q = \bar{d}(T+L) + z\sigma_{T+L} - I$ I - current inventory, and stock on order, for our example I = 3.

$Q = 1.25\ (4+2) + .96(2.76) - 3$ = approx. seven units

Thus the quantity to be ordered of this unit is seven for this month. This gives a 95% probability that demand will be satisfied from inventory on hand. Subsequent months are much simpler, since the only variable likely to change for a staple item is I - inventory on hand. Thus the manager need only count the amount of merchandise on his shelf, plug it into his predetermined function and calculate his order quantity.

This method has many advantages 1) it systematically calculates the amount of merchandise to be carried based on demand, 2) safety stocks are calculated upon a stated service level, rather than subjectively, 3) merchandise need only be counted at the end of the review period, the inventory control system does not have to be perpetual, and 4) once the system is implemented ordering stock becomes a simple task requiring little time.

The main disadvantage to this method is that higher safety stocks for individual items are required than in a perpetual inventory system. However, the fact that ordering of similar merchandise is one at one time reduces ordering costs, and many allow the taking of quantity discounts.

Summary of Alternative Presented

This paper presented three alternative methods of answering the questions, how much of an item should be carried or ordered at a particular time, and how much safety stock is enough? The first alternative discussed was the open-to-buy method. This method determined inventory levels based upon net profit per square foot and expected sales. The main weakness of this method was its subjectivity, it does not systematically determine safety stock levels. The second alternative discussed determined inventory levels based upon calculated economic order quantities, and a specified service level. This method is extremely effective and accurate, orders are placed whenever inventories drop to specified reorder points. Thus a perpetual inventory system is required. The final alternative presented was a fixed time period model. Under this system orders are placed at fixed time periods based upon current stock levels, specified service levels, and calculated safety stocks. This method only requires the calculation of stock levels at specified time intervals, thus a semi-perpetual inventory system is sufficient. Of the three methods presented the fixed time period model has the most appeal for a manual system, allowing the manager to plan his ordering activities for specified times.

Summary of Chapter Two

A review of the literature pertaining to several questions

was presented in Chapter Two. The questions addressed were 1) how can the manager of a small business easily track his inventory to determine the relative turnovers of each item, 2) how should he judge the relative values of these turnovers, and 3) how many of each given item should be carried, ordered, and retained as safety stock.

In response to the question of how could the inventory of a business be tracked five methods were considered, and their relative strengths and weaknesses explained. These five methods were 1) color coding, 2) bin tickets, 3) point of sale terminals, 4) tear-tags, and 5) a written receipt.

The next question considered was how are the individual turnovers of items to be judged. Two methods were discussed, 1) comparing questionable turnovers to the turnovers of known profitable items, and 2) comparing individual turnovers to the turnover required to balance profit with holding and carrying costs. Thus finding a breakeven point in terms of inventory turnover.

The third question examined involved determining the proper amounts of stock to carry, order, and retain as safety stock. Three methods were discussed, 1) determining quantities based on gross profit/sq.ft. and gross profit/ investment, and determining order quantities through the open to buy method. This second method discussed was an inventory system based on using EOQ models and determining safety stock according to stated service levels. The

final method discussed was the fixed time period model, where safety stocks are calcualted based on stated service levles, and orders based on a function of demand and required safety stocks.

CHAPTER THREE - METHODOLOGY AND ANALYSIS

Introduction

Recently the owner of a small bookstore in Minot, North Dakota asked the University of North Dakota, via the Small Business Administration, to assist him in solving some problems he has encountered in running his bookstore. It soon became apparent that many of this firm's problems were related to a lack of inventory control. The firm's profits has been unsatisfactory, frequent stockouts of popular items occurred, many items had slow turnovers, and sales were lost because he was unable to carry items the customers wanted. The alternatives presented as a solution to problems discussed will be evaluated in terms of this firm's situation.

Currently the firm's sales are approximately $36,000/yr. and average inventory is about $15,000, this gives the firm a yearly inventory turnover of approximately 2.4. According to Dun and Bradstreet a bookstore of this size should have an inventory between 2.6 and 5.5. with an average of 2.8.[12] This indicated that this firm's inventory is indeed less productive than it should be, and that a large portion

---

[12] Dun and Bradstreet's 1980 Key Industrial Ratios, 1980 ed. "SIC 5942."

of its inventory may not be producing.

Chapter Three presents the methodology and analysis used to answer the questions raised in this paper as they pertain to a small bookstore in Minot, North Dakota. The chapter develops a methodology to solve the bookstore's inventory related problems. The methodology used is a synthesis of the methods discussed in Chapter Two. The first question addressed is how can the individual items in the store's inventory be tracked, and their individual inventory turnovers determined? Second, the problem of judging these inventory turnovers is confronted. Finally, a method is developed to help the manager determine how many of a particular item should be carried and how many to order at any one time.

Methodology and Analysis

How can individual items of inventory be easily tracked in order to facilitate the gathering of data for the calculation of individual inventory turnovers and other purposes?

In Chapter Two five alternatives were presented and discussed, 1) color coding, 2) bin tickets, 3) point of sale terminals, 4) tear-tags, and 5) written receipts. In this case it is recommended that the bookstore use a combination of two of these methods, color coding and tear-tags. In practice the tear-tags used should be colored, each color representing the quarter in which the item was placed on the shelf. In addition the tear-tag should

contain the firm's logo and item price on the permanently affixed half, and the item number and date placed on sale on the other. Thus when the customer buys the item the cashier merely removes the lower portion of the tag and the firm has a record of the item sold, the day it was placed on the shelf, and the day it was sold. By using the color code system the manager of the firm can walk down the aisles and spot possible trouble items by the color of their tear-tags. After having his attention flagged, the manager can investigate to determine whether or not there is a problem of poor item turnover, stock rotation, or merchandising. Colors should be rotated over a two year period to prevent the confusion of new stock for old.

The use of this method can be easily illustrated. When a shipment of books is received and placed up for sale at the bookstore, each book is tagged with the appropriately colored tag for the quarter, and all the other information as previously noted imprinted upon it. As the books are sold the cashier will remove the lower portion of the tag, annotate the current date and save the tickets. Each morning the manager can review the items sold on the previous day, by comparing the items sold with those he has received he can determine his current inventory levels, and by keeping track of how many of each item he sells he can determine the average demand for each item and its individual inventory turnover. He can use this information to forecast future demand for each item, judge each item's performance

and as an aid in future ordering. In addition, the manager can tell by a quick examination of the tear-tag colors which books are not selling well. This flags the item as requiring further attention to determine the cause of the poor turnover, eg. marketing, location, price, etc.

This method has several strong advantages, 1) it is a relatively low cost alternative compared to such automated systems such as point of sale terminals 2) it provides a means of semi-continuous monitoring of inventory levels, and 3) quick and esay identification of possible trouble items. The method allows the manager to easily determine the demand for individual items and their turnovers. For example, when the records indicate a particular book has had 10 copies sold in the last three months, the manager can estimate that sales will continue at approximately the same level for the rest of the year, and that its individual inventory turnover will be 40 times for the year.

The main disadvantages of this method are that it does not automatically update inventory records as a point of sale terminal would, nor does it provide a mailing list for future marketing efforts as the written receipts method would. However, this system is considerably cheaper than the POS terminal, and a perpetual inventory system is not necessary for this type of business activity anyway. In addition waiting time at the cash register is reduced by not using written receipts, if a mailing list is still desired the manager can acquire names and addresses off

the checks he receives for purchases.

Question Two

How should the inventory turnovers of each item be judged?

Two methods of judging inventory turnovers were presented in Chapter Two. The first method advocated comparing the individual item turnover in question to the turnovers of items known to be profitable. This method established a goal to be striven for, based upon the judgement of the manager. The second method presented established a clear cutoff point for each class of items based upon the turnover point where the firm breaks even. This second method has the most to offer the bookstore under consideration. In order to implement this alternative the manager must determine the average gross profit per book for a stated class. For example the majority of paperbacks carried by the bookstore cost around $1.50 and sell for around $2.50, thus the average gross profit on these paperbacks has been estimated at 35¼¢ and the average holding cost per book per month is approximately 15¼¢. (See Table 2 in the appendix for these calculations.) These holding costs include the opportunity costs of the capital invested in inventory as well as explicit costs. Using this data it is possible to figure the effect of holding and ordering costs on gross profit. The breakeven point in terms of months is equal to: Gross Profit=Ordering Costs + Holding Costs/Month (N)

N= number of months

For the bookstore this formula is $1 = .3525 + .1525(N). N = 4.24 months. Thus if a book of this class remains upon the shelf for more than 4.24 months or 49 weeks the store will lose money. This means that the individual books of the store must maintain an inventory turnover of 2.8 times per year or else fail to yield a profit. This turnover of 2.8/year becomes the cutoff point when judging the performance of individual items of this type.

The advantage of this method over the comparison method is that instead of comparing individual item turnovers to a nebulous target value, we are comparing them to a cutoff value based upon a breakeven value for items of its class. In addition, the calculation of ordering and holding costs for the various classes of items the store carries gives managment an appreciation for the need of a good working inventory and an idea where the money he spends is going. One point should be made about this model, the inclusion of opportunity costs in the model makes the net profit calculated a net economic profit rather than an accounting profit. Thus the profit of 49½¢ which would be received if a book sold within the first month is actually 49½¢ above the expected profit for an investment of this risk level.

Question Three

How many items should be carried or ordered at one time? How should safety stocks be determined? These questions are inter-related and will be examined together.

In Chapter Two three methods of looking at this problem were discussed, 1) allocating space based upon gross profit/square foot and gross profit/investment, and determining order quantities based on the open-to-buy method, 2) using economic order quantity (EOQ) models, and 3) using fixed time period models. The needs of the bookstore are best met by using the fixed time period model, this allows the manager to maintain the relatively simple semi-perpetual inventory system and do his ordering at set intervals. After the initial set up of the system and the initial calculations ordering becomes a simple task which can be accomplished in a relatively short time.

The first step in implementing this model is to calcualte the expected demand for each item and its standard deviation from this demand. This information should be easily gleaned from the records the firm keeps on the sales of individual items. On staple items such as books a simple moving average is often used as a sales forecast. For example the forecasted demand for a particular title is 1.25/week, with a standard deviation of 1.125. This is the average demand for the last four months expressed in terms of weeks, and because of the nature of the item it will be used as the sales forecast for the next month. The calculations and data used to obtain this average and standard deviation are shown in Table 3 of the appendix.

This forecast will be designated by the symbol $\bar{d}$ = 1.25/week. The standard deviation will be designated σ_d= 1.125.

The second step in using this model is to calculate the standard deviation during the time between inventory reviews and the lead time. Since each period's standard deviation is independent the standard deviation over the review period and lead time is equal to the square root of the sum of the variances for each period. For our example the review period is once a month or four week, and the lead time from order placement to order receipt is two weeks. Thus, T=4 weeks (review period) and L=2 weeks. The standard deviation for the period T+L is:

$$\sigma_{T+L} = \sqrt{\sigma_{di}^2} \quad \text{or} \quad \sigma_{T+L} = \sqrt{(4+2)\ (1.125)^2} = \underline{2.76}$$

Step three is to use this calculated value of σ_{T+L} to determine expected number of units short from a normalized table, where the mean is equal to zero, and the σ equal to 1. This expected number short is based on a specified service level, thus if the management of the firm has stated that he wants to be 95% sure that demand for this title will be satisified from stock on hand, the stated service level P is equal to .95. The equation for calculating this expected number of units short is:

$$E(z) = \frac{D_t(1-P)}{\sigma_{T+L}}$$

where:

D_t - is the total demand during the review during the review period, in our example this is 1.25/week x 4 weeks = 5.

P - the specified service level, .95.

σ_{T+L} - the standard deviation of demand during the review period plus lead time.

$$E(z) = \frac{5\ (1-.95)}{2.76} = \underline{.0906}$$

The fourth step is to determine the number of standard deviations (z) for the specified confidence level. This is done by using the E(z) value calculated above and referring to a normalized table such as the one in Table 1 of the appendix. Looking down the E(z) and -E(z) columns we find the value closest to .0906, and interpolate the difference. From this table we determine that z is approximately .96.

The final step is to calculate the amount of this item to reorder for this period. The equation for the reorder point is:

$$Q = \bar{d}(T+L) + z\sigma_{T+L} - I$$

where:

- $\bar{d}$ - demand per week
- T - number of weeks in review period
- L - number of weeks in lead time
- z - number of standard deviations for a specified confidence level.
- σ_{T+L} - standard deviation of demand for review period and lead time.
- I - end of period inventory, in our example 3 books are left.

For our example:

$Q = 1.25\ (4+2) + .96\ (2.76) - 3 = \underline{7.14 \cong 7 \text{ units}}$.

For this example at the end of the review period 7 books of this title should be ordered, and there is a 95% probability that there will be a book in stock during the nedt 6 weeks (T+L) whenever the customer desires it.

How is this model used in practice?

The first part of the function, $\bar{d}$ (T+L), reflects the demand during the 6 weeks that make up the review period and the

lead time. The second part of the equation, $z\sigma_{T+L}$ represents the safety stock necessary to maintain a 95% probability that demand will be satisfies from stock on hand. The last element of the equation, I, represents the inventory on hand, as well as any items backordered. Once the function has been determined for each item of inventory the manager need only count the current inventory on hand and items already on order, insert these values into the equation and determine how many of these items to order. For example, the values for the demand and safety stock have not changed in the last month for the item previously discussed. The function has been simplified to: $Q = 1.25\ (6) + .96(2.76) - I$

$= 10.1496-I.$

Since, the manager of the firm knows that there are 3 items on the shelf, and 2 backordered from the last order, he calculates his next order as $Q= 10.1496-5 = 5.149$. Thus he orders 5 more of the book at this time. If he decides to put the system onto a small computer he need only put the function into the machine and input "I" for each period, and his "Q" will be calculated automatically.

The advantages of this method are many. First, it systematically calculates the amount of merchandise based on forecasted demand. Second, safety stock is determined based on a stated service level, rather than subjectively as is done in the open-to-buy method. Third, conditions at the firm fit this model, whereas to use the EOQ model

the basic assumption that ordering costs are constant would have to be violated. Fourth, merchandise need only be counted at the end of the review period, which facilitates planning, the manager knows that all merchandise from a certain supplier must be counted by a certain time and an order submitted. Fifth, once the fixed time functions have been determined for each item, ordering will become a simple process requiring little time. Finally, this system should be easily transferable to a small personal computer system if desired.

The main disadvantage to this system is that safety stocks are relatively high compared to a perpetual inventory system, because they must be designed to cover both the review period and the lead time, whereas perpetual inventory methods need retain only enough safety stock to cover lead times.

Summary of Chapter Three

The recommended solutions to the firm's inventory problems were presented in this chapter. In answer to the question, how can individual items be easily tracked? The use of a combination of tear-tags and color coding was recommended. The suggested solution to the question, how should the turnovers of individual items be judged, was to calculate the minimum profitable turnover for an average item of the same class and use if for purposes of comparison. Finally, a fixed time period model was presented as the solution for

determining proper inventory levels, order quantities, and safety stocks.

CHAPTER FOUR - SUMMARY, CONCLUSIONS, and IMPLICATIONS

Introduction

This chapter summarizes the paper to this point and discusses the conclusions drawn from this study. Some comments about the implementation of the suggested methodologies are submitted, and implications for future study related to this area of interest are presented.

Summary

Chapter One presented an overall introduction of the paper, listing the major points of each chapter and describing the organization of the study. In addition, Chapter One stated the central issue of the paper in the problem statement.

Specifically the questions addressed in this study were: 1) How can items be tracked easily and efficiently and their individual inventory turnovers be determined? 2) How do we evaluate these turnovers, what is adequate, poor, good? 3) How many of a given item should be stocked or ordered at any one time? How should safety stocks be determined?

Chapter One continued presenting the justifications of the study, as an aid to the managers of small business,

and as a contribution to the understanding of the inventory problems facing the small business. The scope of the study was stated, limiting the study to applications in small businesses using hand calculated rather than automated systems. Next the chapter discussed the limitations of the study and of some of the various models presented. The basic methodology of the study was presented as a review of the literature concerning the problems stated in the problem statement, followed by an application of the selected alternative suggestions to a particular case.

Chapter Two is a review of the literature pertaining the the questions raised in the problem stated. The chapter addressed each of the three questions separately and presented alternative solutions gleaned from literature on the subject. Five alternative solutions were presented to answer the question, how should items be tracked to easily and efficiently in order to determine their individual inventory turnovers? These solutions were 1) the use of color coding, 2) using bin tickets, 3) acquiring a point of sale terminal, 4) a tear-tag system, and 5) the use of written receipts. The advantages and disadvantages of each of these methods were discussed, relating to cost, efficiency, service time, and customer convenience.

The next question addressed was, how should the individual inventory turnovers of various items be judged, what is good, satisfactory, or poor? Two separate alternative solutions to this problem were discussed. The

first method centered on the setting of a target turnover, and using this turnover as a standard of comparison for other individual items. With this method the target turnover was set equal to the turnover of those items which were previously known to be profitable. Thus this target turnover became a goal to be striven for, a point of reference for the manager. The second method of judging individual turnovers involved the setting of a cutoff point or breakeven point in relation to inventory turnover for each class of goods. This method calculated the costs of obtaining and holding inventory and determined how long an item could be held before the firm would begin to lose money. This establishes a concrete cutoff point with which to judge the turnovers of individual items of the same class.

The final question addressed in Chapter Two was, how many of a given item should be carried or ordered at one time, and how should safety stocks be determined? Three alternative solutions were discussed in relation to this question. The first alternative involved the calcualtion of correct quantities to carry based upon gross profit/ square foot. A goal was established in terms of gross profit/square foot and the quantities of each item are expected to be manipulated in order to reach this goals. Safety stocks were determined based upon estimates by the business manager of what he felt was satisfactory for the lead time and the time in between orders. The actual

ordering of merchandise under this methodology was accomplished based upon the "open-to-buy" method.

The second alternative solution presented involved the calculation of economic order quantities (EOQ) for each item. Under this alternative EOQ's were calculated for each item and reorder points estimated, when inventories reached the reorder points additional inventory was ordered. This method made several assumptions which could be difficult to justify, and required the use of a perpetual inventory system.

The last alternative solution to this question requires the implementation of a fixed time period model. Under this system order quantities are calcualted at fixed time period intervals based upon a predetermined function, current inventory, and inventory on order. Safety stocks are set based upon desired service levels. This model is similar to the E.O.Q. model in that it requires the use of some elementary statistical methods.

Chapter Two concludes with a summary of the alternatives described and a discussion of their respective advantages and disadvantages.

Chapter Three is an application of the alternatives presented in Chapter Two to an actual situation. The various alternatives are evaluated in the light of the situation facing a particular bookstore located in Minot, North Dakota. This chapter gives the reader the opportunity to see how the methodologies discussed can be applied to

the needs of a particular situation, and their limitations as well as strengths. In this particular situation it was recommended that the bookstore control and monitor its inventory based upon a combination of color coding and tear-tags. It states that individual item turnovers should be judged based upon a set breakeven point for the items under discussion. Finally, it was suggested that correct order quantities be determined with the use of a fixed time period model.

Conclusions

The system of record keeping, the marking of merchandise with tear-tags, and the calculation of desired inventory levels presented will systematically improve the profitability of the bookstore's inventory. In addition with the application of this system the manager of the firm will have greater control over his inventory and experience fewer stockouts or overages than previously. The other alternative solutions presented will produce similar results from other firms if they are applied correctly.

The development of a turnover figure to be used as a cutoff for a given class of items is merely a rule of thumb for gauging the performance of various items. It cannot be used as a single judge for an item's performance. For example, an item may have a poor inventory turnover because of poor marketing, poor location, or high price, in itself the item may be perfectly suitable for the firm's

customers.

The use of fixed time period model to determine order quantities will achieve good results as long as the data used in the initial calculations remain valid. In other words the data obtained from the methodology is only as good as the data inputted. The function should remain relatively stable over the short run for staple goods, however when stock shortages and overages begin to occur the function will have to be updated. This could be the result of a change in demand, lead times, standard deviations, or review period. In addition the manager of the firm will have to take logical action when special circumstances arise, for example the manager of a bookstore may want to increase his inventory of a particular title when an author is scheduled to appear at the local university to plug his new book. Such spurious data must not be included in the calculations for the inventory model.

Another conclusion that can be drawn from this study is that the newest and most advanced method of inventory control is not always the most practical for the small business. Cost efficiencies do not apply when the labor savings of an automated system do not justify the cost. In addition some firm's just do not have inventories large enough to need such systems, hand calculated systems or those assisted by the use of a small home computer are perfect for many small businesses. The methodology discussed for the bookstore can be easily done by hand or with the

assistance of a $800 micro-processor, no large or complete computerized system is needed.

Implications

This study raises several questions which need to be addressed concerning the future of inventory control for the small business. There are special problems relating to the storage and handling of goods that face the small business. For the small retail outlet, storage must comply with marketing restrictions. Many small firms lack space enough for the proper storage of goods, or the capital for materials handling equipment. The selection of merchandise and inventory is critical for the small business, raising the point that extensive marketing research may be necessary in some cases, but these firm's cannot afford such research.

Many of these questions have been raised and answered for the managers of large firms, but the smaller businesses require more research.

Another area of study which could produce interesting results would be to examine systems where the larger suppliers aid the smaller businesses in the control of their inventory problems, through computer support, marketing advice, tear-tags, or other means. These systems could allow the small business manager to benefit from some of the automated systems used by larger firms. It should be noted that such systems are already common in franchise situations where the home office has a computer based

inventory system to which the individual stores are tied by point of sale terminals. Thus the home office provides the automated service that each individual outlet could not afford. It is concievable that the small business manager could contract with his suppliers for similar services. This is an area where future research could be invaluable.

APPENDICES

Table 1.

Probabilities and partial expectations in the normal probability distribution related to inventory demand and safety stock

z is the number of standard deviation of safety stock (also called safety facor)

P(z) is the probability that demand will exceed z

E(z) is the expected number short with a safety stock of z

E(-z). For negative values of z use the E(-z) column

This table is normalized to z = 1 and area under the curve = 1.

z	P(z)	E(z)	E(-z)
0.00	0.50000	0.39894	0.39894
0.10	0.46017	0.35094	0.45094
0.20	0.42074	0.30690	0.50690
0.30	0.38209	0.26676	0.56676
0.40	0.34458	0.23044	0.63044
0.50	0.30854	0.19780	0.69780
0.60	0.27425	0.16867	0.76867
0.70	0.24196	0.14288	0.84288
0.80	0.21186	0.12021	0.92021
0.90	0.18406	0.10043	1.00043
1.00	0.15866	0.08332	1.08332
1.10	0.13567	0.06862	1.16862
1.20	0.11507	0.05610	1.25610
1.30	0.09680	0.04553	1.34553
1.40	0.08076	0.03667	1.43667
1.50	0.06681	0.02931	1.52931
1.60	0.05480	0.02324	1.62324
1.70	0.04457	0.01829	1.71829
1.80	0.03593	0.01428	1.81428
1.90	0.02872	0.01105	1.91105
2.00	0.02275	0.00849	2.00849
2.10	0.01786	0.00647	2.10647
2.20	0.01390	0.00489	2.20489
2.30	0.01072	0.00366	2.30366
2.40	0.00820	0.00272	2.40272
2.50	0.00621	0.00200	2.50200
2.60	0.00466	0.00146	2.60146
2.70	0.00347	0.00106	2.70106
2.80	0.00256	0.00076	2.80076
2.90	0.00187	0.00054	2.90054
3.00	0.00135	0.00038	3.00038
3.10	0.00097	0.00027	3.10027
3.20	0.00069	0.00019	3.20019
3.30	0.00048	0.00013	3.30013
3.40	0.00034	0.00009	3.40009
3.50	0.00023	0.00006	3.50006
3.60	0.00016	0.00004	3.60004
3.70	0.00011	0.00003	3.70003
3.80	0.00007	0.00002	3.80002
3.90	0.00005	0.00001	3.90001
4.00	0.00003	0.00001	4.00001
4.10	0.00002	0.00001	4.10001
4.20	0.00001	0.00000	4.20000
4.30	0.00001	0.00000	4.30000
4.40	0.00001	0.00000	4.40000
4.50	0.00000	0.00000	4.50000

Source Robert G Brown Decision Rules for Inventory Management (New York Holt, Rinehart, and Winston, 1967), pp. 95-103.

Table 2.

AVERAGE MONTHLY HOLDING COSTS PER PAPERBACK BOOK

AVERAGE INVENTORY OF BOOKS	2000
AVERAGE COST OF BOOKS	$1.50
AVERAGE RETAIL PRICE	$2.50

PAPERBACK BOOKS ARE 55% OF TOTAL INVENTORY

CLERK'S SALARY IS $150, 50% OF HER TIME IS HANDLING INVENTORY

COST OF CAPITAL IS .1575 ANNUALLY

TOTAL RENT		$396
TOTAL INSURANCE ANNUALLY		$130

APPLICABLE RENT	$217.8	396 x .55
APPLICABLE INSUREANCE	5.95	(130/12)(.55)
HANDLING COSTS	41.25	(150/2)(.55)
OPPORTUNITY COST	39.38	(.1575/12)(2,000)(1.50) (books at cost)
	$304.38	

$304.38/2000 = .152

AVERAGE MONTHLY HOLDING COST/BOOK = 15.2¢

AVERAGE ORDERING COST/BOOK

AVERAGE NUMBER BOOKS ORDERED/MONTH		400
PHONE COSTS	$100	
POSTAGE	6	
LABOR	35	10 hrs. @ $3.50
TOTAL	$141	

$141/400 = .3525

AVERAGE ORDERING COSTS/BOOK = 35¼¢

Table 3

AVERAGE SALES/WEEK AND STANDARD DEVIATION

Week	Qty sold	x	$(x-\bar{x})$	$(x-\bar{x})^2$
1	1	1.25	-.25	.0625
2	2	1.25	.75	.5625
3	1	1.25	-.25	.0625
4	0	1.25	-1.25	1.5625
5	0	1.25	-1.25	1.5625
6	2	1.25	.75	.5625
7	1	1.25	-.25	.0625
8	1	1.25	-.25	.0625
9	1	1.25	-.25	.0625
10	2	1.25	.75	.5625
11	3	1.25	1.75	3.06
12	1	1.25	-.25	.0625
13	4	1.25	2.75	7.56
14	0	1.25	-1.25	1.5625
15	0	1.25	-1.25	1.5625
16	1	1.25	-.25	.0625
				18.995

$\bar{x} = 20/16 = 1.25$

$n = 16$

$$\sigma = \sqrt{\frac{(x-\bar{x})^2}{n-1}} \qquad \sigma = \sqrt{\frac{18.995}{15}} = 1.125$$

Implementation Checklist

1. Attach an appropriately marked and colored tear-tag to all merchandise.

2. Take a complete inventory of all merchandise and list by tag number.

3. Attempt to reconstruct past sales history of each item from past records. If not possible begin record keeping at once.

4. Calculate the average turnover for each class of item which will yield a net profit. See Chapter 3 for details.

5. Note all merchandise with questionable turnovers a decision must be made to 1) promote the item, 2) buy less, or 3) replace with more profitable merchandise.

6. As soon as past sales data is available the fixed inventory model can be implemented. See Chapter 3 for details.

7. Monitor sales trends for all items, if shortages or overages occur frequently question the data used in the inventory function.

BIBLIOGRAPHY

Aquilano, Nicholas J. and Chase, Richard B., Production and Operations Management. Homewood, Illinois: Richard D. Irwin, Inc., 1981.

Dun and Bradstreet, Inc., 1980 Key Industrial Ratios. New York: Dun and Bradstreet, Inc., 1981.

Fuchs, Jerome H., Computerized Inventory Control Systems. Englewood Cliffs, New Jersey: Prentice-Hall, Inc. 1978.

Laws, Dwayne, Starting and Managing a Small Retail Hardware Store. Washington, D.C.: Small Business Administration, 1965.

Sanders, Donald H., Computers in Business. New York: McGraw Hill Book Company, 1979.

Small Business Administration, Business Basics - Retail Buying Function. Washington, D.C. Small Business Administration, 1953.

Small Business Administration, Business Basics - Retail Merchandise Managment. Washington, D.C.: Small Business Administration, 1953.