INFORMATION TO USERS

This material was produced from a microfilm copy of the original document. While the most advanced technological means to photograph and reproduce this document have been used, the quality is heavily dependent upon the quality of the original submitted.

The following explanation of techniques is provided to help you understand markings or patterns which may appear on this reproduction.

1. The sign or "target" for pages apparently lacking from the document photographed is "Missing Page(s)". If it was possible to obtain the missing page(s) or section, they are spliced into the film along with adjacent pages. This may have necessitated cutting thru an image and duplicating adjacent pages to insure you complete continuity.

2. When an image on the film is obliterated with a large round black mark, it is an indication that the photographer suspected that the copy may have moved during exposure and thus cause a blurred image. You will find a good image of the page in the adjacent frame.

3. When a map, drawing or chart, etc., was part of the material being photographed the photographer followed a definite method in "sectioning" the material. It is customary to begin photoing at the upper left hand corner of a large sheet and to continue photoing from left to right in equal sections with a small overlap. If necessary, sectioning is continued again — beginning below the first row and continuing on until complete.

4. The majority of users indicate that the textual content is of greatest value, however, a somewhat higher quality reproduction could be made from "photographs" if essential to the understanding of the dissertation. Silver prints of "photographs" may be ordered at additional charge by writing the Order Department, giving the catalog number, title, author and specific pages you wish reproduced.

5. PLEASE NOTE: Some pages may have indistinct print. Filmed as received.

Xerox University Microfilms
300 North Zeeb Road
Ann Arbor, Michigan 48106
LAMBERT, Douglas McGlashan, 1945-
THE DEVELOPMENT OF AN INVENTORY COSTING
METHODOLOGY: A STUDY OF THE COSTS
ASSOCIATED WITH HOLDING INVENTORY.

The Ohio State University, Ph.D., 1975
Business Administration

Xerox University Microfilms, Ann Arbor, Michigan 48106

© 1975

DOUGLAS McGGLASHAN LAMBERT

ALL RIGHTS RESERVED

THIS DISSERTATION HAS BEEN MICROFILMED EXACTLY AS RECEIVED.
THE DEVELOPMENT OF AN INVENTORY COSTING METHODOLOGY:

A STUDY OF THE COSTS ASSOCIATED WITH

HOLDING INVENTORY

DISSERTATION

Presented in Partial Fulfillment of the Requirements for
the Degree Doctor of Philosophy in the Graduate
School of The Ohio State University

By

Douglas M. Lambert, B.A., M.B.A.

* * * * *

The Ohio State University

1975

Reading Committee: Approved By

Dr. Bernard J. La Londe
Dr. James F. Robeson
Dr. John R. Grabner

Adviser
Department of Marketing
ACKNOWLEDGMENTS

Very few worthwhile accomplishments are possible without the encouragement and support of many individuals. This is especially true in the case of a dissertation and numerous individuals have lent their support to this endeavor.

I would like to thank the executives who shared my interest and enthusiasm for the topic, gave freely of their time and provided me with the necessary data. Regretfully the confidentiality of the information provided precludes personal recognition for their support.

The Canada Council contributed to the study by providing financial assistance in the form of a doctoral fellowship and The National Council of Physical Distribution Management provided partial funding through the annual A. T. Kearney Award. The support of both organizations is greatly appreciated.

Professor Bernard J. La Londe, chairman of my dissertation committee and my adviser throughout the doctoral program deserves special recognition not only for his
many contributions to this dissertation but for the high standards of professional competence and conduct which he consistently displayed. His scholarly demeanor, maturity, uncompromised values and genuine concern and respect for the needs of his students represented an ideal for which to strive.

I would like to express my sincere appreciation to the other members of the Reading Committee, Professors Grabner and Robeson, and to Professors Clark and House for their valuable suggestions.

Mrs. Jane Burrows must be recognized for her role in typing and retyping of the manuscript. She gave generously of her time, a fact that contributed significantly to the completion of this project within the deadlines to which I was committed.

Finally, I would like to express my gratitude to my wife, Nancy, for her encouragement, good humor and the many sacrifices made on my behalf.
VITA

June 30, 1945. . . . . Born - Toronto, Canada

1969 . . . . . . . . . . B.A. (Honors Business Administration), The University of Western Ontario, London, Canada

1969-1970. . . . . . . Research Associate, The School of Business Administration, The University of Western Ontario

1971. . . . . . . . . M.B.A., The University of Western Ontario

1971-1973. . . . . . . Lecturer, The School of Business Administration, The University of Western Ontario

1973-1975. . . . . . . Research Associate, College of Administrative Science, The Ohio State University, Columbus, Ohio

PUBLICATIONS


FIELDS OF STUDY

Major Field: Marketing


Seminar in Marketing Models. Professor James Ginter

Seminar in Contemporary Marketing Problems. Professor Bernard J. La Londe

Seminar in Consumer Research. Professor Roger D. Blackwell.

History of Marketing Thought. Professor Robert Bartels

Minor Field: Logistics

Physical Distribution Management. Professor John R. Grabner, Jr.

Individual Studies in Business Logistics. Professor James F. Robeson

Theory of Business Logistics. Professor Bernard J. La Londe
Minor Field: Logistics (continued)

Seminar in Logistics. Professor Bernard J. La Londe

Quantitative Methods and Research Tools

Quantitative Methods—Deterministic. Professor Kindig

Quantitative Methods—Stochastic. Professor Kenneth Gordon

Principles and Techniques of Marketing Research. Professor James Ginter

Group Studies in Multivariate Analysis. Professor James Ginter

Analysis of Variance. Professor Erickson

Readings in Numerical Taxonomy. Professor Robert Hansen
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACKNOWLEDGMENTS</td>
<td>ii</td>
</tr>
<tr>
<td>VITA</td>
<td>iv</td>
</tr>
<tr>
<td>LIST OF TABLES</td>
<td>x</td>
</tr>
<tr>
<td>LIST OF FIGURES</td>
<td>xii</td>
</tr>
<tr>
<td>GLOSSARY OF TERMS</td>
<td>xiii</td>
</tr>
</tbody>
</table>

### CHAPTER

#### I. INTRODUCTION. ........................................ 1

- Background .............................................. 2
- The Business Problem .................................. 5
- Customer Service Levels .............................. 6
- Transportation Costs .................................. 9
- Warehousing Costs ..................................... 10
- Lot Quantity Costs .................................... 12
- Inventory Carrying Costs ............................. 12
- The Research Purpose .................................. 15
- Research Objectives ................................. 16
- Research Questions .................................... 16
- The Scope of the Research ............................ 18
- Limitations ........................................... 18
- Potential Contributions .............................. 20
- Organization ......................................... 20

#### II. REVIEW OF THE LITERATURE. ......................... 22

- The Components of Inventory Carrying Costs ....... 23
- The Cost of Capital ................................... 43
- The Valuation of Inventory ........................... 48
- Availability of the Cost Data ...................... 52
- Summary ............................................... 54
<table>
<thead>
<tr>
<th>CHAPTER</th>
<th>CONTENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>III. RESEARCH DESIGN</td>
<td>Page</td>
</tr>
<tr>
<td>Development of the Model</td>
<td>59</td>
</tr>
<tr>
<td>Capital Costs</td>
<td>59</td>
</tr>
<tr>
<td>Inventory Service Costs</td>
<td>60</td>
</tr>
<tr>
<td>Storage Space Costs</td>
<td>61</td>
</tr>
<tr>
<td>Inventory Risk Costs</td>
<td>63</td>
</tr>
<tr>
<td>Framework for Data Collection</td>
<td>65</td>
</tr>
<tr>
<td>Data Analysis</td>
<td>67</td>
</tr>
<tr>
<td>The Pretest</td>
<td>71</td>
</tr>
<tr>
<td>The Sample</td>
<td>73</td>
</tr>
<tr>
<td>Interview Procedure</td>
<td>76</td>
</tr>
<tr>
<td>IV. THE FINDINGS</td>
<td>Page</td>
</tr>
<tr>
<td>General Results</td>
<td>80</td>
</tr>
<tr>
<td>What Costs Should Be Included in Inventory Carrying Costs?</td>
<td>80</td>
</tr>
<tr>
<td>For What Types of Decisions Would Managers Use Inventory Carrying Costs as an Input?</td>
<td>81</td>
</tr>
<tr>
<td>Are the Costs of Holding Inventory Currently Available from the Accounting Data of the Companies Studied?</td>
<td>82</td>
</tr>
<tr>
<td>How Much Time and Effort Is Required to Accurately Assess the Cost of Carrying Inventory?</td>
<td>86</td>
</tr>
<tr>
<td>If Any Parts of the Data Are Not Easily Attainable Would the Benefits Derived from Knowing These Costs Exceed the Expenses Involved in Gathering Them?</td>
<td>92</td>
</tr>
<tr>
<td>Does One Inventory Carrying Cost Percentage Accurately Reflect the True Costs of All Companies?</td>
<td>94</td>
</tr>
<tr>
<td>viii</td>
<td></td>
</tr>
</tbody>
</table>
CONTENTS (continued)

<table>
<thead>
<tr>
<th>CHAPTER</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>IV. (continued)</td>
<td></td>
</tr>
<tr>
<td>Are the Inventory Carrying Costs Used by the Companies Studied Inaccurate?</td>
<td>99</td>
</tr>
<tr>
<td>Other Findings</td>
<td>102</td>
</tr>
<tr>
<td>A Concluding Note</td>
<td>103</td>
</tr>
<tr>
<td>V. SUMMARY AND CONCLUSIONS</td>
<td>104</td>
</tr>
<tr>
<td>Summary of Research Purpose and Design</td>
<td>104</td>
</tr>
<tr>
<td>Review of the Research Questions and Findings</td>
<td>105</td>
</tr>
<tr>
<td>Major Conclusions</td>
<td>110</td>
</tr>
<tr>
<td>Amplifications of the Model</td>
<td>116</td>
</tr>
<tr>
<td>Implications</td>
<td>119</td>
</tr>
<tr>
<td>Suggestions for Future Research</td>
<td>122</td>
</tr>
<tr>
<td>APPENDICES</td>
<td>125</td>
</tr>
<tr>
<td>A. E.O.Q. FORMULAS</td>
<td>126</td>
</tr>
<tr>
<td>B. AN ILLUSTRATION OF THE IMPORTANCE OF INVENTORY CARRYING COSTS</td>
<td>131</td>
</tr>
<tr>
<td>C. SUGGESTED FORMAT FOR DATA COLLECTION</td>
<td>133</td>
</tr>
<tr>
<td>D. INTERVIEW GUIDE</td>
<td>141</td>
</tr>
<tr>
<td>E. THE PRETEST</td>
<td>149</td>
</tr>
<tr>
<td>F. CARRYING COST PERCENTAGES USED BY THE COMPANIES PRIOR TO THIS RESEARCH</td>
<td>171</td>
</tr>
<tr>
<td>G. AN INCORRECT APPLICATION OF INVENTORY CARRYING COSTS</td>
<td>180</td>
</tr>
<tr>
<td>BIBLIOGRAPHY</td>
<td>182</td>
</tr>
</tbody>
</table>

ix
# LIST OF TABLES

<table>
<thead>
<tr>
<th>TABLE</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>ESTIMATES OF INVENTORY CARRYING COSTS</td>
<td>24</td>
</tr>
<tr>
<td>2.</td>
<td>INVENTORY CARRYING COSTS</td>
<td>27</td>
</tr>
<tr>
<td>3.</td>
<td>HOW TO FIGURE YOUR OWN COST OF POSSESSION</td>
<td>32</td>
</tr>
<tr>
<td>4.</td>
<td>HOLDING COSTS</td>
<td>35</td>
</tr>
<tr>
<td>5.</td>
<td>ACQUISITION COSTS</td>
<td>36</td>
</tr>
<tr>
<td>6.</td>
<td>FRAMEWORK FOR RECORDING DATA AVAILABILITY</td>
<td>72</td>
</tr>
<tr>
<td>7.</td>
<td>USES OF INVENTORY CARRYING COSTS</td>
<td>83</td>
</tr>
<tr>
<td>8.</td>
<td>AVAILABILITY OF THE COST COMPONENTS</td>
<td>87</td>
</tr>
<tr>
<td>9.</td>
<td>PROBLEMS ENCOUNTERED IN DATA COLLECTION</td>
<td>93</td>
</tr>
<tr>
<td>10.</td>
<td>SUMMARY</td>
<td>95</td>
</tr>
<tr>
<td>11.</td>
<td>INVENTORY CARRYING COSTS: THE COST OF COMPILATION</td>
<td>96</td>
</tr>
<tr>
<td>12.</td>
<td>AMOUNT OF INVENTORY ASSOCIATED WITH A $10,000 CHANGE IN OUTCOME</td>
<td>98</td>
</tr>
<tr>
<td>13.</td>
<td>BEFORE AND AFTER CARRYING COSTS AND METHOD OF DETERMINING INVENTORY INVESTMENT</td>
<td>113</td>
</tr>
<tr>
<td>14.</td>
<td>FRAMEWORK FOR DECISION MAKING</td>
<td>115</td>
</tr>
<tr>
<td>15.</td>
<td>A FRAMEWORK FOR FUTURE RESEARCH</td>
<td>123</td>
</tr>
</tbody>
</table>
### TABLES (continued)

<table>
<thead>
<tr>
<th>TABLE</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>16.</td>
<td>TERMINAL INVENTORY AND SHRINKAGE FOR 1973</td>
<td>164</td>
</tr>
<tr>
<td>17.</td>
<td>INVENTORY CARRYING COSTS FOR PRODUCT XYZ</td>
<td>165</td>
</tr>
<tr>
<td>18.</td>
<td>INVENTORY CARRYING COSTS FOR PRODUCT LMN</td>
<td>167</td>
</tr>
<tr>
<td>19.</td>
<td>ADDITIONAL ANNUAL INVENTORY CARRYING COST DUE TO EACH TERMINAL</td>
<td>169</td>
</tr>
<tr>
<td>20.</td>
<td>TERMINAL REQUIREMENTS FOR THE PROPOSED EXPANSION—1975 ESTIMATED COSTS</td>
<td>170</td>
</tr>
</tbody>
</table>
## LIST OF FIGURES

<table>
<thead>
<tr>
<th>FIGURE</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>COST TRADEOFFS REQUIRED IN THE LOGISTICS SYSTEM</td>
<td>7</td>
</tr>
<tr>
<td>2.</td>
<td>INVENTORY POSITIONS IN THE LOGISTICS SYSTEM</td>
<td>14</td>
</tr>
<tr>
<td>3.</td>
<td>INVENTORY CARRYING COSTS</td>
<td>56</td>
</tr>
<tr>
<td>4.</td>
<td>INVENTORY CARRYING COSTS</td>
<td>56</td>
</tr>
<tr>
<td>5.</td>
<td>NORMATIVE MODEL OF INVENTORY CARRYING COST METHODOLOGY</td>
<td>68</td>
</tr>
</tbody>
</table>
GLOSSARY OF TERMS*

ABSORPTION COSTING. That type of product costing which assigns fixed manufacturing overhead to the units produced as a product cost. Contrasts with direct costing.

ALLOCATION. Assigning one or more items of cost or revenue to one or more segments of an organization according to benefits received, responsibilities, or other logical measures of use.

CAPITAL BUDGETING. Long-term planning for proposed capital outlays and their financing.

CASH FLOW. The net effect of cash receipts and disbursements for a specified period.

CONTROLLABLE COST. A cost which may be directly regulated at a given level of managerial authority, either in the short run or in the long run.

CONTROLLER. The chief management accounting executive. Also spelled "comptroller."

COST OF GOODS SOLD. Inventoriable costs released to the current period (an expense) as a result of the sale of goods.

DIRECT COSTING. That type of product costing which charges fixed manufacturing overhead immediately against the revenue of the period in which it was incurred, without assigning it to specific units produced. Also called "variable costing" and "marginal costing."

DIRECT LABOR. All labor which is obviously related and specifically and conveniently traceable to specific products.

DIRECT MATERIAL. All raw material which becomes an integral part of the finished good and which can be conveniently assigned to specific physical units.

ECONOMIC ORDER QUANTITY. The amount of inventory which should be ordered at one time in order to minimize the associated annual costs of the inventory.

FACTORY OVERHEAD. All factory costs other than direct labor and direct material. Also called "factory burden," "indirect manufacturing costs," "manufacturing overhead," and "manufacturing expense" (the latter is a misnomer).

FINISHED GOODS INVENTORY. The cost of a manufacturer's completed product which is being held for sale.

FIXED COST. A cost which, for a given period of time and range of activity called the relevant range, does not change in total but becomes progressively smaller on a per-unit basis as volume increases.

JOINT COST. A cost which is common to all the segments in question and which is not clearly or practically allocable except by some questionable allocation base. Also called "common cost."

JOINT PRODUCT COSTS. Costs of two or more manufactured goods, of significant sales values, that are produced by a single process and that are not identifiable as individual products up to a certain stage of production known as the "split-off point."

OPPORTUNITY COST. The maximum alternative earning that might have been obtained if the productive good, service, or capacity had been applied to some alternative use.

OUT-OF-POCKET COSTS. Costs which entail current or near-future outlays for the decision at hand.
QUANTITY DISCOUNT. A reduction in unit price inversely proportional to the size of the order. Usually constrained by the Robinson-Patman Act.

RELEVANT RANGE. The band of activity in which budgeted sales and expense relationships will be valid.

RETURN ON INVESTMENT (rate of return). The most widely used single measure of a firm's operating efficiency. It is the ratio of net income to invested capital or asset turnover times margin on sales.

STANDARD ABSORPTION COSTING. That type of product costing in which the cost of the finished unit is calculated as the sum of the costs of the standard allowances for the factors of production, without reference to the costs actually incurred.

STANDARD COST. A carefully predetermined cost that should be attained. Usually expressed per unit.

STANDARD DIRECT COSTING. That type of product costing in which the cost of the finished unit is calculated as the sum of the costs of the standard allowances for the factors of production, excluding fixed factory overhead, which is treated as a period cost, and without reference to the costs actually incurred.

STEP VARIABLE COSTS. Those variable costs which change abruptly at intervals of activity because their acquisition comes in indivisible chunks.

SUNK COST. A cost which has already been incurred and which, therefore, is irrelevant to the decision-making process. Also called "historical cost."

VARIABLE COST. A cost which is uniform per unit, but which fluctuates in total in direct proportion to changes in the related total activity or volume.

VARIABLE COSTING. See Direct Costing.

WORK IN PROCESS INVENTORY. The cost of uncompleted goods still on the production line.
CHAPTER I
INTRODUCTION

Inventory carrying costs, the costs that are associated with the quantity of inventory stored, include a number of different cost components and generally represent one of the highest costs in physical distribution. The magnitude of these costs and the fact that inventory levels are influenced by the configuration of the physical distribution system demonstrates the need for an accurate assessment of inventory carrying costs if the appropriate trade-offs are to be made within the firm. Currently, most managers who consider the cost of holding inventory use estimates or traditional industry benchmarks. In fact, many corporations do not consider inventory carrying costs even though these costs are both real and substantial.

Recently, much effort has been placed on distribution system modelling but relatively little progress has been made in the area of cost measurement which is required to
provide the cost parameters for such models. Although many authors have addressed the types of costs that should be considered in inventory carrying costs and have estimated that these costs range in total from 12 percent to 35 percent, there is not a generally accepted methodology for determining inventory carrying costs or for that matter even a framework for developing such costs.

The thrust of this dissertation is to develop and test a methodology, based on existing accounting, distribution and production literature that can be used to determine inventory carrying costs. In addition, the specific uses for and importance of the figure are investigated.

Background

Business Logistics, "a term which denotes a total approach to the management of the distribution process, including all of those activities involved in physically moving raw materials, in-process inventory, and finished


3 This is documented in Chapter II.
goods inventory from point of origin to point of use or consumption,"\(^4\) is gaining importance in the business world as a means of improving customer service and reducing costs.\(^5\) Through better managed physical distribution activities the marketing effort of the company can be improved by adopting distribution policies that result in consistent and dependable customer service. However, the knowledgeable corporate executive realizes that increased sales are not the only way to improve corporate profitability. The issue is sales at a profit which brings us to the second major benefit to be realized by the company that adopts the business logistics approach and that is control of expenses. Distribution costs have been estimated at approximately 25 percent of the cost of doing business at the manufacturing level.\(^6\) Better management of the distribution function offers large potential


savings which would contribute to corporate profitability. 7

One of the key costs of distribution is the cost of holding inventory.

Collectively, inventories made up about 7.5% of the net tangible assets of the United States in 1965, a year in which American business had an average investment of about $144 billion in inventories...Inventory carrying costs make up about 41% of all logistics costs. 8

The key word in the above statement is "about." The authors go on to explain that these figures are "estimates," "based on the commonly accepted ratio of such costs to the average value of inventory on hand...."

Wendell Stewart has estimated that inventory carrying costs represent about one-third of the total distribution costs of a company, or about 7.5 percent of sales on the average. 9 Costs of such magnitude deserve more attention than they are currently receiving.

---


The Business Problem

The cost of carrying inventory has a direct impact not only on the number of warehouses that a company maintains, but on all of the firm's distribution policies. Given the same customer service level, low inventory carrying costs lead to multiple warehouses and a slower mode of transportation such as railroads. High inventory carrying costs, on the other hand, result in a limited number of stock locations and require a faster means of transportation, such as motor carriers or perhaps aircraft in order to minimize total costs. Without an accurate assessment of the costs of carrying inventory, it is unlikely that a company would choose the distribution policies that would minimize costs.

In addition, the cost of carrying inventory is also required to accurately determine economic manufacturing quantities, economic order quantities, and sales discounts,¹⁰ all of which are currently calculated on the basis of estimated costs in the majority of companies who use these formulae.

The total cost associated with carrying inventory must be known if cost tradeoffs are to be made within the logistics system. Figure 1 illustrates the tradeoffs that are necessary when establishing customer service levels, purchasing policies, transportation policies, and warehousing systems if maximum corporate profitability is to be realized. The cost categories introduced in Figure 1 are: Customer Service Levels (The Cost of Lost Sales); Transportation Costs; Warehousing Costs; Lot Quantity Costs; and Inventory Carrying Costs.

**Customer Service Levels**

The area of customer service represents distribution's interface with the demand creation portion of marketing. Distribution represents the demand supply part of marketing. Consequently, customer service, or availability, is part of the "four p's" of marketing: product, place, price, and promotion. As such it is a critical input in the marketing mix decision. Customer service not only impacts on the "place" component of the marketing mix, but also influences the "price" of the product. Product availability can be used to differentiate
Objective: Minimize Total Costs

Total Costs = Inventory Carrying Costs + Lot Quantity Costs + Warehousing Costs + Transportation Costs + Cost of Lost Sales.

FIGURE 1. COST TRADEOFFS REQUIRED IN THE LOGISTICS SYSTEM
the product and may influence the market price if customers are willing to pay more for better product availability. In addition, distribution costs are added to product costs and as such may affect the market price set by the company.

The cost associated with customer service levels is the cost of lost sales which is not only the margin lost by not meeting the current sales demand, but is the present value of all future contribution to profit foregone by losing a customer due to poor availability. The cost of lost sales is indeed difficult, if not impossible, for most businessmen to measure. If only the measurable costs associated with back-ordering are included in this category, the objective then becomes one of minimizing the total costs given a specified level of customer service. With this type of information, it is possible for management to make a knowledgeable judgment about the likelihood of recovering through increased sales, the increase in total system costs brought about by an increase in customer service levels. Another possibility, of course, would be to reduce spending in some other component of the marketing mix, promotion for example, in order to maintain profit levels with similar sales volume.
Likewise, with decreases in customer service levels, profitability can be improved or other components of the marketing mix may enjoy increased levels of expenditure in an effort to maintain or improve market position.

It would seem that even though the cost of lost sales associated with various levels of customer service are elusive, better management decisions may be possible if good cost data are available for the other four cost categories shown in Figure 1.

Transportation Costs

The next category of costs to be considered is that associated with the transportation function. Transportation costs can be dealt with in total or on an incremental basis. Incremental costs are the costs that will change with a proposed change in the distribution system. Transportation cost, if not currently available in any other form, can be determined by a statistical audit of freight bills. The preferred practice would be to develop standard transportation costs for each type of common carrier used and for the private fleet, if private trucking is utilized. There has been a reasonable amount of effort expended in this area and these costs can be obtained.
Warehousing Costs

Warehousing costs are comprised of all of the expenses that can be eliminated or must be increased if warehousing facilities are either deleted or added. There has been a great deal of confusion in the literature about these costs.\(^{11}\) Many authors have included warehousing costs in inventory carrying costs.\(^{12}\) While warehousing costs may be considered as being part of the cost of possession and could be eliminated if a wholesaler was used rather than selling direct to the customer, the decision to use a wholesaler is a special case. The inclusion of warehousing costs in inventory carrying costs is clearly a misconception since the majority of warehousing costs will not change with the level of inventory stocked, but rather with the number of stocking locations. Nevertheless, the converse is true. The number of warehouses employed within the distribution system will have

\(^{11}\) This is documented in Chapter II.

\(^{12}\) See literature search in Chapter II.
an impact on the levels of inventory held.\textsuperscript{13,14} In addition, in the case of leased or owned facilities, warehousing costs take the form of step-functions. Consequently, their inclusion in inventory carrying costs necessitates a recalculation of the carrying cost percentage each time a decision involves the possibility of opening or closing a warehouse. The most straight-forward method is to separate the warehousing costs into two distinct categories: those related to throughput and those related to storage. The former group of costs should be included in warehousing costs so that the increments can be easily added or subtracted with changes in distribution system configurations. These costs are readily available in the majority of companies. The latter cost category is related to the amount of inventory held and for this reason should be considered part of inventory carrying costs.

\textsuperscript{13} Donald J. Bowersox, Edward W. Smykay, and Bernard J. La Londe, \textit{op. cit.}, pp. 220 and 221.

\textsuperscript{14} Ronald H. Ballou, \textit{op. cit.}, pp. 283-85.
Lot Quantity Costs

Lot quantity costs are those costs that will change as a result of the proposed system revision and usually will include some or all of the following costs:

1. Cost of issuing and closing orders
2. Related costs of handling
3. Production preparation costs
   a. Set-up time
   b. Inspection
   c. Set-up scrap
   d. Inefficiency of beginning operation
4. Lost capacity due to changeover
5. Materials handling costs
6. Scheduling costs
7. Expediting costs

The production preparation costs and the lost capacity costs are usually available since they are used as inputs to production planning.

The other costs can be approximated by taking the costs incurred at different levels of activity and dividing by the increment in volume. The number obtained can be used as an input to logistics system design.

Inventory Carrying Costs

Conceptually, inventory carrying costs has been one of the most difficult costs to determine, and next to the cost of lost sales probably the most difficult.
carrying costs should only include those costs that vary with the level of inventory stored and can be categorized into the following four groups: (1) Capital Costs; (2) Inventory Service Costs; (3) Storage Space Costs; and (4) Inventory Risk Costs.\textsuperscript{15}

The implicit assumption underlying this research is that a reduction in finished goods inventory will lead to a corresponding reduction in inventory throughout the system (Figure 2). That is, a one-time reduction in finished goods inventory results in a one-time reduction in raw materials purchased as inventory is pushed back through the system. Similarly, a planned increase in finished goods inventory results in a one-time increase in the quantity of raw materials purchased and subsequently pushed through the system.

Inventory is just one of five cost centers that can affect return on investment. In order to maximize corporate return on investment, it is necessary to minimize total costs in the logistics system, subject to marketing

\textsuperscript{15} The interested reader will find in Appendix B a simple example which illustrates how the exclusion of inventory carrying costs changes a distribution decision.
Assumption: A one-time increase/decrease in finished goods inventory results in a one-time increase/decrease in raw materials inventory.

FIGURE 2. INVENTORY POSITIONS IN THE LOGISTICS SYSTEM
constraints on customer service levels and production constraints on inventory levels. Of the five cost categories introduced in Figure 1, inventory carrying costs have proven to be the most difficult to measure. It soon becomes obvious that a methodology that will result in an accurate determination of inventory holding costs is required.

The Research Purpose

The purpose of this research was to determine the specific cost components that should be included in the cost of carrying inventory and whether these numbers were available within the existing accounting records of the companies included in this research.

In situations in which the required data were not available, changes in the accounting system were suggested considering the appropriate cost-benefit analysis for such changes. The goal was to develop a methodological framework that could be used by management to develop inventory carrying cost percentages. In addition, management perceptions of the types of decisions in which inventory carrying costs would be a useful component were also explored.
Research Objectives

The specific objectives of the research were as follows:

1. To identify the key cost elements involved in determining the cost of carrying inventory;
2. To develop from these data a normative model or general methodological framework for determining the cost of carrying inventory;
3. To test this model using case studies to determine if the framework is workable within the present accounting systems used by the companies included in this study;
4. To generate hypotheses for further research studies.

Research Questions

The research attempted to find answers to questions such as:

1. From a theoretical point of view, what costs should be included in the calculation of inventory carrying costs?
2. For what types of decisions would managers use inventory carrying costs as an input?

3. To what degree are these costs available from the current accounting system?

4. How much time and effort is required to accurately assess these costs?

5. If any parts of the data are not easily attainable would the benefits derived from knowing these costs exceed the expense involved in gathering them?

6. Will one inventory carrying cost figure, for example 25 percent, accurately reflect the true costs of all companies? In other words, must each company calculate its own inventory carrying costs and not rely on industry benchmarks or currently published averages?

7. Are the inventory carrying costs used by the companies studied inaccurate?

These research questions will be operationalized in Chapter III to assist the researcher in gathering the information required to provide answers to the questions.
The Scope of the Research

The research required working closely with the accounting and distribution personnel of six packaged goods manufacturers with differing distribution systems, in order to develop for each of these companies a working methodology for calculating inventory carrying costs. The "model" developed in Chapter III was used as the basis for the data collection. The result is a generalized methodology that addresses the various costs from both a theoretical and a pragmatic outlook. The problems of operationalizing such a procedure, a subject heretofore neglected in the literature, is dealt with in considerable detail.

Limitations

The companies that took part in the case studies were not selected at random but rather on the basis of previous association with the university or because management was aware of the need to accurately determine inventory carrying costs. Consequently it is conceivable that these companies are managed by executives who are more knowledge-
able and aware than those employed by the majority of companies. For this reason it is possible that more sophisticated information retrieval techniques are used in these companies.

All of the companies studied were manufacturers of packaged goods with national distribution of their products within the United States. Five of the six companies were in the food industry and although the sixth company's products were not food items, they were marketed through traditional food channels. This fact should be recognized when considering the results of the study.

Typically, the food industry is characterized by high throughput companies and relatively low obsolescence costs. Obsolescence is not a major factor due to the relatively long shelf life of the products and the large number of inventory turns per year.

Although the sample may not be representative of all companies, it does reflect a broad range of possible distribution systems and information retrieval problems. The research should have encountered the major theoretical and pragmatic issues that a manager of a similar company is likely to face when attempting to classify these costs.
Potential Contributions

The major potential contribution is a methodology that managers can use to develop inventory carrying cost figures for their companies. A secondary potential contribution is the analysis of the problems involved with using the inventory carrying cost figure in decision making. In other words, the results are not limited to a "model" showing what costs to collect and how to collect them but includes a framework to explain how to apply the figure once it has been calculated.

In addition to consolidating the existing theories, the research attempted to resolve present or potential conflict between theory and practice and reveal areas where new theoretical developments were necessary. Where applicable, improvements in "generally accepted accounting practice" are suggested.

Organization

The balance of the dissertation is presented in Chapters II through V. Chapter II contains the literature review that serves as the underlying theoretical structure for the research. In this chapter previous studies on inventory carrying costs and literature in the areas of
accounting, finance, logistics, and production are explored in order to determine which cost components should be included in the "model." The importance of each of these sources in the development of a methodology for calculating inventory carrying cost is investigated.

Chapter III deals with the research design. In this chapter the methodology is developed and a framework for data collection is provided. Other topics included in this chapter are: data analysis, the pretest, the research sample, and the interview procedure.

The main findings and supplementary findings are dealt with in Chapter IV. A discussion of any unexpected findings and an examination of the differences between the model and the data collected are included. Facts or other information that appeared confusing or contrary to the hypotheses are analyzed and explanations for such outcomes are suggested.

In Chapter V, the conclusions are summarized, the contributions of the findings and their implications for businessmen and academicians are explored. Suggestions for further study also are included.
CHAPTER II

REVIEW OF THE LITERATURE

Chapter II contains the literature review that will serve as the underlying theoretical structure for the research. The literature review is divided into the following five sections:

1. The Components of Inventory Carrying Cost
2. The Cost of Capital
3. The Valuation of Inventory
4. Availability of the Cost Data
5. Summary

The section on the components of inventory carrying cost includes a review of previous studies on inventory carrying costs as well as literature in the areas of accounting, finance, logistics and production. The section is used as a basis for determining the components that should be included in inventory carrying cost.
The cost of capital section presents a review of selected accounting literature and provides the necessary background for establishing the figure to be used as the cost of money invested in inventory.

The section on inventory valuation is included to investigate the possible methods of inventory valuation since the inventory carrying cost must be applied to some value of inventory.

The perceived availability of the cost parameters is briefly explored in the section entitled "Availability of the Cost Data."

The final section presents a summary of the literature to be used in formulation of the methodological framework.

The Components of Inventory Carrying Costs

A literature search revealed that a number of authors had estimated the annual cost of carrying inventory as a percentage of the average inventory held. Thirteen of these estimates are summarized in Table 1.

As a starting point in the development of the model, a publication by Ronald Foster, one of the most recent and probably the most widely used documents in the area, was examined.
<table>
<thead>
<tr>
<th>Author</th>
<th>Publication</th>
<th>Estimate of Carrying Costs as a Percent of Inventory Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dean S. Ammer</td>
<td>MATERIALS MANAGEMENT (Richard D. Irwin, Inc. 1962), p. 137</td>
<td>20-25%</td>
</tr>
<tr>
<td>Clifford M. Baumback, James D. Harty, George W. Flossl and Oliver W. Wight</td>
<td>MANAGEMENT OF LOT-SIZE INVENTORIES (American Production and Inventory Control Society, 1963), p. 17</td>
<td>15-25%</td>
</tr>
<tr>
<td>Gordon T. Crook</td>
<td>&quot;Inventory Management Takes Teamwork,&quot; PURCHASING, March 26, 1962, p. 70.</td>
<td>25%</td>
</tr>
<tr>
<td>Thomas W. Hall</td>
<td>&quot;Inventory Carrying Costs; A Case Study,&quot; MANAGEMENT ACCOUNTING, January 1974, pp. 37-39</td>
<td>20.4%</td>
</tr>
<tr>
<td>John B. Holbrook</td>
<td>MANAGING THE MATERIALS FUNCTION (American Management Association, 1959), p. 67</td>
<td>24%</td>
</tr>
</tbody>
</table>
### TABLE 1 (continued)

<table>
<thead>
<tr>
<th>Author</th>
<th>Publication</th>
<th>Estimate of Carrying Costs as a Percent of Inventory Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>John F. Magee</td>
<td>&quot;The Logistics of Distribution.&quot; HARVARD BUSINESS REVIEW, July-August 1960, p. 99</td>
<td>20-35%</td>
</tr>
<tr>
<td>Benjamin Melnitsky</td>
<td>MANAGEMENT OF INDUSTRIAL INVENTORY (Conover-Mast Publication, Inc., 1951), p. 115</td>
<td>25%</td>
</tr>
</tbody>
</table>
The question that is too little understood and too often overlooked in figuring the cost of operation of a distribution business is WHAT DOES IT COST TO CARRY INVENTORY?

Let's look at the total annual cost of carrying inventory as a percentage of the total value of the average inventory. For example, a firm's annual inventory carrying cost would be twenty-five percent (25%) if it cost the company $50,000 in one year to carry $200,000 of average inventory in stock. Does this appear high? Low?16

Foster did not provide answers to these questions, but he did suggest that the twenty-seven cost elements listed in Table 2 be considered when calculating the total cost of carrying inventory. He offered the following explanation of the nature and behavior of these costs.

The above costs are REAL. It may take some time to calculate them for your firm BUT, can you afford NOT to know what YOUR INVENTORY CARRYING COSTS ARE?

While the total costs of carrying inventory are found by adding up the cost elements in the above list, some of these elements may not vary with the amount of inventory carried. That is, some costs will remain relatively "fixed" in the short run, regardless of variations in the levels of inventory stock.17


17 Ibid.
TABLE 2

INVENTORY CARRYING COSTS*

STORAGE SPACE COSTS
(Proportionate share of each)

1. Taxes on land and building
2. Insurance on building
3. Depreciation on building (if owned)
4. Depreciation on warehouse installations
5. Maintenance and repairs of building
6. Utility cost including heat, light and water
7. Janitor, watchman and maintenance salaries
8. Rent (if paid)

HANDLING EQUIPMENT COSTS

9. Depreciation on equipment
10. Fuel for equipment
11. Maintenance and repair of equipment
12. Insurance and taxes on equipment

INVENTORY RISK COSTS

13. Insurance on inventory
14. Obsolescence of inventory
15. Physical deterioration of inventory
16. Pilferage
17. Losses resulting from inventory price declines

INVENTORY SERVICE COSTS

18. Taxes on inventory
19. Labor costs of handling and maintaining stocks
20. Clerical costs of keeping records
21. Employer contribution to social security for all "space", "handling", and inventory "service" personnel
22. Unemployment compensation insurance for all "space", "handling" and inventory "service" personnel
23. Employer contributions to pension plans, group life, health and accident insurance programs for all "space", "handling", and inventory "service" personnel
24. A proportionate share of general administrative overhead, including all taxes, social security, pension and employer contributions to insurance programs for administrative personnel

CAPITAL COSTS

25. Interest on money invested in inventory
26. Interest on money invested in inventory handling and control equipment
27. Interest on money invested in land and building to store inventory (if owned)

*Source: Ronald S. Foster, Ph.D., What Does It Cost to Carry Inventory?, (Washington, D.C.: National Association of Wholesalers)
In this article he recognized that a number of costs are not incremental at the unit of inventory level, that is, they are step variable. Step variable expenses vary with levels of activity, but within a specified range of activities they are fixed. It is necessary to be able to isolate these costs and determine the range of activity over which they remain fixed. For example,

If any inventory space is rented (item 8); or, if the space could be used for other profitable purposes; or, if additional storage facilities are needed, then space costs (items 2 through 8) may be directly affected by the amount of inventory on hand.18

This statement is true in part, but it is more likely that these costs are fixed unless it is possible to close a warehouse. In the case of plant warehouses, the space costs cited by Foster are not relevant since they will continue with or without inventory being held at the plant.

He stated that depreciation on equipment is a cost that continues regardless of inventory, but that it may vary with the "magnitude of inventory held." This assumes, of course, that by having additional inventory the assets will wear out sooner or that more materials handling equip-

18Ibid.
ment will be required which will result in higher depreciation charges. Nevertheless, a clearer presentation of the nature of these costs and the accounting principles involved is required if a manager is to operationalize this concept.

Foster also raised the issue that money invested in inventory has a definite cost to it. He recognized that the going interest rate was not an adequate measure of this cost and consequently recommended that the cost of this money be set at something "slightly higher than its (the company's) usual interest costs" to compensate for the risk involved. Once again, the criticism applies that it is difficult for a manager to operationalize a concept as broad as "slightly higher." What is required is a procedure that illustrates how these costs can be arrived at on a day-to-day operating basis.

If one accepts the principle that it is necessary to include a risk factor in the calculation of the cost of money invested in inventory, that is, to use something "slightly higher" than the current interest rate, then it

---

19 Ibid.
would seem logical that there should also be an opportunity cost associated with the money that is invested in plants and equipment. Foster used depreciation and the interest on the money invested in plants and equipment, but ignored completely the risk factor attached to that investment. He also appeared to neglect the concept of time value of money and did not say what cost, book value, original cost, or some other number, the interest rate should be applied against. It is essential to establish if the various methods of determining inventory investment would significantly change the carrying cost figure. In addition, the opportunity cost of capital might be a more representative cost to the company than the current interest rate or something "slightly higher."

In order to obtain a more thorough understanding of the behavior of these costs, a number of industry publications, as well as the accounting literature, was reviewed. The first of these is a 1973 publication by the Steel Service Center Institute entitled "We Could Save You a Few Thousand Bucks." In this publication, it is suggested that the costs of inventory possession should include thirty-three cost categories listed under seven general
headings as shown in Table 3. Although it is a somewhat more comprehensive list of costs and includes not only depreciation and interest on land, buildings and inventory, but also an "estimated loss of return on capital tied up," the authors seemed to be inconsistent since they did not apply the same "loss of return" concept to handling equipment even though they included depreciation and interest.

It is important to note that the purpose of this publication was to promote Steel Service Centers. Consequently, many of the costs only apply in the case of a company that is trying to determine if it should use its own warehouses or if it should operate through a middleman such as a wholesale distributor. However, even in this specialized case, a number of costs which are included are not relevant to the decision unless the inventory is housed in separate buildings and requires the use of equipment that would not be used to move the materials being shipped to distributors. Likewise, the use of wholesalers would not preclude the need for some plant warehousing and the associated costs would continue.

A third approach to the calculation of inventory carrying costs is offered by Magee and Company, Inc.
TABLE 3

HOW TO FIGURE YOUR OWN COST OF POSSESSION

HIDDEN COSTS OF HOUSING YOUR INVENTORY

1. Depreciation on entire building (or portion of building) used to house your metals inventory.
2. Rent of building space.
3. Heat and other utilities.
4. Janitorial and guard personnel.
5. Routine and special building maintenance and repair (include all supplies, contract work, etc.).
6. Taxes on land and building.
7. Insurance on building and equipment.
8. Liability insurance.
9. Estimated loss of return on capital tied up in land.
10. Profit that could be realized by converting storage space to design, engineering, production, or finished product inventory operations.

CAPITAL COSTS IN YOUR METALS INVENTORY ITSELF

11. Yearly interest on loans made to purchase metals.
12. Estimated loss of return on your own capital tied up in inventory.
13. Tax on metals inventory.
15. Average yearly loss stemming from materials obsolescence, a: ___________.
   Pilferage, b: ___________. Using improper size or grade just because it was in stock, c:
16. Average cost of in-plant metal damage or deterioration.
17. Estimated cost of added fabrication, finishing, and treating caused by inventory dust, dirt, and rust buildup.

COST OF SCRAP

18. Total dollar loss through scrap.

COSTS OF MATERIALS HANDLING AND PRE-PRODUCTION PROCESSING SYSTEMS.

19. Yearly depreciation on materials handling equipment.
20. Depreciation on pre-production processing equipment.
21. Interest on loans for new materials handling or pre-production processing equipment.
22. Electricity, LP gas, oxygen, acetylene, etc., used by materials handling and pre-production processing equipment.
23. Servicing and repairing materials handling and pre-production processing equipment, including tool and die costs.

COSTS OF MANPOWER AND SUPERVISION

24. Yearly cost of employing labor to receive, stack and maintain identity of materials.
25. Labor to move metals to and from pre-production processing operation.
26. Labor to pre-production process metals.
27. Extra accounting hours necessitated by inventory control; maintaining manpower and machine time records.
TABLE 3 (continued)

28. Supervisory cost in inventorying and pre-production processing metals.
29. Estimated yearly cost of top management time spent solving inventory and pre-production processing problems.

DELIVERY COSTS

30. Estimated yearly loss through transportation damage not recovered by claims.
31. Estimated yearly freight car demurrage.

COSTS OF SYSTEM FAILURE

32. Manhours wasted due to stockouts or pre-production processing equipment breakdowns.
33. Estimated cost of lost business, goodwill, or penalties due to late delivery of materials.

OTHER COSTS -- BECAUSE OF YOUR SPECIALIZED OPERATION

34. Itemize them here:

Source: "We Could Save You a Few Thousand Bucks," The Steel Service Center Institute, 1973.
a firm of management consultants. The Magee and Company, Inc., list, which is used by the company staff in inventory management related assignments, includes thirty-six holding costs and is shown in Table 4. The Magee and Company, Inc. report also included a list of thirty "Acquisition Costs" that "possibly increase due to faster turnover of inventory" (Table 5).

These "Acquisition Costs" are analogous to the "Lot Quantity Costs" shown in Figure 1 and illustrate the trade-offs previously discussed.

It should be cautioned that only incremental handling costs should be used. Many of the costs included in Table 5 are fixed in nature and probably would be over the range of activities a company is likely to consider. Unless a reduction in inventory also leads to the elimination of warehousing locations these costs are not relevant for decision making.

Heskett, Glaskowsky and Ivie considered materials handling costs as throughput costs, and for this reason they said that materials handling costs should not be included as a cost of carrying inventory.20 However, if a

**TABLE 4**

**HOLDING COSTS**

Possible Increase Due to Slower Turnover of Inventory

1. Capital tied up in inventory -- limit other projects.
2. Interest on capital tied up in inventory.
3. Loss due to inflation when no selling price increase.
4. Loss due to inability to buy more on later supplier's promotion.
5. Risk of obsolescence -- and markdowns.
6. Greater risk of damage due to overcrowding warehouse.
7. Risk of quality deterioration.
8. More warehouse area required for storage -- capital.
10. More racking required -- capital.
12. Lift man's time in finding open reserve slots.
13. Lift man's time in recording distant reserve location.
14. Lift man's extra travel time in replenishing slots.
15. Lift man's time in taking bottom of 2-item stack.
16. Order picker's time due to crowded warehouse.
17. Order picker's time due to longer selection line.
18. Depreciation on pallets.
19. Depreciation on racking.
20. Depreciation on shelving.
21. Depreciation on warehouse storage area.
22. Maintenance on warehouse storage area.
23. Janitorial expense on warehouse storage area.
24. Lighting expense in warehouse storage area.
25. Heating expense in warehouse storage area.
26. Insurance expense in warehouse storage area.
27. Taxes in warehouse storage area.
28. Insurance expense on inventory.
29. Taxes on inventory.
30. Additional clerical time in verifying IBM counts.
31. Additional time in taking physical inventory.
32. Reduced flexibility in planning store promotions.
33. Increased chance of theft -- crowded or larger warehouse.
34. Crowded reserve may mean more out-of-stock.
35. More time by warehouse supervision in finding open space.
36. More double-handling in unloading operations.

Source: Magee and Company, Inc., "Basic Research on Inventory Turnover and Management for the Wholesale and Chain Grocery Inventory."
**TABLE 5**

**ACQUISITION COSTS**

Possible Increase Due to Faster Turnover of Inventory

| 1. Stock counting time (actual or tubs) |
| 2. Posting count to stock cards or book. |
| 3. Buyer's time to review cards or book. |
| 4. Buyer's time to write P.O. |
| 5. Clerical time to type P.O. |
| 6. Postage to mail P.O. |
| 7. Clerical time to file P.O. in office. |
| 8. Clerical time to file P.O. in warehouse. |
| 9. Receiver's time to check in carrier. |
| 10. Receiver's time to instruct carrier on P.O. |
| 11. Receiver's time to count cases received. |
| 12. Receiver's time to sign out carrier. |
| 13. Receiver's time to put on slot sticker. |
| 14. Lift man's time to put away H.S. item. |
| 15. Lift man's time to put away pallet item. |
| 16. Lift man's time in replenishing pick slot. |
| 17. IBM time to prepare new cards for receipt. |
| 18. Buyer's time to review manifest for receipt. |
| 19. Accounts Payable time to process invoice. |
| 20. Postage to mail check to supplier. |
| 21. Clerical time to file paid invoice. |
| 22. Receiver's time to write up O.S. & D. report. |
| 23. Receiver's time to process claims. |
| 25. Loss of discount or allowance. |
| 26. Slower delivery may mean more out of stock. |
| 27. Loss of gross margin on coming supplier price increase. |
| 28. Faster turnover may mean more outs. |
| 29. Loss of gross margin on coming selling price increase. |
| 30. More slot stickers required (marking pens). |

Source: Magee and Company, Inc., "Basic Research on Inventory Turnover and Management for the Wholesale and Chain Grocery Inventory."
company eliminated a field warehouse it would require a smaller investment in materials handling equipment. This seems to indicate that materials handling costs should only be considered as throughput costs in plant warehouses since elimination of any other company-owned warehouse would reduce these costs.

Ziegler, in a 1973 doctoral dissertation, offered the following general guide to the components of inventory carrying cost:

The costs of holding inventory are all the costs that could be avoided if the firm did not engage in the inventory storage activity, but rather purchased and received the items instantly for use in meeting demand. 21

The assumption present in this statement seems to be that the current order quantities being used by management are so inaccurate that drastic changes in warehouse requirements will take place when a calculated carrying cost percentage is used.

The components of inventory carrying costs advocated

by Ziegler were the costs of: space, utilities and maintenance, material handling, insurance, taxes, cost of physical inventory, shrinkage, and the cost of capital.

He defined space costs as the opportunity cost associated with the use of warehouse space. Utilities and maintenance were defined as the out-of-pocket costs associated with utilities and maintenance. For the materials handling component, he recommended that the standard cost associated with a unit of employee services or a unit of machine services times the appropriate number of hours be used as a component of inventory carrying costs. The insurance and taxes figure associated with holding inventory were defined as the out-of-pocket expenditure made on the inventory investment. Ziegler viewed the cost of physical inventory as the costs associated with taking the inventory count and suggested that the standard cost of employee time plus the out-of-pocket costs for special tags, forms, or current assets be used to formulate this component. He recommended that the average shrinkage be expressed as a percentage of the average inventory and be used as the

22 Ibid., pp. 186-99.
shrinkage component. The last component, the cost of capital, was defined as the average rate of return on corporate capital, or if inventory is viewed as being of lower risk than the rest of the assets of the firm, a charge of something less than the average cost of capital should be used.

The authors heretofore cited have included a number of step variable expenses in the calculation of inventory carrying costs. While many of these costs may change with varying levels of inventory, many of them would remain fixed over the range of inventory reductions or increases being considered by any given company. No consideration has been given to how a company might operationalize the collection of these costs for decision making. In addition, many fixed costs are included that are not relevant for policy making.

John F. Magee, Research Director of the Operations Research Group, Arthur D. Little, Inc., pointed out in a 1956 article in the Harvard Business Review, that the relevant costs are "out-of-pocket" in nature.

The costs shall represent "out-of-pocket" expenditures, i.e., cash actually paid out or opportunities for profit foregone. Overtime premium payments are out-of-pocket;
Depreciation on equipment on hand is not. To the extent that storage space is available and cannot be used for other productive purposes, no out-of-pocket cost of space is incurred; but to the extent that storage is rented (out-of-pocket) or could be used for other productive purposes (foregone opportunity), a suitable charge is justified. The charge for investment is based on the out-of-pocket investment in inventories or added facilities, not on the "book" or accounting value of the investment.

The rate of interest charge on out-of-pocket investment may be based either on the rate paid banks (out-of-pocket) or on the rate of profit that might reasonably be earned by alternative financial policies of the business. In some cases, a bank rate may be used on short-term seasonal inventories and an internal rate for long-term, minimum requirements.

Obviously, much depends on the time scale in classifying a given item. In the short run, few costs are controllable out-of-pocket costs; in the long run, all are.\(^{23}\)

Magee qualified this statement by adding that only out-of-pocket costs or opportunity costs that are affected by the "schedule or plan" should be included.

Many overhead costs, such as supervision costs, are out-of-pocket, but neither the timing nor the size is affected by the schedule. Normal material and direct labor costs are unaffected.

---

in total and so are not considered directly; however, these as well as some components of overhead cost do represent out-of-pocket investments and accordingly enter the picture indirectly through any charge for capital.24

A major question that must be resolved is, "Can depreciation be considered a legitimate inventory expense?" In theory, depreciation reflects the amount of the asset used while obtaining revenue during a period and is required by the matching concept of financial accounting. According to Davidson, "Depreciation is—and must be recognized as being—a cost of doing business, one that nobody can deny."25

Hadley and Whitin supported Magee in his contention that only "out-of-pocket" costs be considered. They also recommended that the opportunity cost—be used for capital tied up in inventory.

...included in these costs are the real out-of-pocket costs such as costs of insurance, taxes, breakage and pilferage at the storage site, warehouse rental if the warehouse is not owned by the inventory system, and the costs of operating the warehouse such as light, heat, night watchmen, etc. A cost which is frequently the most important cost is not a direct out-of-

24 Ibid.

pocket cost but rather an opportunity cost which would never appear on an accounting statement. This is the cost incurred by having capital tied up in the inventory rather than having it invested elsewhere, and it is equal to the largest rate of return which the system could obtain from alternative investments. By having funds invested in inventory, one foregoes this rate of return, and hence it represents a cost of carrying inventory.26

It would seem that the cost of capital should be used as the charge placed against the company's investment in inventory rather than the current interest rate, since it is obvious that a company would not invest in a business venture that would only return the current interest rate. However, the "measure of the cost of capital is far more complex than the accountant's usual notion: he ordinarily thinks of the cost of capital as being the interest expense that appears on the conventional income statement."27

This leads to the two critical questions: (1) What is the cost of capital; and (2) How is it measured?


The Cost of Capital

A precise definition of the cost of capital is elusive; however, Goodman defined it as follows:

The cost of capital refers to that amount of money which a company, as a result of accepting a proposal, is expected to pay to and/or reinvest for the suppliers of funds during the life of the proposal, over and above the amount of funds required to initially finance the proposal.²⁸

He made the point that it is a fallacy to think of the cost of capital as the interest rate plus financing changes since such a position assumes "that the owner's investment, including retained earnings, is cost free."

The measurement of cost of capital is very complex and much confusion is evident in the minds of academicians and businessmen alike. For example, the coupon rate on bonds is not an accurate measure of the cost of debt capital. Also, to measure the cost of debt capital, the impact of the marginal use of debt on the market price of common stock must be estimated. This issue has not been resolved. Basic financial management texts often employ a device commonly referred to as "weighted-average cost

of capital." However, the principal deficiency of this device rests on the assumptions regarding the optimum capital structure, debt and preferred stock capacity, the debt-equity mix, and optimum dividend policy.

Some authors maintain that any project that yields more than the cost of money should be accepted. Horngren cautioned against the use of a short-run approach:

The principal objection to the short-run approach is the insidious effect of low-cost debt financing on projects over a series of years. To illustrate, the cost of 100 percent financing by 6 percent bonds is only 3 percent after applying a tax rate of 50 percent. If unlimited debt could be arranged in a given year, any project with an after-tax return of over 3 percent would be accepted. Next year, the debt limit for an optimum capital structure may already be reached, and equity financing may show a high cost of 20 percent after taxes. This would mean that any project that could not produce such a high return would be automatically rejected.

The reasoning underlying the calculation of a weighted average cost of capital is complex and subject to disagreement....A prime feature of this framework is that cash dividends are the foundation for valuation.

The reasoning underlying the weighted average cost of capital is that by financing in the proportions specified and accepting proposals
that yield more than the average cost, the firm can increase the market price of its stock over the long run.  

Robichek and McDonald recommended using the minimum required rate of return on common stock equity as an alternative to the traditional approach of selecting capital projects because they satisfy a minimum weighted average cost of capital when the discounted cash-flow of return is employed.  

Some authors, including Modigliani and Miller, believe that the cost of capital is independent of the debt-to-equity ratio, but others maintain that the company can establish the optimal capital structure that will minimize the cost of capital. The figure used for the cost of capital will depend on whether the security valuation is made on the basis of investment opportunities, stream of dividends, stream of earnings, or discounted cash flow.


What is required is a straight-forward method of calculating the cost of capital that can be easily understood and applied by businessmen in the development of an inventory carrying cost percentage.

Mao examined the concept of hurdle rate—the rate over which projects will be accepted—as it pertained to a perfect capital market and to capital rationing. Although the real world is probably far removed from a perfect capital market, the concept deserves explanation.

Under perfect capital market conditions the supply of funds to a firm is completely elastic, meaning that there is no limit to the amount of funds that the firm can raise at the prevailing rate of interest. It is reasonable to assume that the firm has already taken advantage of all existing opportunities for profitable investments, so the market rate of interest accurately measures the return on the firm's marginal investments.

In a perfect capital market, firms and security buyers know precisely what present and future cash flows may be expected from any project. So security buyers need not distinguish between stocks and bonds, and there is only one yield on securities, designated here as the rate of interest. Because there is no uncertainty, the firm may justly regard the market rate of interest as the hurdle rate that the IRR of any investment must exceed if the project is to be judged worthwhile.  

However, when a firm's capital is rationed Mao defined the hurdle rate as the rate of return on marginal investments, due to the principle of opportunity cost.

Consider, for example, a firm which pays 10 percent for the funds that it acquires and that, because of capital rationing, is currently turning down marginal investments promising annual returns of 15 percent. For this company the hurdle rate in investment decisions is 15 percent, although the cost of capital is only 10 percent. This means that the relevant time value of money is measured by the return on the most lucrative investments foregone by the firm, rather than by the price at which the funds were originally acquired. Of course, the 15 percent hurdle rate could also be designated as the cost of capital to the firm, if this term is interpreted generically.33

Goodman supported Mao's view concerning opportunity cost. For most pragmatic business decisions, he stated that "capital rationing" was a more meaningful concept than "capital budgeting" and that a weighted average cost of capital was inferior to the concept of opportunity cost. "For most decision-making situations, it is the opportunity calculated cost of capital which is far more

33 Ibid.
important for a given decision than an actual calculated
cost of capital based upon something which happened yester-
day." 34

It is evident from the literature search that there is
not a generally accepted method of calculating inventory
carrying costs. In fact the authors of a 1963 special
report published by the American Production and Inventory
Control Society reached the following conclusion:

Because realistic, dependable inventory carrying
costs are so difficult to determine, a great
deal of reliance seems to be placed on surveys.
These surveys are a great help to the practi-
tioner who is trying to get an absolute value
for this very nebulous cost factor. 35

The Valuation of Inventory

One question that has not been dealt with up to this
point, but one which certainly requires resolution, is
"What method of inventory valuation should be used?"

The position taken on this matter by the American In-
stitute of Certified Public Accountants is as follows:

34 Sam R. Goodman, Financial Manager's Manual and

35 Clifford M. Baumberg, James D. Harty, George W.
Plossl and Oliver W. Wight, Management of Lot-Size Inventor-
ies (Chicago, Ill.: American Production and Inventory
Cost for inventory purposes may be determined under any one of several assumptions as to the flow of cost factors (such as first-in first-out, average, and last-in first-out); the major objective in selecting a method should be to choose the one which under the circumstances most clearly reflects periodic income.36

The statement goes on to say:

Although selection of the method should be made on the basis of individual circumstances, it is obvious that financial statements will be more useful if uniform methods of inventory pricing are adopted by all companies within a given industry.37

However, most companies use one of the following three methods for inventory valuation:

(1) First-in, first-out (FIFO) - Stock acquired earliest is assumed to be sold first leaving stock acquired more recently in inventory;

(2) Last in, first-out (LIFO) - Sales are made from the most recently acquired stock leaving stock acquired in earliest time period in inventory. This method attempts to match the most recent costs of acquiring inventory with sales. LIFO will result in lower inventory valuation and lower profits than the FIFO method in periods of rising prices. The converse is true when prices are declining.


37 Ibid.
(3) Average cost - This method could be a moving-average in which each new purchase is averaged with the remaining inventory to obtain a new average unit price or a weighted average in which the total cost of the opening inventory plus all purchases is divided by the total number of units.

In a 1967 survey of Accounting Trends and Techniques by the AICPA about one-fourth of the 600 companies surveyed used LIFO and about one-third of the companies used FIFO. 38

In times of inflation,

. . . LIFO shows less income than FIFO and thus it tends to postpone outlays for income taxes. Also, the periodic LIFO method permits immediate influencing of net income by timing of purchases, a feature that has not received the attention it deserves.... It should also be recognized that neither FIFO or LIFO isolates and measures the effects of price fluctuations as special managerial problems.

. . . . . . . . . . . . . . . . . . . . . .

Here again we see the benefit of a standard-cost approach. When currently attainable standards are in use, standard costing automatically provides a measure of price "gains" or "losses" that can be reported separately on an income statement. This has two advantages: (a) It prevents price changes from influencing appraisals of

38 Ibid., p. 89.
efficiency in operations; (b) it spotlights and measures the impact of some price changes on overall company results.\textsuperscript{39}

The issue is further complicated by the costing assumption used by the firm. That is, does the company use only direct costs in determining the inventory value or does it use some form of absorption costing?

Direct costing is that method of cost accounting which is based upon the segregation of costs into fixed and variable categories. The fixed-variable cost breakdown is reputed to yield more informative and current financial statements. Under direct costing the fixed costs of production are excluded from inventory values. In absorption costing which Horngren identifies as "the traditional approach" fixed factory overhead is inventoried. Horngren draws an even finer distinction by recognizing four distinct costing possibilities:

1. \textbf{Normal absorption costing}. Includes actual prime costs (direct material and direct labor) plus predetermined variable and fixed manufacturing overhead.

2. **Standard absorption costing.** Includes predetermined prime costs plus predetermined variable and fixed overhead.

3. **Normal direct costing.** Includes actual prime costs plus predetermined variable manufacturing overhead; excludes fixed manufacturing overhead.

4. **Standard direct costing.** Includes predetermined prime costs plus predetermined variable manufacturing overhead; excludes fixed manufacturing overhead.  

The preceding section on inventory valuation tends to support the contention that industry averages of inventory carrying costs will not suffice. This is due to the fact that the various component percentages may not be calculated using comparable inventory valuation systems.

For the purposes of this research, inventory carrying cost percentages will be based on whatever method of inventory valuation is most readily available to the distribution manager. The method of inventory valuation will be documented to enable comparative analysis.

**Availability of the Cost Data**

Inventory carrying costs represent one of the highest costs in physical distribution. In order to make the

---

necessary cost trade-offs within the logistics system an accurate assessment of inventory carrying costs is required. Many authors believe that accurate distribution cost information is difficult to obtain due to the limitations presented by conventional cost accounting.

Perhaps the first and most serious of these problems is the lack of adequate data. By this we mean that distribution costs in most companies are usually too gross and not available in the fine detail needed to conduct an accurate evaluation of alternate distribution methods and systems. Also, many of the costs that should be in view are hidden in vendor invoices and buried in other cost centers such as manufacturing and marketing.41

There is, however, little argument with the proposition that it is necessary to accurately determine inventory carrying costs if a total systems approach is to be taken with regard to distribution management. Cost trade-offs between various elements of the logistics system and between the logistics system and the other functions of a business are basic to the logistics concept. Profits may be increased by reducing inventory and substituting higher

transportation costs or by increasing expenditures within the total logistics system if the improvement in customer service results in more profitable customers. "If cost tradeoffs are at the heart of the logistics concept, then adequate cost information is at the heart of cost tradeoffs."\textsuperscript{42}

**Summary**

The literature contained in the components of inventory carrying cost section indicated that although there have been a number of publications that have produced "laundry lists" of the types of costs that ought to be included in inventory holding costs, no one has addressed the problem of how to rationalize the collection of such costs. Some of the issues that have been ignored are: (1) Is interest expense the true cost of money? (2) To what value of inventory should the cost of capital be applied? (3) Are there different costs that should be considered,

depending on the distribution system used? (4) If the company does not have an established cost of capital figure, how should it determine the relevant percentage?

The evidence supported the contention that just out-of-pocket costs or opportunity costs should be included in inventory carrying costs since in the vast majority of cases, companies must make decisions regarding the volume of inventory held and not whether or not to hold inventory. Fixed costs are not relevant for these type of decisions.

The costs that should be included in inventory will depend to a certain extent on the use to be made of the figure. For example, a number of the costs included in Table 2 and in Ziegler's definition are relevant only if the decision involves the complete elimination of inventory. However, it must be taken as fact that some inventory is required in order to conduct business.

Step variable costs associated with changes in the number of rented or company-owned field warehouses (see Figures 3 and 4) should be considered as changes in warehousing costs of the throughput variety and, as such, they are not related to the storage of inventory (see Figure 1).
FIGURE 3. INVENTORY CARRYING COSTS
All Variable Costs

FIGURE 4. INVENTORY CARRYING COSTS
Some Variable and Some Step Variable Costs
From the literature reviewed in this section the components of inventory carrying cost were determined to be the following costs:

1. Capital Costs
   a. On inventory investment
   b. On investment in assets required by inventory

2. Inventory Service Costs
   a. Insurance
   b. Taxes

3. Storage Space Costs
   a. Plant warehouses
   b. Public warehouses
   c. Rented warehouses
   d. Company owned warehouses

4. Inventory Risk Costs
   a. Obsolescence
   b. Damage
   c. Shrinkage
   d. Relocation costs

Based on the cost of capital section, it was concluded that interest was not the true cost of money, but that the cost of capital should be used to reflect the
the opportunity cost. The rate of return currently being refused on new investments, due to lack of funds, is the investment hurdle rate and this should be used as the opportunity cost of capital for determining inventory carrying costs.

The section on inventory valuation was included in order to investigate the possible methods of inventory valuation. The researcher's conclusion was that the cost of capital should be applied only to the variable manufacturing cost of the products held in inventory at the plant plus variable distribution costs, for those products stored in field warehouses. Allocated costs should not be included in the inventory valuation since these costs will continue regardless of the quantity of product produced and held in inventory.

The brief section on availability and the first section on the components of inventory carrying costs illustrated the importance of accurate cost data and the stated or implied lack of such data in the accounting records of most corporations. The issue of availability was one of the important questions this research attempted to answer since the literature appeared to assume that good accounting data was not present for these costs.
CHAPTER III
RESEARCH DESIGN

The purpose of this chapter is to present the methodology that was developed on the basis of the literature review in Chapter II and to structure the remaining research design so that the methodological framework can be tested using the actual accounting records of six firms with varying distribution policies and product line characteristics.

The chapter has the additional goal of presenting a clear and complete presentation of the methodology so that the research findings can be confirmed or invalidated.

The complete research design is presented in six sections entitled: Development of the Model; Framework for Data Collection; Data Analysis; The Pretest; The Sample; and Interview Procedures. Appendices C, D and E are designed as supplements to this chapter.

Development of the Model

The literature review section was used as the basis for the development of the methodological framework to be
used to determine inventory carrying costs.

The following four basic cost categories must be considered when calculating inventory carrying costs: (1) Capital Costs; (2) Inventory Service Costs; (3) Storage Space Costs; (4) Inventory Risk Costs.

1. Capital Costs

Holding inventory ties up money that could be used for other types of investments. This reasoning holds for internally generated funds as well as funds obtained from outside sources. Consequently, the company's opportunity cost of capital should be used in order to accurately reflect the true cost involved.

The cost of capital used in this research is the hurdle rate concept as presented by Mao.\(^4^3\) It is used for companies experiencing capital rationing which is the rule rather than the exception. Where capital rationing does not exist, the capital invested in inventory should be expected to earn a rate competitive with marketable securities and/or other liquid investments of the firm.

Generally speaking, there are two types of capital costs that should be considered:

**Inventory Investment.**—Many businessmen think that inventory is a relatively liquid and riskless investment. However, this is not the case in most companies since inventory must be maintained in order to obtain sales. The cost of capital should only be applied to the out-of-pocket investment in inventory. Although most companies use some variation of absorption costing for inventory valuation, only variable manufacturing costs are relevant. That is, the cost of capital, the minimum acceptable rate of return on new investments, should be applied only to the variable costs directly associated with the investment in inventory.

**Investment in Assets.**—The cost of capital also should be applied to the investment in physical assets such as materials handling equipment if the amount of investment varies directly with the volume of inventory held and not the quantity of inventory shipped.

2. **Inventory Service Costs**

The inventory service costs are made up of:
Taxes.—Taxes vary depending on the state in which inventories are held. The tax rates can range from zero in states where inventories are exempt to 19.8 percent of the assessed value in Indiana. In general, taxes vary directly with inventory levels.

Unless large changes in the tax rates are expected or major changes in distribution have taken place affecting the states in which inventory is held, it is recommended that the tax component be calculated by using the actual taxes paid during the previous year over the average inventory value during that year and multiplying this value by 100 percent.

Insurance.—Although insurance rates are not strictly proportional to inventory levels since insurance is usually purchased for a specified time period, the insurance policy will be revised periodically based on expected inventory policy changes. Therefore insurance rates may be considered to be variable with inventory levels. Even though this relationship may not be linear over all possible ranges of inventory, it is doubtful that assuming linearity will significantly effect the ultimate carrying cost percentage.
Insurance rates vary depending on the materials used in the construction of the building, its age, and considerations such as the type of fire prevention equipment installed.

3. **Storage Space Costs**

In general there are four types of facilities that should be considered and the treatment is quite different for each one.

**Plant Warehouses**.—The costs associated with plant warehouses are usually fixed in nature, although some variable costs such as the cost of taking inventory and other direct expenses should be included in inventory carrying costs. Fixed charges and allocated costs are not relevant for inventory policy decisions unless the warehouse space could be rented or used for some other productive purpose, if not used for storing inventory.

**Public Warehouses**.—Space in public warehouses is usually rented on a dollar per hundred-weight or on a volume occupied basis. The use of public warehouses is a policy decision made because it is the most economical way to provide the desired level of customer service without incurring excessive transportation costs.
For this reason, the costs associated with public warehouses should be considered as throughput costs and only charges for recurring storage that are explicitly or implicitly included in the rental cost should be considered in carrying costs.

Of course, the capital costs associated with holding inventory in public warehouses must be included in inventory carrying costs. These costs are equal to the variable manufacturing costs plus variable distribution costs multiplied by the opportunity cost of capital.\textsuperscript{44}

**Rented (Leased) Warehouses.**—When warehouse space is rented, it is normally contracted for, and the contract is in force for a specified length of time. The amount of space rented is based on the maximum amount needed for the period of the contract. Thus the rate of incurring warehouse rental charges does not fluctuate from day to day with changes in the inventory level, although the rental rates can vary from month to month or year to year when a new contract is negotiated. Most operating costs are fixed with time although some may vary with the inventory level. In any case, they could be eliminated

\textsuperscript{44}Minimum acceptable rate of return which is the hurdle rate.
by not renewing the contract and are therefore a relevant input for decision making. However, these costs should not be included in inventory carrying costs, but rather in the warehousing costs category (see Figure 1). Their inclusion in inventory carrying costs simply clouds the issue and forces an unnecessary recalculation of the inventory carrying cost percentage with each change in the number of facilities.

Privately Owned Warehouses.—All operating costs that could be eliminated by closing the warehouse or the net savings resulting from a change to public warehouses should be included in warehousing costs and not in inventory carrying costs.

4. Inventory Risk Costs

These costs vary from company to company and include charges for obsolescence, damage, pilferage and relocation of inventory.

Obsolescence.—The cost of obsolescence is the cost of each unit which must be disposed of at a loss because it becomes obsolete. It is the difference between the original cost of the unit and its salvage value. This figure may or may not show up on the profit and loss statement as a separate item. Usually obsolescence results in
an over-statement of the cost of goods manufactured account or the cost of goods sold account. Consequently, some difficulty may be experienced in arriving at this figure.

**Damage.**—This cost should only be included for the portion of damage that is directly attributable to the volume of inventory held. Damage incurred during shipping must be considered a throughput cost since it will continue regardless of inventory levels. Often this figure is identified as the net amount after claims against the carriers.

**Pilferage.**—Shrinkage is an increasingly important problem for American businessmen. Inventory theft in the view of many authorities is a more serious problem than cash embezzlement. It is far more common and involves far more employees and is hard to control. This cost may be more closely related to company security measures than inventory levels, although it will definitely vary with the number of warehouse locations.

**Relocation Costs.**—Relocation costs are associated with transshipment of inventory from one stocking location to another. In most cases they are the result of
tradeoffs between transportation and warehousing costs and are not relevant for inventory holding costs.

The previous year's actual inventory risk costs as a percentage of average annual inventory will be used for analysis in the current period.

This framework has been summarized in Figure 5 which, in addition to illustrating an interpretation of the data required to adequately assess the costs of holding inventory, shows the perceived availability of such data.

**Framework for Data Collection**

It was necessary to obtain the following information in order to accurately determine inventory carrying costs.

1. A documented opportunity cost of capital figure. An interview with the company's controller or someone else with the appropriate background was used to obtain this data. This figure represents the company's minimum acceptable rate of return on new projects.

2. Insurance and taxes on finished goods inventory for the past year or for the budgeted year. The total taxes on finished goods inventory for
Available - but probably the most difficult to obtain
- REQUIRED - Standard costs for each product
- inventory levels for each product
- the company's opportunity cost of capital (minimum acceptable rate of return)

Currently available with minimal effort. Use dollars paid in past year or this year's budgeted cost over average finished goods inventory to calculate percentage.

Available - Only the out-of-pocket costs that are related to the amount of inventory held should be included. Any warehousing costs that can be eliminated or must be added if a warehouse facility is deleted or added are related to throughput and should be included in the warehousing costs category (see Figure 1), not inventory carrying costs.

Available with some effort. Use previous year's numbers as a percentage of the previous year's finished goods inventory as an estimate of the current expense.

FIGURE 5. NORMATIVE MODEL OF INVENTORY CARRYING COST METHODOLOGY
the product group or division being studied was considered to be an adequate measure.

3. Breakdown of warehousing costs both fixed and variable by plant warehouses and field warehouses. In this situation variable costs were considered to be those costs that changed with an increase or decrease in the level of inventory investment.

4. The inventory risk costs associated with finished goods inventory and expressed in dollars for the time period being studied. These costs were comprised of:
   -- obsolescence
   -- shrinkage
   -- damage
   -- relocation costs (if any)

5. Standard manufacturing costs for each product as well as information concerning the costs included in these standards.

6. Average monthly finished goods inventory for each product (either last year's actual or this year's projected).

7. Average annual total finished goods inventory for the past year.
8. Breakdown of where in the system inventory was held, for example:
   -- 33% - field warehouses
   -- 45% - plant warehouses
   -- 22% - in transit


10. Copies of any in-house or consultant's studies in which inventory carrying costs were included or should have been included.

11. Examples of the kinds of decisions in which management used, or expected to use, inventory carrying costs.

12. Time required to obtain this information.

13. Problems involved with implementation of the methodology.

The forms that were used as a suggested format for the data collection are contained in Appendix C. The complete interview guide that was used in this research is included in Appendix D.
Data Analysis

It must be recognized that the data was not collected from randomly selected respondents under controlled experimental conditions. Consequently, standard statistical tests were not applicable. However, the research questions presented in Chapter I required that the data be subjected to analysis and the intended methods for measuring responses are outlined briefly.

Research question number one, which dealt with costs that should be included in inventory carrying costs, was addressed by the literature review and the methodological framework that resulted is shown in the development of the model section of this chapter.

The second research question, which was concerned with the use of the carrying cost percentage, required a study of the types of decisions that would be made using the data. This data was gathered in the personal interviews.

The third research question was concerned with the availability of the cost data from the current accounting records of the companies studied. This was measured using the format shown in Table 6.
TABLE 6

FRAMEWORK FOR RECORDING DATA AVAILABILITY

<table>
<thead>
<tr>
<th>Cost Component</th>
<th>Is the Data Available?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yes</td>
</tr>
</tbody>
</table>

1. 
2. 
3. 
4. 
5. 

In addition, the problems encountered during the data collection were documented.

Research Question four was answered by measuring effort in terms of the time required to collect the data and converting these hours into dollars at the equivalent hourly rate of the person responsible for the annual update.

The fifth research question required analysis of the possible system changes needed to refine the collection process and the costs of implementing such changes. The costs of "fine tuning" the data collection were evaluated by considering the sensitivity of the inventory carrying cost figure to changes in the particular cost component.
Research question six, "will one inventory carrying cost figure accurately reflect the costs for all companies," was "tested" by reviewing the percentages calculated for each company and determining how large the inventory change would have to be to result in a $10,000 difference in the total inventory carrying cost measured in dollars. It was assumed that if a $10,000 or greater difference occurred between two alternatives that economic considerations would be the over-riding factor. However, for situations in which the difference was less than $10,000 non-economic factors may determine the outcome.

The final research question was tested by reviewing prior distribution decisions to determine if their outcomes would be different using the calculated inventory carrying costs rather than the numbers used, or not used, in these studies. Each company was asked to provide two studies from the current accounting period.

The Pretest

The goal of this research was to develop a methodology that was flexible enough to adapt to the needs of as
many types of companies and distribution systems as possible. It was felt that durable, packaged goods and process industries may represent unique situations with regard to distribution systems, accounting practices and the corresponding problems of developing a general working methodology. Before determining a specific sample for the research a pretest was undertaken.

The purpose of the pretest was to attempt to uncover any problems that might be involved with the methodology or in applying it and to obtain first-hand knowledge about the time required to operationalize the methodology within a company.

The company used in the pretest was self-selected, in that the management of the company approached the researcher to obtain help in setting up an inventory carrying cost procedure. The company was in the chemical industry and it soon became apparent that the issue of joint product costs would be a problem associated with companies in the process industry.

Joint cost is the term applied to costs associated with the manufacturing of goods that are produced, usually from a basic raw material using a single process. Typ-
ically these products are not identifiable until a stage of production known as the split-off point or point of separation is reached. Examples of such products include petroleum products and chemicals. Joint costs are the total costs incurred up to the point of separation and because they are not directly attributable to any specific product they must be allocated in a more or less arbitrary fashion.

Since the capital costs were expected to represent by far the largest single component of the carrying costs, the method of allocating the joint product costs would have a direct impact on the magnitude of the holding costs. To accept on faith the allocation currently being made by companies faced with this problem would be capricious, if not irresponsible, and to thoroughly investigate such practices would be a worthy dissertation topic in itself. For this reason it was decided to preclude the process industry from the major portion of this research.

The pretest was conducted over a six-month period which seemed to indicate that the final sample size would have to be small. It was also learned that an interview guide would be necessary in order to facilitate orderly collection of the data.
No problems were encountered in the methodological framework since the costs components included within the framework reflected the cost behavior of the firm associated with changes in inventory levels.

A detailed summary of the researcher's experience with this company is subjected to cursory analysis in Appendix E which is entitled "the pretest."

The Sample

In an effort to generate results that would be generalizable the decision was made to opt for depth rather than breadth and this study was restricted to the manufacturers of packaged goods who sold to consumer or institutional markets.

The six companies included in the research were manufacturers of packaged goods products with the majority of their sales volumes coming from the household consumer market although some of the companies had substantial institutional sales volumes. All of the companies had annual sales of over $1 billion or were divisions of multi-

---

45 Cursory in the sense of accepting the company's joint product allocations without subjecting them to scrutiny.
national corporations with sales volumes in excess of $1 billion annually. Every company included in the research had multiple products that were marketed on a national basis in the United States.

Three of the firms used public warehouses to satisfy 100 percent of their field warehousing requirements and one made exclusive use of leased facilities. Another company used public warehouses and corporate managed facilities on a 50-50 basis. The last company included in the sample used private, leased and public warehouses on a 10 percent, 40 percent, and 50 percent basis, respectively.

In addition to plant warehouses, the number of warehouses used by the respondents ranged from five to over twenty with two companies falling into the last category.

Interview Procedure

Initial contact was made by phone in every case but one in which the manager volunteered the use of his company during a seminar on distribution management. In every case, the primary company contact was established with the senior distribution executive to whom the purpose of the research was explained. This led to the mailing of
a formal proposal which outlined the purpose of the research, the data requirements, the responsibilities of the researcher and the company, and a statement of proprietary interest.

The initial phase was followed up, within two or three weeks, by a visit to the company during which the research was discussed with the senior distribution executive and the corporate financial officer. Typically a lower level staff manager in the distribution area was assigned to work with the researcher on the data collection. In general the entire process took from eight to twelve weeks for each company.

At the end of the research each company received a report documenting the procedure used to collect the data including the sources of this information. The reports which were approximately 50 pages in length included sections on cost tradeoff analysis and a comparison of the calculated carrying cost percentage with the number used by the company prior to this research.

In summary, the research process was comprised of the following steps:
1. Telephone contact

2. Follow-up within a week with a research proposal

3. Initial interview at company with senior distribution executive

4. Follow-up visits to collect cost data

5. Mail report to staff manager assigned to project for his comments

6. Incorporate suggested improvements

7. Mail final report to senior distribution executive
CHAPTER IV

THE FINDINGS

The findings of the research are presented in this chapter. The chapter begins with a summary of the results of the data collection including the number of managers interviewed in each company, the length of time required and some general impressions of management interest towards the topic. The body of the chapter follows the organization of the research questions that were outlined in detail in Chapter I. Facts or other information that appeared confusing are analyzed and explanations are offered for these outcomes. The chapter also includes any unexpected findings and an examination of the differences between the model proposed in Chapter III and the researcher's experience.

General Results

A total of almost 50 interviews were obtained with an average of about eight per company. Interviews ranged in length from fifteen minutes to one-half a day or more
depending on the person being interviewed. Typically a minimum of two hours was spent with the senior distribution executive discussing the parameters of the research.

Without exception, the attitude toward the research topic was enthusiastic and cooperation was evident from all levels of management. Four of the six companies were considering their own studies prior to being contacted by the researcher. In fact, the corporate staff group of one of the companies was conducting its own study on a corporate basis although the divisional vice-president of distribution referred to it as a "less scientific approach" to the problem.

What Costs Should Be Included in Inventory Carrying Costs?

The first research question dealt with the issue of what costs should be included in the calculation of inventory carrying costs. The framework for calculating inventory carrying costs was developed in Chapter III and is explained in detail on pages 59 through 67.
For What Types of Decisions Would Managers Use Inventory Carrying Costs as an Input?

The second research question was concerned with the types of decisions in which inventory carrying costs would be used. The data is summarized in Table 7. Review of the responses indicates that managers believed inventory carrying costs would be most useful as an input to: (1) distribution system design; (2) decisions regarding customer service levels or objectives; (3) balancing production schedules; (4) determining inventory levels and, (5) the analysis of product profitability. In all of the companies interviewed, the senior distribution executive believed that inventory carrying costs are a necessary input to distribution system design.

It should be noted that managers other than those in distribution may find inventory carrying costs to be a useful component in their decision-making. However, the researcher was only involved with the controller and distribution personnel in this study. Consequently, the responses contained in Table 7 may not be representative of total corporate uses for inventory carrying costs.
<table>
<thead>
<tr>
<th>Question: For What Kinds Of Decisions Would You Use Inventory Carrying Costs As A Component?</th>
<th>COMPANY A</th>
<th>COMPANY B</th>
<th>COMPANY C</th>
<th>COMPANY D</th>
<th>COMPANY E</th>
<th>COMPANY F</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. In The Design Of Warehouse And Distribution Systems (Number and Location of Warehouses)</td>
<td>Manager, Material Management Planning and Analysis -Director, Distribution</td>
<td>Manager, Distribution Research -Director, Distribution</td>
<td>Vice-President, Distribution</td>
<td>Director of Distribution</td>
<td>General Manager, Logistics -Manager, Facilities Planning</td>
<td></td>
</tr>
<tr>
<td>2. In The Determination Of Inventory Levels</td>
<td></td>
<td></td>
<td>Director of Systems</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Cost Trade-Off Decisions</td>
<td></td>
<td></td>
<td></td>
<td>Distribution Manager -Inventory Planning Manager</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Determination of Shipment Sizes</td>
<td></td>
<td></td>
<td>Director of Systems</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Plant/Warehouse Expansion</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>COMPANY A</td>
<td>COMPANY B</td>
<td>COMPANY C</td>
<td>COMPANY D</td>
<td>COMPANY E</td>
<td>COMPANY F</td>
</tr>
<tr>
<td>-------</td>
<td>-----------</td>
<td>-----------</td>
<td>-----------</td>
<td>-----------</td>
<td>-----------</td>
<td>-----------</td>
</tr>
<tr>
<td>6. Balancing Production Schedules</td>
<td>Manager, Materials Management Planning and Analysis</td>
<td></td>
<td>Manager, Distribution Planning</td>
<td>Vice-President Distribution Manager, Transportation Services</td>
<td>Inventory Planning Manager</td>
<td></td>
</tr>
<tr>
<td>7. Setting Levels Of In-Process Inventories</td>
<td>Manager, Materials Management Planning and Analysis</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Produce ourselves or contract outside</td>
<td></td>
<td>Manager, Distribution Planning</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. To measure the ability to hedge against inflation</td>
<td>Manager, Materials Management Planning and Analysis</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. E.O.Q. Analysis Of Purchased Materials</td>
<td></td>
<td></td>
<td>Director of Systems</td>
<td></td>
<td>Manager, Facilities Planning</td>
<td></td>
</tr>
<tr>
<td>11. Cost of continuing or discontinuing a product (product line profitability)</td>
<td>Manager, Distribution Research</td>
<td></td>
<td>Manager, Distribution Planning</td>
<td>Manager, Transportation Services</td>
<td></td>
<td>General Manager, Logistics</td>
</tr>
<tr>
<td></td>
<td>COMPANY A</td>
<td>COMPANY B</td>
<td>COMPANY C</td>
<td>COMPANY D</td>
<td>COMPANY E</td>
<td>COMPANY F</td>
</tr>
<tr>
<td>---</td>
<td>-----------</td>
<td>-----------</td>
<td>-----------</td>
<td>-----------</td>
<td>-----------</td>
<td>-----------</td>
</tr>
<tr>
<td>12. New Product Evaluation</td>
<td>- Manager, Distribution Research</td>
<td>- Director of Corporate Development</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14. Evaluation of Price Deals (Since they require inventory build-up)</td>
<td>- Manager, Distribution Research</td>
<td></td>
<td>- V-P, Distribution</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15. Evaluation of Quantity Discounts</td>
<td>- Manager, Distribution Research</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16. Evaluation of any marketing practice that may cause a fluctuation of sales</td>
<td>- Manager, Distribution Research</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Are the Costs of Holding Inventory Currently Available from the Accounting Data of the Companies Studied?

The third research question was concerned with the availability of the cost data from the accounting records of the companies included in the sample. Table 8 shows the 13 cost components and discloses their availability in the six firms. With few exceptions, the data was readily available in each of the companies. One company did not have a specific hurdle rate for new investments and another company, although it used a hurdle rate of 20 percent, was required to pay its corporate head office only 8 percent for money that was invested in inventories. Consequently, the 8 percent figure was used as the division's cost of money.

The inventory investment and the insurance and taxes on the inventory investment were all available although in one company it required three days' work to determine the accurate tax calculation of .460 percent of the inventory value. Since a small percentage error in this number would have little impact on a carrying cost of 30 percent, it was recommended that in the future, the
### Table 8

**Availability of the Cost Components**

<table>
<thead>
<tr>
<th>COST COMPONENT</th>
<th>COMPANY A</th>
<th>COMPANY B</th>
<th>COMPANY C</th>
<th>COMPANY D</th>
<th>COMPANY E</th>
<th>COMPANY F</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Cost of Capital (Opportunity)</td>
<td>Yes^a</td>
<td>Yes</td>
<td>The company did not have a specific hurdle rate and 25% was suggested as a reasonable figure</td>
<td>Yes^a - but company only paid parent 8% on inventory investment so 8% was used as the cost of capital</td>
<td>Yes^a</td>
<td>Yes</td>
</tr>
<tr>
<td>2. Inventory Investment</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>3. Cost of Assets (to support Inventory)</td>
<td>Not Applicable</td>
<td>Not Applicable</td>
<td>Not Applicable</td>
<td>Not Applicable</td>
<td>More closely related to throughput than inventory levels</td>
<td>Inventory only held at plant until shipment can be made. Thus, costs are related to throughput.</td>
</tr>
<tr>
<td>4. Taxes on Inventory</td>
<td>Yes</td>
<td>Estimate - Required 3 days to obtain actual-use inventory of product group as a percentage of total inventory and apply to total taxes paid on inventory</td>
<td>Yes - Multiplied the average value of inventory held at each location by the appropriate tax rate</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>5. Insurance on Inventory</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>COST COMPONENT</td>
<td>COMPANY A</td>
<td>COMPANY B</td>
<td>COMPANY C</td>
<td>COMPANY D</td>
<td>COMPANY E</td>
<td>COMPANY F</td>
</tr>
<tr>
<td>----------------------------------------</td>
<td>--------------------------------------------</td>
<td>--------------------------------------------</td>
<td>--------------------------------------------</td>
<td>--------------------------------------------</td>
<td>--------------------------------------------</td>
<td>--------------------------------------------</td>
</tr>
<tr>
<td>6. Cost of Plant Warehouses (Variable Storage)</td>
<td>Fixed Only&lt;sup&gt;b&lt;/sup&gt;</td>
<td>Fixed Only&lt;sup&gt;b&lt;/sup&gt;</td>
<td>Fixed or related to throughput</td>
<td>Fixed or related to throughput</td>
<td>Plant Outside Storage was occasionally required to handle production surges - this cost should be considered in E.O.Q. analysis</td>
<td>Fixed or related to throughput&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>7. Cost of Public Warehouses (Variable Storage)</td>
<td>Yes</td>
<td>Not Applicable</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>8. Cost of Leased Warehouses</td>
<td>Not Applicable</td>
<td>Fixed Only&lt;sup&gt;b&lt;/sup&gt;</td>
<td>Fixed</td>
<td>Not Applicable</td>
<td>Not Applicable</td>
<td>Not Applicable</td>
</tr>
<tr>
<td>9. Cost of Private Warehouses</td>
<td>Not Applicable</td>
<td>Not Applicable</td>
<td>Fixed</td>
<td>Not Applicable</td>
<td>Not Applicable</td>
<td>Not Applicable</td>
</tr>
<tr>
<td>10. Obsolescence</td>
<td>Not A Factor - product has shelf life of 18 months and inventory turns 12 times/year</td>
<td>Not A Factor - products have shelf life ranging from 4 to 12 months and inventory turns 18 times per year</td>
<td></td>
<td></td>
<td></td>
<td>Not A Factor - the product had a shelf life of 8 months and the inventory turned 5 times per year</td>
</tr>
<tr>
<td>11. Damage</td>
<td>One number - amount net of claims against carriers and public warehouses</td>
<td>Required a managerial judgement to isolate the portion related to the volume of inventory stored</td>
<td></td>
<td></td>
<td></td>
<td>Required a managerial judgement to determine the portion related to the volume of inventory stored</td>
</tr>
<tr>
<td>12. Shrinkage</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>No hard data was available to determine the portion related to storage</td>
</tr>
</tbody>
</table>

<sup>a</sup> Nil - claims are made against carriers and public warehouses for any shrinkage or damage.

<sup>b</sup> Not Available - management estimate was used and procedure recommended to isolate these costs.

<sup>c</sup> Plant Outside Storage was occasionally required to handle production surges - this cost should be considered in E.O.Q. analysis.
### TABLE 8 (continued)

<table>
<thead>
<tr>
<th>COST COMPONENT</th>
<th>COMPANY A</th>
<th>COMPANY B</th>
<th>COMPANY C</th>
<th>COMPANY D</th>
<th>COMPANY E</th>
<th>COMPANY F</th>
</tr>
</thead>
<tbody>
<tr>
<td>13. Relocation Costs</td>
<td>Negligible</td>
<td>Negligible</td>
<td>Not available - management estimate was used and procedure recommended to isolate these costs</td>
<td>Negligible</td>
<td>A managerial judgement was required to isolate the relocation costs that were variable with inventory stored</td>
<td>Negligible</td>
</tr>
</tbody>
</table>

**KEY**

*Yes - Actual Cost Is Available
No - Not Available

*Changed Required - Actual Data Is Available But A Change In Accounting Procedures Is Required (Estimated Cost Of Change Is Shown In Parentheses)*

*Estimate - The Cost Is Not Available In Form Required But Since It Represents Such A Small Portion Of The Total Cost An Estimate Is Made*

*a Post Audit studies are used to substantiate the projected R.O.I.*

*b opinion of warehouse management*

*c inventory was held at the plant only until quality control measures had been assured and then it was shipped*
percentage of total inventory represented by each product group be applied to the total taxes figure, a procedure which would require approximately fifteen minutes.

The cost of assets necessary to support changes in the inventory investment did not appear to be a significant factor for the companies studied. These costs were more closely related to throughput than to the quantity of inventory stored.

The variable costs associated with the volume of inventory held were available in every company; however, the costs of damage and shrinkage and to some extent the cost of obsolescence required managerial estimates. Only one company did not have a record of these costs but the others did require an estimate of the portion attributable to the volume of inventory stored. For example, typically, in addition to the level of inventory, damage is a function of such factors as: throughput; general housekeeping; the quality and training of management and labor; the type of product; the quality of protective packaging; the materials handling system; the number of times the product is handled; and how it is handled. To say which of these factors is most important and how much damage each one
accounts for is extremely difficult, if not impossible. Even an elaborate reporting system may not yield the desired results as employees may try to shift the blame for the damaged products. The quality of screening damage during the receiving function and the fact that higher inventories may hide damaged product until inventories fall may contribute to the level of damage reported regardless of the cause.

One possible method of isolating the damage related to storage would be to graphically plot damage rates over time by warehouse location or use regression analysis with these same data points. Not only would this provide a comparative measure of warehouse management performance but it would allow the study of the relationship of the rate of damage to inventory levels. In the interim management judgments were used.

Relocation costs which are the costs associated with the transshipment of inventory from one stocking location to another were believed to be negligible. In most cases these costs are the result of conscious trade-offs between transportation and warehousing costs and are not relevant for inventory carrying costs.
Documentation of the problems encountered during the data collection was also used to answer this question on availability. Table 9 contains a summary of these problems. Inspection of the data presented in the table reveals that generally there were no problems encountered in the implementation of the methodology. However, in four of the six companies the data on inventory risk costs was not available. Due to the product lines carried by these businesses, inventory risk costs were not a major portion of inventory carrying costs and consequently a managerial estimate had little effect on the final percentage. However, in some industries these costs can be substantial and every effort should be made to accurately assess their magnitude.

How Much Time and Effort Is Required to Accurately Assess the Cost of Carrying Inventory?

The fourth research question was "how much time and effort is required to accurately assess the costs of carrying inventory?" This was answered by measuring effort in terms of the time required to collect the data and converting these man-hours into dollars based on the rate of pay of the person who would be responsible for the
## TABLE 9

PROBLEMS ENCOUNTERED IN DATA COLLECTION

<table>
<thead>
<tr>
<th>Company</th>
<th>Problems Encountered</th>
</tr>
</thead>
<tbody>
<tr>
<td>Company A</td>
<td>None</td>
</tr>
<tr>
<td>Company B</td>
<td>Damage and shrinkage related to the volume of inventory stored required a managerial judgment.</td>
</tr>
<tr>
<td>Company C</td>
<td>The corporate hurdle rate was not established.</td>
</tr>
<tr>
<td></td>
<td>- Data on obsolescence, shrinkage, damage and relocation costs were not available.</td>
</tr>
<tr>
<td>Company D</td>
<td>Damage and shrinkage related to the volume of inventory stored required a managerial estimate.</td>
</tr>
<tr>
<td>Company E</td>
<td>Good data available easily (from existing reports) for all cost components. However, managerial judgments were necessary in order to isolate the percentages of inventory risk costs related to the volume of inventory stored.</td>
</tr>
<tr>
<td>Company F</td>
<td>None. Good data available from existing reports for all cost categories.</td>
</tr>
</tbody>
</table>
annual update of the figure. This data is included in Table 10 and shows that for the six companies studied the annual cost would range from $150 to $300. The senior distribution executive of each of the firms was asked what he would consider to be a reasonable cost to incur to determine inventory carrying costs for his company. These estimates are summarized in Table 11. In all instances the estimated cost of the annual update was much less than the managers' estimates of a reasonable cost to incur. Therefore it is concluded that the data is available at a low cost.

If Any Parts of the Data Are Not Easily Attainable Would the Benefits Derived from Knowing These Costs Exceed the Expenses Involved in Gathering Them?

The fifth research question required that the costs of improving the quality of the data be evaluated by considering the sensitivity of the inventory carrying cost figure to changes in the particular cost component. Analysis of the data in Tables 9 and 10 shows that inventory risk costs was the only area in which the data was not available. However, only in the case of Company D
<table>
<thead>
<tr>
<th>Inventory Carrying Cost Components</th>
<th>Company A</th>
<th>Company B</th>
<th>Company C</th>
<th>Company D</th>
<th>Company E</th>
<th>Company F</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. Capital Costs</td>
<td>40.00%</td>
<td>29.00%</td>
<td>25.50%</td>
<td>8.00%</td>
<td>30.00%</td>
<td>26.00%</td>
</tr>
<tr>
<td>II. Inventory Service Costs</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Insurance</td>
<td>0.09%</td>
<td>0.210%</td>
<td>1.689%</td>
<td>0.058%</td>
<td>0.093%</td>
<td>4.546%</td>
</tr>
<tr>
<td>- Taxes</td>
<td>1.897%</td>
<td>0.440%</td>
<td>0.005%</td>
<td>1.166%</td>
<td>0.028%</td>
<td>0.334%</td>
</tr>
<tr>
<td>III. Storage Space Costs</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Recurring Storage</td>
<td>0.738%</td>
<td>_</td>
<td>0.573%</td>
<td>2.893%</td>
<td>0.456%</td>
<td>2.923%</td>
</tr>
<tr>
<td>IV. Inventory Risk Costs</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Obsolescence</td>
<td>_</td>
<td>_</td>
<td>_</td>
<td>_</td>
<td>_</td>
<td>N/A</td>
</tr>
<tr>
<td>- Damage</td>
<td>_</td>
<td>_</td>
<td>_</td>
<td>_</td>
<td>_</td>
<td>_</td>
</tr>
<tr>
<td>- Shrinkage</td>
<td>_</td>
<td>_</td>
<td>_</td>
<td>_</td>
<td>_</td>
<td>_</td>
</tr>
<tr>
<td>- Transhipment Costs</td>
<td>_</td>
<td>_</td>
<td>_</td>
<td>_</td>
<td>_</td>
<td>_</td>
</tr>
<tr>
<td>Total Inventory Carrying Costs (Before Taxes)</td>
<td>42.959%</td>
<td>30.06%</td>
<td>28.347%</td>
<td>14.203%</td>
<td>32.962%</td>
<td>33.805%</td>
</tr>
<tr>
<td>Average Inventory of Division or Product Group Studied</td>
<td>$10,000,000</td>
<td>$25,000,000</td>
<td>$8,000,000</td>
<td>$500,000</td>
<td>$45,000,000</td>
<td>$2,000,000</td>
</tr>
<tr>
<td>Method of Inventory Valuation</td>
<td>Full Manufactured Cost</td>
<td>Variable Cost Delivered to Customer</td>
<td>Actual Variable Costs of Production</td>
<td>Full Manufactured Cost</td>
<td>Variable Cost Delivered to B.C.</td>
<td>Full Manufactured Cost</td>
</tr>
<tr>
<td>Time Required For Data Collection</td>
<td>15 hours</td>
<td>70 hours but only 20 hours per year required for update</td>
<td>40 hours</td>
<td>30 hours</td>
<td>20 hours</td>
<td>20 hours</td>
</tr>
<tr>
<td>Cost of Data Collection</td>
<td>$150</td>
<td>$300</td>
<td>$300</td>
<td>$225</td>
<td>$150</td>
<td>$200</td>
</tr>
</tbody>
</table>

a) as a percentage of the variable costs delivered to the distribution center. (This allows comparison to be made across all companies.

b) Inventory Carrying Costs were 35.44% of the full manufactured cost.

c) Inventory Carrying Costs were 14.10% of the full manufactured cost.

d) Inventory Carrying Costs were 27.32% of the full manufactured cost.
### TABLE 11
**INVENTORY CARRYING COSTS: THE COST OF COMPILATION**

<table>
<thead>
<tr>
<th></th>
<th>Company A</th>
<th>Company B</th>
<th>Company C</th>
<th>Company D</th>
<th>Company E</th>
<th>Company F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Estimated Cost of Providing An Annual Inventory Carrying Cost(^a)</td>
<td>$150</td>
<td>$300</td>
<td>$300</td>
<td>$225</td>
<td>$150</td>
<td>$200</td>
</tr>
<tr>
<td>Management Estimate Of A Reasonable Cost To Obtain Inventory Carrying Costs(^b)</td>
<td>$1,000</td>
<td>$5,000 max.</td>
<td>$10,000(^c)</td>
<td>Very important but can't provide a value</td>
<td>$2,000</td>
<td>$1,000(^d)</td>
</tr>
</tbody>
</table>

\(^a\) Estimate based on hours required to compile data and the rate of compensation of the person responsible for the annual procedure.

\(^b\) Respondents were replying to the following question:
"What would you consider a reasonable cost to incur in order to obtain an accurate measure of inventory carrying costs?"

\(^c\) "The potential for making a bad decision must be considered"

\(^d\) "It is worth at least a $1,000 to know that you have a solid number"
would even a 50 percent error in the estimate affect the carrying cost to any appreciable extent. Consequently, it would not seem prudent to incur a large expense in an effort to produce accurate figures. Nevertheless, it was recommended that management plot the costs of obsolescence, damage and shrinkage against inventory levels over time. This would enable managers to determine if there was a relationship between each of these costs and the volume of inventory stored.

**Does One Inventory Carrying Cost Percentage Accurately Reflect the True Costs of All Companies?**

In order to test the sixth research question, "does one inventory carrying cost figure accurately reflect the true costs for all companies?" the percentages obtained for each company were reviewed and the change in inventory investment necessary to result in a $10,000 change in total carrying costs was calculated. Table 12 illustrates that the change in inventory that would increase or decrease total carrying costs by $10,000 ranges from $23,000 to $72,000. On this basis it would seem that one inventory carrying cost cannot accurately reflect the true costs of the companies included in this research.
<table>
<thead>
<tr>
<th></th>
<th>Company A</th>
<th>Company B</th>
<th>Company C</th>
<th>Company D</th>
<th>Company E</th>
<th>Company F</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Inventory Carrying Costs</strong></td>
<td>43%</td>
<td>30%</td>
<td>28%</td>
<td>14%</td>
<td>33%</td>
<td>34%</td>
</tr>
<tr>
<td><strong>Change in inventory investment necessary to result in a $10,000 change in total carrying cost measured in dollars.</strong></td>
<td>$23,000</td>
<td>$33,000</td>
<td>$36,000</td>
<td>$72,000</td>
<td>$30,000</td>
<td>$29,000</td>
</tr>
</tbody>
</table>

* figures rounded to nearest thousand
Are the Inventory Carrying Costs Used by the Companies Studied Inaccurate?

The final research question was tested by reviewing prior distribution decisions to determine if their outcomes would have been different using the calculated inventory carrying costs rather than the numbers that were used, or not used, in these past studies.

In order to make any comparison valid the studies had to be from the current fiscal year. Each company was asked to provide two studies but only six studies were obtained in total.

Company A provided two studies that involved changing or closing a warehouse location. In both studies the savings associated with the present warehouse locations were so large that no change resulted when the new carrying cost percentage was used in the analysis. This was due to the way that the previous carrying cost percentage of 9.5 percent had been applied. Management had subtracted inventory carrying cost as an expense and still subtracted inventory carrying cost as an expense and still

469.5 percent after taxes, 19.0 percent before taxes. The company used the after taxes figure although it was being compared with before tax numbers for transportation and warehousing.
expected a satisfactory return on investment on the addi-
tional inventory. This double counting had the effect of
reducing the disparity between the before and after
carrying cost figures.

Company B also provided two studies. The first study
was an evaluation of three warehousing alternatives. The
new carrying cost figure did not change the financial
advantage that was associated with alternative three but
it did change the magnitude of the advantage from $4,000 to
$48,000. It can be argued that for a difference of $4,000
the decision may be made on the basis of non-financial
considerations. However, the $48,000 figure would make
the decision primarily economic.

The second study provided by Company B was a profit-
ability analysis on slow moving items. With the old
carrying cost, the contribution provided by these products
was $13,882. The calculated carrying cost percentage
reduced this contribution to $336. Neither analysis in-
cluded the cost of management time required to control such
inventories. Clearly, the $336 contribution margin
raises more doubts about the future of these products.
The only study that was available from Company C was twelve years old. For this reason, any before and after comparison would be irrelevant.

No studies were available from Company D. Due to conflicting statements from the managers who were interviewed, it was impossible to ascertain with any confidence if no such reports were in existence or if management was reluctant to release these confidential documents.

Company E had one study which met the recency requirement. This was a Warehouse Space Model which simulated the corporation's warehouse requirements. However, it was impossible to know the exact impact of the change in carrying costs without resubmitting the program. Nevertheless, the model had indicated that 580,000 square feet of additional warehouse space was required, at a cost of almost $5,000,000. Consequently, even a 1 percent change in the output would result in a difference of $50,000. The change in inventory carrying costs caused the order interval to change from 2.7 weeks to 2.4 weeks.

Company F also provided one study. It was a report on the profitability of a product line and the new carrying cost figure increased the six-month loss from $18,000 to $24,000.
In summary, it would be reasonable to assume that two of the six decisions could change as a result of using the calculated inventory carrying cost figure and even in the other cases the manager could have more confidence in the decision he made if the calculated percentage was used. Consequently, a statement that "the carrying costs used by the six companies are accurate" would have to be rejected based on the results previously stated. For this reason, it would seem, for the six companies studied, that the current inventory carrying costs were not accurate.

The results are especially encouraging since one would not expect management to disclose those studies in which the decision might change and cause someone a degree of embarrassment. That is, since the studies were selected by the managers they may not be representative.

Other Findings

The major guiding assumption of the study was that the methodology developed in Chapter III could be considered a general framework for determining inventory carrying costs. It is assumed, since no difficulties were encountered applying the methodology in the six companies
included in the research, that the methodology can be considered a general framework at least for companies selling packaged goods to consumer and institutional markets.

One minor problem was experienced in terms of using the carrying cost percentage in E.O.Q. analysis. If the quantity generated from this formula required that additional fixed storage space be added, then the E.O.Q. should be recalculated including the cost of any additional facilities that are necessary. Should the E.O.Q. change appreciably, a number of additional recalculations would be necessary in order to find the best trade-off between order quantity and the additional capital costs.

A Concluding Note

The findings of the research have been presented in this chapter and have followed the organization of the research questions. Chapter V contains a summary of the research questions and findings in addition to the conclusions and suggestions for further research. Consequently, there is no need to review and summarize the findings in this chapter.
The purpose of Chapter V is to present a summary of the research and the major conclusions. The chapter begins with a brief summary of the purpose of the study and the research design. In the next section the research hypotheses and findings are reviewed. The following sections are comprised of the major conclusions, amplifications of the model, and implications for businessmen and academicians. The chapter closes with a section that contains some suggestions for future research.

Summary of Research Purpose and Design

The purpose of this research was to develop a methodology for determining the cost of carrying inventory. A search of the appropriate literature in the areas of accounting, physical distribution and production was required in order to establish which costs should be included in inventory carrying costs. The next step was to determine if these numbers could be extracted, at a
reasonable cost, from the accounting records or management reports of the companies studied. The question of the availability of the data was answered by working closely with the accounting and distribution personnel to develop an inventory carrying cost for each of the companies. A total of approximately 50 interviews were held.

All of the companies that took part in the research manufactured packaged goods for both the household consumer and institutional markets and distributed these products nationally in the United States.

Review of the Research Questions and Findings

In the following sections the findings of the study will be reviewed with respect to each of the research questions posited in Chapter I.

1. From a Theoretical Point of View, What Costs Should Be Included in the Calculation of Inventory Carrying Costs?

The first research question dealt with the costs that should be included in inventory carrying costs. This was answered in Chapter III and the results are summarized in Figure 5 which appears on page 68.
2. For What Types of Decisions Would Managers Use Inventory Carrying Costs as an Input?

The second research question was concerned with the types of decisions in which inventory carrying costs would be used.

The research indicated that there were a number of applications in the areas of distribution, marketing and production. The five most mentioned uses were as an input to: (1) distribution system design; (2) decisions regarding customer service levels or objectives; (3) balancing production schedules; (4) determining inventory levels and, (5) the analysis of product profitability.

3. To What Degree Are These Costs Available from the Current Accounting System?

The third research question dealt with the availability of the cost components from the accounting records of the companies included in the sample.

The data were available for capital costs, insurance, taxes, and variable storage costs. However, one company did not have data for the costs of obsolescence, damage and shrinkage and in three of the other companies, managerial estimates were necessary in order to isolate the
portion of some or all of these costs components that was related to the volume of inventory stored.

Although these costs were relatively insignificant when compared to the total inventory carrying cost percentage, they do represent a potentially large absolute number of dollars and they deserve the close attention of management.

4. How Much Time and Effort Is Required to Accurately Assess These Costs?

The fourth research question was concerned with the time and cost required for the data collection.

For all six companies the cost of annually updating the carrying cost figure was estimated to be less than $300 and the estimates ranged from $150 to $300. These figures were based on data collection experience in the companies and the rate of pay of the person or persons responsible for the annual update. In each case this projected cost was less than what the senior distribution executive indicated was a reasonable amount to spend. When asked what they thought was a reasonable cost to incur to obtain an inventory carrying figure for their companies, the costs ranged from $1,000 to $10,000.
Some caution should be exercised in viewing the $300 data collection expense as the absolute maximum. This is due to the fact that the $150 to $300 range experienced in this study assumes a certain level of sophistication in terms of the accounting data available within the company. In a less sophisticated company it is conceivable that substantial additional effort may be required in order to accurately trace some of the cost components. For example, in situations in which inventory risk costs represent a substantial proportion of the total inventory carrying costs a managerial estimate of the proportion of these costs related to the level of inventory held would not suffice. Consequently, it would be necessary to implement a reporting system that would accurately reflect these costs.

5. If Any Parts of the Data Are Not Easily Attainable Would the Benefits Derived from Knowing These Costs Exceed the Expenses Involved in Gathering Them?

The fifth research question required that the costs of improving the quality of the data be evaluated by considering the sensitivity of the inventory carrying cost
figure to changes in the cost components in which estimates had been used.

In only one case would even a 50 percent error in the estimate used affect the carrying cost to any appreciable extent. Consequently, it would not seem prudent to incur a large expense in an effort to produce accurate figures for inventory risk costs. Nevertheless, it was recommended that management plot the costs of obsolescence, damage and shrinkage against inventory levels over time to determine if there was a relationship between each of these costs and the volume of inventory stored.

6. Will One Inventory Carrying Cost Figure Accurately Reflect the True Costs of All Companies?

The sixth research question sought to determine if one carrying cost percentage, for example 25 percent, would accurately reflect the costs for all companies. The results suggest that each company should calculate its own figure since individual carrying cost percentages ranged from a low of 14 percent to a high of 43 percent.

7. Are the Inventory Carrying Costs Used by the Companies Studied Inaccurate?
The seventh research question was concerned with management decisions and how an inventory carrying cost figure developed from the company data might result in different outcomes than those obtained using the company's present figure.

Six studies were obtained from the companies in the sample and in two of the six cases the outcomes varied enough to change the decision and in only one situation was the change relatively insignificant. Consequently, it would appear that the current figures were not accurate and that each company should calculate its own inventory carrying cost percentage.

**Major Conclusions**

The major conclusions and implications of the research are presented in this section.

1. The major contribution of this research is the methodology that was developed in Chapter III. The existing accounting literature was distilled into a methodology that can be applied in a business setting. The framework is conceptually sound and represents an improvement over most previous attempts to quantify this
figure. This framework was based on existing knowledge in the fields of accounting, distribution, finance and production. In addition, the methodology addressed the issue of inventory valuation and as such represents a unique contribution to the literature. Since the inventory-carrying cost percentage has to be applied to an inventory figure, the determination of an accurate inventory value is a critical factor. The cost of money only should be applied to the direct variable costs associated with the manufacture and delivery of the product to the storage location. Any costs that are not variable with the number of units manufactured and delivered should be treated as period costs and not built into the inventory value.

2. The second conclusion of the study is that inventory carrying costs are a necessary input to a number of important management decisions in the areas of distribution, marketing and production, as well as management control applications. The specific uses mentioned most often by the executives who participated in this study were as an input to: (1) distribution system design; (2) the setting of customer service objectives and service
levels; (3) balancing production schedules; (4) determining inventory levels and (5) the analysis of product profitability.

3. The third conclusion of the research is that the methodology developed can be used by managers to determine inventory carrying costs specifically geared to their firm and this can be achieved at a low cost.

4. The fourth conclusion is that it is important for each firm to determine its own carrying costs. It was established that carrying costs do have the ability to change a management decision if the wrong number is used. Table 13 summarizes the before and after carrying costs for the six companies studied and these two numbers are substantially different for each company. There was also considerable variation in the figures that were calculated for each of the companies.

Not only were the company generated figures not accurate, but in all of the companies the percentage was not applied to the correct value of inventory and in some instances the concept was improperly applied. For example, one mistake was using an after tax inventory carrying cost percentage and comparing the number obtained
TABLE 13
BEFORE AND AFTER CARRYING COSTS AND METHOD OF DETERMINING INVENTORY INVESTMENT

<table>
<thead>
<tr>
<th></th>
<th>COMPANY A</th>
<th>COMPANY B</th>
<th>COMPANY C</th>
<th>COMPANY D</th>
<th>COMPANY E</th>
<th>COMPANY F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inventory carrying cost</td>
<td>9.5%*</td>
<td>15%</td>
<td>20%</td>
<td>8%</td>
<td>25%</td>
<td>15%</td>
</tr>
<tr>
<td>percentage used prior to</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>this research</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inventory carrying cost</td>
<td>35%</td>
<td>30%</td>
<td>28%</td>
<td>14%</td>
<td>33%</td>
<td>27%</td>
</tr>
<tr>
<td>percentage calculated</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>during this research</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Value of inventory to</td>
<td>Full Manu-</td>
<td>Variable</td>
<td>Variable</td>
<td>Full Manu-</td>
<td>Variable</td>
<td>Full Manu-</td>
</tr>
<tr>
<td>which number is applied</td>
<td>factured</td>
<td>cost delivered</td>
<td>costs of</td>
<td>factured</td>
<td>cost delivered</td>
<td>factured</td>
</tr>
<tr>
<td>Cost</td>
<td>Cost</td>
<td>to the distribution center</td>
<td>production</td>
<td>Cost</td>
<td>to the distribution center</td>
<td>Cost</td>
</tr>
</tbody>
</table>

*Although 9.5% was the after tax number the company had been using it as a before taxes figure in the cost tradeoff analysis.*
with the before tax dollars paid for transportation and storage. Another misapplication was using the inventory carrying cost and return on investment analysis in tandem. Appendix F contains an example of such an error in application of the carrying cost figure. Table 15 illustrates one way of judging alternative distribution systems.

Although obsolescence, shrinkage and damage were not major factors for the companies included in this study, the cost of shrinkage accounted for approximately one quarter of the carrying costs for the chemical company in the pretest, the results of which are included in Appendix E.

5. The fifth conclusion is concerned with the number of carrying cost percentages that each company must calculate. That is, in the case of a company with a relatively homogeneous product line and a twelve-month inventory plan, it would appear that one figure may be possible for all of its products. This figure would require updating on an annual basis when the new inventory plan, updated cost information and the previous year's or projected expenditures for insurance and taxes become available. However, for companies with heterogeneous
<table>
<thead>
<tr>
<th>Lot Quantity Costs</th>
<th>Alternative A</th>
<th>Alternative B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plant to Warehouse Expense</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Warehouse Expenses</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Freight to Customer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inventory Carrying Costs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cost of Back-orders, etc.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Choose least cost alternative.

\[a\] In product line profitability analysis subtract inventory carrying cost from product line contribution to determine net contribution.
products, it seems to be necessary to calculate an inventory carrying cost figure for each product.

6. The sixth conclusion is that for E.O.Q. analysis a slight modification is required in the application of the methodology. For this type of analysis, if the E.O.Q. required that additional fixed facilities be added or any other step-variable cost must be incurred, the formula should be reworked adding the new incremental costs to the inventory carrying costs. Such a procedure would allow management to test the sensitivity of the calculation to the carrying costs and make the necessary tradeoff between the order quantity and the amount of the additional capital expenditure.

Amplifications of the Model

Although no problems were encountered in applying the methodology in the six food product manufacturers, each of the companies had a reasonably sophisticated data base from which to work. In some firms it is conceivable that a substantial expenditure may be required to develop a reporting system that will provide accurate data. For example, managerial judgments concerning the portion of
inventory risk costs that is related to inventory levels would not suffice when obsolescence, damage, shrinkage, and transshipment costs represent a significant part of the total carrying costs. In the food products business these costs represented such a small percentage of the total carrying costs that large errors in personal judgment would not affect the outcome significantly. However, in other industries it may be necessary to trace these costs by initiating new management reports.

In addition, some changes in the methodology and in the updating procedure may be required if management wants the model to more closely reflect the needs of a particular company. This could be accomplished in a number of ways. For example, the methodology could be updated on a more frequent than annual basis in order to make the percentage more current. More frequent updating would enable management to adjust the percentage to reflect changes in cost components such as the obsolescence, shrinkage, damage, and the hurdle rate.

Furthermore, if budgeted costs are available, they may provide a more current input to the carrying cost percentage than actual costs from the previous fiscal
year. If management wanted to "fine tune" some of the cost components, regression analysis could be used as a means of determining the relationship between the amount of inventory held and cost components such as: variable storage costs, obsolescence, damage, shrinkage, and relocation costs. This would be a less expensive alternative to developing more elaborate reporting systems and the results may be as useful in refining the costs.

Refinements also may be required in order to incorporate certain special business situations such as those present in the canning industry. The product must be packed when the fruits and vegetables are available and inventories are built up on a seasonal basis to support sales throughout the year. Typically, in these cases, short-term money is used to finance the inventory investment and the loan is repaid as inventory is liquidated. Consequently, the short-term rate of interest paid by the company is the relevant cost of money since the hurdle rate concept assumes that long-term financing is being used. Short-term inventory financing is not in direct competition with projects requiring long-term financial commitments and the hurdle rate concept is not applicable.
A further amplification of the model would be to use it in "what if" kinds of analysis. Managers may want to determine the effects of changes in such factors as product mix, transportation mode, packaging, and shrinkage on the carrying cost percentage and the resulting trade-off analysis.

Implications

The research has a number of implications for businessmen and academicians. Based on the findings, it would seem prudent for managers to use inventory carrying costs as a component in a number of distribution, marketing and production decisions. These costs should be generated internally for each company on an annual basis.

Once obtained, the carrying cost will be a vital component in the analysis to establish the firm's distribution policies. Discovering the company's actual carrying costs also could result in changes in ordering quantities, manufacturing quantities, and even in the products manufactured and sold. In fact, one of the companies included in this research used the methodology to calculate carrying costs for raw materials inventories and work-in-process inventories. The cost of carrying
raw materials should be charged against the purchasing department. In times of inflation the purchasing executive may be motivated to buy and store excessive quantities of raw materials or component parts if he is not expected to compare inflationary inventory gains to the cost of holding this inventory.

Potential uses of inventory carrying costs that were not suggested by the managers interviewed during this study but which have implications for management decision-making are outlined briefly. One possible application that shows particular promise is as an input to the estimation of the potential profitability of new products. Carrying costs also can be considered as an expense to profit centers within the sales department and as an input to customer profitability analysis. Finally, applications of the carrying cost percentage in retailing and wholesaling include department and product profitability analysis.

The fact that an incorrect inventory carrying cost can result in a different management decision would seem to indicate that corporate profitability can be enhanced by proper documentation and application of this figure.
However, since inventory acts as a buffer between marketing, production and distribution, there may be some managers who do not want to know the costs of carrying inventory. If inventory is considered to be a free good in the sense that none of the three functional areas are responsible within the corporation for managing the costs of holding inventory, it is easier for a manager to control the costs for which he has responsibility. That is, the marketing manager has a better chance of meeting sales objectives if inventory costs are not assigned to him. Similarly, it is less difficult for a production manager to achieve low production costs if he is permitted at no cost to build inventories by using long production runs. The distribution manager who is rewarded for reducing transportation costs can accomplish this by increasing in-transit and warehouse inventory if inventory is not his responsibility.

The above scenario indicates that there may be a need for academicians and management to educate many managers to the total cost concept. If inventory carrying costs are to reach their full potential as an input to decision-making, the reward and punishment systems of
many companies will require modification in order to make managers responsible for actions that impact on inventory levels within the firm.

**Suggestions for Future Research**

This research represents a substantial break-through in the area of distribution costs and management of these costs. It would appear that data exists to enable management to make better distribution decisions.

The following paragraphs address the possible directions of future research in the area of inventory carrying costs.

1. Since this study only included the manufacturers of packaged goods, future research should broaden the sample to include other manufacturing groups (Table 15 shows one possible grouping), retailers and wholesalers.

2. Considering the response to the topic received from industry during this study, it may be possible to contact a statistically valid sample of companies and allow them to apply the methodology themselves. The problems of implementation, if any, the results and perceived uses could be recorded by survey using a
questionnaire. This would remedy the problem of generalizability.

**TABLE 15**

A FRAMEWORK FOR FUTURE RESEARCH

<table>
<thead>
<tr>
<th>Type of Manufacturer</th>
<th>Markets</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Consumer</td>
</tr>
<tr>
<td>Durables</td>
<td></td>
</tr>
<tr>
<td>Packaged Goods</td>
<td>xxxxxxx</td>
</tr>
<tr>
<td>Process</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
</tr>
</tbody>
</table>

3. A longitudinal study over a broad range of applications and companies with a possible post-audit of results would act as further documentation of the importance of these costs and their ability to change management decisions.

4. The area of customer service looks particularly attractive for future study. Now that the evidence indicates that inventory carrying costs are available at
a low cost, attention must be directed towards the costs associated with lost sales. The costs related to various levels of customer service are still a "black box" and these costs are an important input to the cost tradeoff analysis.
APPENDICES
APPENDIX A

E.O.Q. FORMULAS
The "Sawtooth" Diagram:

$\frac{Q}{2} = \text{Average Inventory}$

Graphic Representation of E.O.Q.:

$TC = \frac{Q}{2} CI + \frac{R}{Q} S$

$CC = \frac{Q}{2} CI$

$OC = \frac{R}{Q} S$

Size of Q
E.O.Q. and Total Cost Equation

\[ Q = \sqrt{\frac{2RS}{CI}} \]

Total Cost = \( \frac{Q}{2} CI + \frac{R}{Q} S \)

Average Inventory = \( \frac{Q}{2} \)

Number of Orders Per Year = \( \frac{R}{Q} \)

Where:

- \( Q \) = the most economical quantity to order
- \( R \) = annual demand
- \( S \) = cost of placing each order
- \( C \) = cost price or value of the item
- \( I \) = imputed inventory carrying cost
The "Flow" Model

"Sawtooth" Diagram

\[ Q = \sqrt{\frac{2RS}{CI(1 - \frac{U}{P})}} \]

Total Cost = \( \frac{Q}{2} CI(1 - \frac{U}{P}) + \frac{R S}{Q} \)

Average Inventory = \( \frac{Q}{2}(1 - \frac{U}{P}) \)

Number of Orders Per Year = \( \frac{R}{Q} \)

Where:

- \( U \) = rate at which inventory is "flowing" out
- \( P \) = rate at which inventory is "flowing" in
SENSITIVITY OF E.O.Q. FORMULA
TO INVENTORY CARRYING COSTS*

Total Cost curve is relatively flat for volumes one-quarter larger or smaller than the exact E.O.Q.

Example: Annual usage: 25,000 pieces
Ordering costs: $100
Cost per piece: $14
Inventory Carrying Cost: 20 percent

\[
\text{E.O.Q.} = \sqrt{\frac{2 \times 25,000 \times 100}{14 \times 0.20}}
\]

\[
= 1,336
\]

Therefore the item should be bought in quantities of between 1,000 and 1,700 units.

"It won't matter much where, in between, you set the quantity."

An Inventory Carrying Cost of 35.5% yields an E.O.Q. of 1000 units.

An Inventory Carrying Cost of 12.5% yields an E.O.Q. of 1700 units.

APPENDIX B

AN ILLUSTRATION OF THE IMPORTANCE

OF INVENTORY CARRYING COSTS
AN ILLUSTRATION OF THE IMPORTANCE
OF INVENTORY CARRYING COSTS

Problem: Should a public warehouse be utilized in Columbus, Ohio?

<table>
<thead>
<tr>
<th>Cost to Company*</th>
<th>Using Public Warehouse</th>
<th>Shipping Direct Customer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freight to Public Warehouse from Plant</td>
<td>$34,705</td>
<td>---</td>
</tr>
<tr>
<td>Warehousing Costs</td>
<td>22,529</td>
<td>---</td>
</tr>
<tr>
<td>Freight to Customer</td>
<td>93,280</td>
<td>$162,900</td>
</tr>
<tr>
<td>Total Cost without Consideration for Inventory Carrying Costs</td>
<td>$150,514</td>
<td>$162,900</td>
</tr>
<tr>
<td>Inventory Carrying Cost (38% on additional inventory of $63,000)</td>
<td>$23,940</td>
<td>---</td>
</tr>
<tr>
<td>Total Cost when Inventory Carrying Costs are Included</td>
<td>$174,454</td>
<td>$162,900</td>
</tr>
</tbody>
</table>

NOTE: When the cost of carrying inventory is not considered it is clear that using the services of a public warehouseman is desirable and results in a $12,386 cost savings. However, when inventory carrying costs are included in the calculation the decision to ship directly from the plant to the customer results in a cost savings of $11,554.

*Assumptions: All figures used in this example are before-tax numbers. Customer Service is at the same level for both alternatives. Lot Quantity Costs do not change appreciably between the two alternatives.
APPENDIX C

SUGGESTED FORMAT FOR DATA COLLECTION
WAREHOUSING COSTS (FINISHED GOODS)

<table>
<thead>
<tr>
<th>Nature of Cost*</th>
<th>(Warehouse Location)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Payroll</td>
<td></td>
</tr>
<tr>
<td>Labor - Direct</td>
<td></td>
</tr>
<tr>
<td>Overtime</td>
<td></td>
</tr>
<tr>
<td>Shift Premium</td>
<td></td>
</tr>
<tr>
<td>TOTAL PAYROLL</td>
<td></td>
</tr>
<tr>
<td>DIRECT (Variable EXPENSES)</td>
<td>(Fixed TOTAL</td>
</tr>
<tr>
<td>INSURANCE Stock</td>
<td></td>
</tr>
<tr>
<td>Fire Plant</td>
<td></td>
</tr>
<tr>
<td>TAXES</td>
<td></td>
</tr>
<tr>
<td>DEPRECIATION</td>
<td></td>
</tr>
<tr>
<td>TOTAL INSURANCE, TAXES &amp; DEPRECIATION</td>
<td></td>
</tr>
<tr>
<td>TOTAL BEFORE ALLOCATIONS</td>
<td></td>
</tr>
</tbody>
</table>

**ALLOCATIONS**

<table>
<thead>
<tr>
<th>Basis for Allocation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supervision &amp; Benefits</td>
</tr>
<tr>
<td>Plant Administration</td>
</tr>
<tr>
<td>Plant Floor Space</td>
</tr>
<tr>
<td>Electricity</td>
</tr>
<tr>
<td>Water</td>
</tr>
<tr>
<td>Light</td>
</tr>
<tr>
<td>Steam</td>
</tr>
<tr>
<td>Compressed Air</td>
</tr>
<tr>
<td>Maintenance</td>
</tr>
<tr>
<td>TOTAL</td>
</tr>
</tbody>
</table>

*Fixed or variable
## Inventory Service Costs - 197-

<table>
<thead>
<tr>
<th>COST CATEGORY</th>
<th>PERCENTAGE OR DOLLAR AMOUNT</th>
<th>SOURCE</th>
<th>TIME REQUIRED TO OBTAIN DATA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insurance</td>
<td><strong>Inventory in Plant Warehouses</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Based on inventory (average monthly) of approximately $____</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>$____% of inventory values.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Taxes</td>
<td><strong>Summary</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Warehouses</strong></td>
<td><strong>Taxes</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>A</td>
<td>$____</td>
<td></td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>$____</td>
<td></td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>$____</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Public</td>
<td>TOTAL</td>
<td>$____</td>
</tr>
<tr>
<td></td>
<td>Taxes as a Percent of Inventory = $____</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cost of Capital</td>
<td><strong>Cost of Capital = $____</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Inventory at Full Factory Cost = $____</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Variable Cost = $____% of Full Cost</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- The Cost of Capital should only be applied to the variable portion of inventory cost</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
19L FINISHED GOODS INVENTORY PLAN

(in thousands of dollars of Factory Cost)

<table>
<thead>
<tr>
<th>Products</th>
<th>January</th>
<th>February</th>
<th>March</th>
<th>April</th>
<th>May</th>
<th>June</th>
<th>July</th>
<th>August</th>
<th>September</th>
<th>October</th>
<th>November</th>
<th>December</th>
<th>Monthly Average</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Total Finished Goods Inventory/Month</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td>PRODUCTS</td>
</tr>
<tr>
<td>----------</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>
197- AVERAGE MONTHLY FINISHED Goods Inventory Plan
(Public Warehouses Only)
(in thousands of dollars)

<table>
<thead>
<tr>
<th>PRODUCTS</th>
<th>Average Monthly Inventory in Public Warehouses</th>
<th>Variable Cost of Distribution as a Percentage of Variable Factory Cost</th>
<th>Total Variable Cost of Distribution</th>
<th>Total Variable Distributed Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(A) Total System Inventory at Total Factory Cost = $ $
(B) Inventory Held at Public Warehouses = $ at Factory Cost \([(A) \times \$]$
(C) Distributed Cost of (B) at Variable Cost = $
(D) Variable Distributed Cost as a Percentage of Total Factory Cost
\[ \frac{(C)}{(B)} \times 100\% = \$ \]
### AVERAGE MONTHLY FINISHED GOODS INVENTORY PLAN

(in thousands of dollars)

<table>
<thead>
<tr>
<th>PRODUCTS</th>
<th>Average Monthly Inventory at Full Factory Cost</th>
<th>Percentage of Factory Costs That are Variable</th>
<th>Average Monthly Inventory at Variable Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Total Finished Goods Inventory/Month</th>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

VARIABLE COST AS A PERCENTAGE OF FULL FACTORY COST

\[
\times \frac{A}{B} \times 100 = \% \]

<table>
<thead>
<tr>
<th>Total Finished Goods Inventory/Month</th>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Calculation of Variable Costs Associated with System Inventory

<table>
<thead>
<tr>
<th>Segment</th>
<th>Approximate Percent of Total Inventory</th>
<th>Percent Variable Cost</th>
<th>Weighted Percentage (Variable Costs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Public Warehouses</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plants Released</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plants Non-Released</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>In-Transit</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Therefore, of the approximately $\frac{\_\_\_\_\_\_\_}{\_\_\_\_\_\_\_\_}$ of system inventory, about $\frac{\_\_\_\_\_\_\_}{\_\_\_\_\_\_\_\_}$ of that value represents direct variable costs tied up in inventory.

1. Weighted Average of Variable Costs Associated with System Inventory
APPENDIX D

INTERVIEW GUIDE
1. Company Background

   Product Line

   Sales
   Customers

Distribution
   a. Number of Warehouses, Public, Private, Plant
   b. Amount of Finished Goods Inventory Held at Each Location

Organizational Structure
2. What would you consider a reasonable cost to incur in order to obtain an accurate measure of inventory carrying costs?

| Person | Response |
1. Does your company have an established cost of capital?

2. How do you calculate it?

3. What is the current return expected on new investments?

4. Do you think that this return should also be expected from investments in inventory?
<table>
<thead>
<tr>
<th>Data</th>
<th>Source</th>
<th>Time Required To Obtain Data</th>
<th>Value ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Insurance and taxes on inventory for the past year.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Breakdown of warehousing costs both fixed and variable by plant warehouses and field warehouses.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Inventory risk costs (expressed in dollars for the past year)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- obsolescence</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- shrinkage</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- damage</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- relocation costs (if any)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Standard manufacturing costs for each product.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Average monthly finished goods inventory for each product (either last year's actual or this year's projected)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Average annual total finished goods inventory for the past year</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Breakdown of where in the system inventory is held, for example:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>33% - field warehouses</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>45% - plant warehouses</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>22% - in transit</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Current inventory carrying cost and method of calculation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(if used)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(also obtain explanation for costs included)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cost Component</td>
<td>Yes</td>
<td>No</td>
<td>With modification state change</td>
</tr>
<tr>
<td>--------------------------------------</td>
<td>-----</td>
<td>----</td>
<td>---------------------------------</td>
</tr>
<tr>
<td>1. Cost of Capital (Opportunity)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Inventory Investment</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Cost of Assets</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(to support Inventory)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Taxes on Inventory</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Insurance on Inventory</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Cost of Plant Warehouses</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Variable Storage)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Cost of Public Warehouses</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Variable Storage)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Cost of Rented Warehouses</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Cost of Private Warehouses</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. Obsolescence</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. Damage</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12. Pilferage</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13. Relocation Costs</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
USES OF INVENTORY CARRYING COSTS

1. For what kinds of decisions would you use inventory carrying costs? Why?

2. Do you have copies of any studies to which inventory carrying costs were used?

3. Can you relate any decisions in which inventory carrying costs were considered?

4. Title of Person Responding
SUMMARY

A. Who will have the task of updating the inventory carrying cost figure?

B. Estimated time to complete

C. Rate of Compensation?
APPENDIX E

THE PRETEST
THE PRETEST

The company selected for the study was in the chemical industry, had sales in excess of $1 billion and over $150 million invested in inventories. Its products were sold directly from company plants and through nine public facilities and one company-owned facility.

Due to the vastly different nature of bulk chemical products in terms of storage requirements, shrinkage, terminal locations and because of the absence of an inventory forecast, it was necessary to determine an inventory carrying cost figure for each major product or class of products. There was an additional problem caused by the fact that the selling price per ton, the full factory cost and variable costs per ton varied by plant and also varied within a plant throughout the year.

For the purposes of the study, two products were chosen in consultation with management from the chemicals manufactured by the industrial chemicals division. The one product was selected because it had a relatively low variable cost of production and the other was chosen because its variable cost of production represented a substantially
higher percentage of the full manufactured cost. The two products selected were representative of the range of products manufactured by the company in terms of cost, shipping and storage requirements. Since the variable costs of transportation would be different for each stocking point, inventory carrying costs were calculated as a percentage of variable costs so that the figure could be applied to inventory held at any location. At the time of the study the company did not have an established inventory carrying cost figure and did not consider these costs when making distribution decisions.

Data Collection

1. Capital Costs (Cost of Money Invested in Inventory)

   This figure represents the corporation's opportunity cost of capital. The company's minimum attractive rate of return on new investments was applied to the investment in inventory.

   An interview with the controller revealed that a 20 percent return after taxes was required on new investments
of over $500,000. As a result of this meeting, it was established that the opportunity cost of capital to be applied to inventory investment would be 20 percent after taxes or 40 percent before taxes. The latter made it comparable to the other expenses, such as transportation and terminal expenses, considered in the logistics system tradeoff analysis. The opportunity cost of capital should only be applied to the "out-of-pocket" investment in inventory. The first step in the analysis of these out-of-pocket costs was to determine the standard variable costs of each product and to express these costs as a percentage of average net back per ton.\(^1\) Since all monthly warehouse inventory valuation reports contain average net back, this figure was also used and all components of inventory carrying costs were expressed as a percentage of average net back per ton. However, depending on where the inventory is held, the variable costs as a percentage of average net back per ton may change. For example, transportation costs should be added to field inventory.

The inventory carrying costs were also calculated as

\[^1\text{Average net back per ton = average selling price per ton minus the selling expenses per ton.}\]
a percentage of full manufactured costs (see Tables 17 and 18).

2. **Inventory Service Costs**

Inventory service costs are made up of insurance and taxes paid on the inventory investment.

**Insurance.**—These costs apply to the insurance that is purchased to cover the loss of inventory. The company was self-insured for $250,000 of finished product inventory at each warehouse location, but for inventory over $250,000 at any specific location the insurance rate was $0.2648 per $100 of average inventory. Since the cost of the insurance on the first $250,000 of inventory was not readily available, the $0.2648 per $100 figure was used in the calculation of inventory carrying costs with the realization that it may be fractionally below or above the actual figure.

**Taxes.**—Taxes paid on inventory vary depending on the state and city in which the terminal is located. The actual tax rate payable for each location should be used when determining specific sites for the terminals. However, in preliminary studies it was recommended that the average tax figure for the preceding year be used. Based
on average monthly inventory for 1973 and 1973 taxes this represented 0.270 percent of inventory valued at average net back. This figure was such a small portion of the total inventory carrying cost percentage that it was doubtful that using the actual tax figure for a location would alter the decision.

3. Storage Space Costs

There were four types of warehouse facilities that required consideration, and the treatment was different for each one.

Plant Storage Tanks.--The costs associated with plant storage were fixed in nature and therefore not relevant for decisions related to increasing or decreasing the level of inventory in any particular storage tank. If an increase in inventory required additional plant storage and the installation of new tanks, a capital budgeting decision would be required. Once an additional storage tank was built, changes in the amount of product held in the tank would not affect the storage costs.
Rented Terminal Space.--A similar argument held for rented terminal space since the cost of such space was fixed on an annual basis. The cost per gallon might decrease as larger quantities of storage space were contracted, but the total annual cost was usually insensitive to the quantity of product held within a given tank. Handling costs were related to sales (throughput) and not to the quantity of product held in storage. The Manager of Warehouse and Terminal Operations said that in some instances it was necessary to guarantee four turns of inventory per year. A logistics analyst confirmed that although terminal lease costs were required when making a decision to locate a terminal, once the terminal was on-stream the terminal costs were considered fixed when deciding if other customers should be routed through the terminal.

Field Warehouses for Packaged Products.--These warehouses could be further segmented into public and private warehouses.

a. Public Warehouses. In public warehouses a handling charge plus a storage charge made up the total cost. Storage costs were based on
the product, package type, and the time that the product was held in storage. Therefore, it was recommended that the company initiate a monthly report in which storage costs per product could be traced. This number could then be used as a percentage of the inventory value for the storage cost component of inventory carrying cost on a product or product group basis.

b. **Private Warehouses.** In order to determine the storage costs associated with private warehouses, monthly expenses for each warehouse should be reported on a fixed and variable basis with careful attention paid to the basis of variation. For example, costs that vary with sales are not relevant since they are throughput costs. Only the costs that vary with the amount of inventory held should be included.

**Plant Warehouses.** The collection of storage costs by plant warehouse would require a procedure similar to that described for private field warehouses.
Warehousing costs were not considered in depth since the purpose of this study was to determine the inventory carrying costs associated with bulk industrial chemicals.

4. **Inventory Risk Costs**

These costs usually include obsolescence, damage, pilferage, and relocation costs.

Obsolescence was not a factor since the company was experiencing a "seller's market" for its products due to product shortages in the chemical industry. However, in a "buyer's market" the obsolescence costs should be measured.

Damage that resulted while the product was in the custody of a carrier was claimed, and was therefore not a significant cost. It is recognized that managing the claims function has costs attached to it, but the variable cost of making these claims against carriers should not be included in inventory carrying costs since the majority of claims are related to throughput and not the amount of inventory held.

All other shrinkage costs amounted to 1.51 percent of the average inventory for all products in 1973 (Table 16). However, they varied substantially by product.
The wide fluctuation in price of any product, caused by such factors as the plant in which it was produced and the supply-demand relationship, made the dollar shrinkage figure as determined by management extremely tenuous. For this reason a weighted average cost per ton was calculated for the two products being studied (Table 16). However, this problem could be avoided by just considering the shrinkage in tons as a percentage of average annual inventory in tons. This yields a percentage figure that is independent of dollars (Table 16).

Relocation costs which are the costs associated with the transshipment of inventory from one stocking location to another were believed to be negligible and were not included.

5. **Total Inventory Carrying Costs**

The total inventory carrying cost figure to be used for decision making was 67.47 percent of variable costs before taxes for Product XYZ and 57.75 percent of variable costs before taxes for Product LMN. These percentages may seem high, but they are only applied to the variable costs associated with the inventory and not to full manufacturing costs. For example, if these figures were calculated as percentages of the full manufactured costs they
would be 5.47 and 33.89 percent, respectively. As percentages of the average net back per ton,\(^2\) they would be 3.11 percent for Product XYZ and 11.95 percent for Product LMN (see Tables 17 and 18, respectively).

Both of these latter percentages\(^3\) were calculated under the assumption that the inventory would be held at the plant. However, if the inventory was located in field warehouses, the variable costs would include transportation costs and would represent a higher percentage of average net back. Consequently, it was recommended that the percentage based on variable costs be used when calculating inventory carrying costs. By doing this, the same percentage figure can be used wherever the inventory is located in the system and only the variable costs to which the percentage is applied will change.

**An Application—The Feasibility of a Terminal for Product XYZ in Market M**

The actual inventory carrying cost figure to be used would be determined by both product and location. For

\(^2\)Average net back per ton equals the average selling price less the average cost of sales.

\(^3\)The percentages based on full manufactured costs per ton and average net back per ton.
this reason a specific example is included which illustrates how the percentage might be applied.

Tables 19 and 20 contain the calculations involved in the evaluation of specific sites for a new terminal. It becomes clear that inventory carrying costs for Product XYZ are relatively insignificant relative to other costs associated with the decision. This, however, may not be the case for a product with a larger percentage of variable costs to the average net back per ton.

In this example, it was apparent that City C was the least-cost alternative and the decision was most sensitive to an accurate assessment of freight savings and terminal costs. On the other hand, it was relatively insensitive to changes in inventory carrying costs. For this reason no attempt was made to measure the cost of additional inventory that might build up in the channel.

Based on sales of 60,000 tons in the Market M, approximately twelve barge shipments per year would be required (each barge holds 5,000 tons). Consequently, inventory owned by the company would be in transit at various times during the year, and some inventory build-up may be experienced at the plant in order to load the
barges. Therefore, the average system inventory (excluding the terminal) may be further increased by 2,000 or 3,000 tons. At $2.34 variable cost per ton this would only result in $3,158 (2,000 x $2.34 x 67.74%) or $4,755 in additional inventory carrying costs, which does not affect the decision.

Should a Terminal Be Opened?

Based on an average net back per ton of $50.84 and variable costs of $19.14 per ton (Table 18), each additional ton of Product XYZ sold in Market M because of the improvement in customer service would yield a contribution to profit of $31.70 per ton. Therefore, the additional sales required to break even on the investment (at City C) equalled 910 tons ($28,855 ÷ $31.70). Given a market for Product XYZ of 60,000 tons, this only represents a 1.52 percent increase in sales. A discussion with marketing should determine if such an increase is likely. Since the commitment for the terminal would be for a seven-year period, it would be reasonable to expect marketing to

4 Additional channel inventory (in transit and at the plant) might raise this to 1.68 percent

\[
\frac{28,855 + 158}{31.70} \div 60,000 \times 100\%
\]
establish whether the 1.52 percent sales increase could be maintained over the seven-year life of the investment.

**Summary of Pretest**

The company had traditionally not used inventory carrying costs in decision making, but management had recently used the 25 percent figure referred to in a distribution textbook in a terminal location problem.

This company did not have an inventory plan available and for this reason it was not possible to find a weighted average of the variable manufacturing and shipping costs associated with the total inventory. The vastly different nature of bulk chemical products, in terms of storage requirements, shrinkage, terminal locations, combined with the fact that the full factory cost and variable costs per ton varied by plant location as well as within a plant for each product, made it necessary to develop an inventory carrying cost figure for each product. This figure was calculated as a percentage of variable costs so that it could be applied to inventory held at any location (out-of-pocket transportation costs also varied by location).

Bulk terminals were storage tanks in which only one type of chemical could be stored. The storage cost
incurred was based on the size of the tank leased and the type of chemical stored, but once the tank had been rented storage costs were independent of the volume of product stored. Therefore, these costs were considered as warehousing costs of the throughput variety (see Figure 1) and were not included in inventory holding costs.

Considerable difficulty was experienced in collecting the data in this company. The insurance and tax figures had to be extracted from reports at the corporate head office. The company had not been separating fixed and variable expenses at the field warehouse level and procedures were implemented to bring this about. It is unlikely that more than two weeks per year would be required to establish inventory carrying costs for each product. This would represent a cost of $400 to $600 depending on level of accountant assigned to the project.

The company had before-tax inventory carrying costs of 5.47 percent and 33.89 percent of average inventory valued at budgeted full manufactured cost for the two products considered. Both of these percentages are substantially different from the 25 percent "rule of thumb."
<table>
<thead>
<tr>
<th></th>
<th>Product XYZ</th>
<th>Product LMN</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Dollars Tons $/Ton</td>
<td>Dollars Tons $/Ton</td>
<td></td>
</tr>
<tr>
<td>January</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>February</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>March</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>April</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>May</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>June</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>July</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>August</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>September</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>October</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>November</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>December</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Monthly Average</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Annual Shrinkage</td>
<td>b</td>
<td>b</td>
<td></td>
</tr>
<tr>
<td>Percent Shrinkage</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\(^a\)From Summary of Warehouse Valuation report from Distribution Accounting.

\(^b\)Best number to use since it is independent of the price per ton (since percentage can be applied to any value of inventory). However, this percentage should only be applied to out-of-pocket costs. Since variable manufacturing costs do not include transportation costs, it is recommended that this shrinkage percentage be applied to full manufacturing costs (surrogate measure for variable manufacturing cost plus transportation).
### TABLE 17

INVENTORY CARRYING COSTS FOR PRODUCT XYZ

<table>
<thead>
<tr>
<th></th>
<th>Percentage Based on</th>
<th>Percentage Based on</th>
<th>Percentage Based on</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Average Net Back per Ton</td>
<td>Budgeted Full Manufacturing Costs per Ton</td>
<td>Variable Costs per Ton</td>
</tr>
<tr>
<td>I. Capital Costs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Capital Cost</td>
<td>1.841</td>
<td>3.240</td>
<td>40.000</td>
</tr>
<tr>
<td>II. Inventory Service Costs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Insurance</td>
<td>0.265</td>
<td>0.466</td>
<td>5.757</td>
</tr>
<tr>
<td>- Taxes (vary with location --average)</td>
<td>0.274</td>
<td>0.482</td>
<td>5.865</td>
</tr>
<tr>
<td>III. Storage Space Costs</td>
<td>5.757</td>
<td>5.865</td>
<td></td>
</tr>
<tr>
<td>IV. Inventory Risk Costs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Obsolescence</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Pilferage (Shrinkage)</td>
<td>0.730</td>
<td>1.284</td>
<td>15.852</td>
</tr>
<tr>
<td>- Damage</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Relocation Costs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>TOTAL (before taxes)</strong></td>
<td>3.110</td>
<td>5.472</td>
<td>67.474</td>
</tr>
</tbody>
</table>
This depends on the percentage of average net back per ton that variable manufacturing costs plus variable transportation costs represent. For product held at the plant and based on $2.34 per ton variable cost and $50.84 average net back per ton (March 1974). Variable Cost = 4.602% of average per ton net back. Therefore Capital Costs = .04602 x 40% = 1.841%. For field inventory transportation costs would be added before calculating the variable cost percentage.

Based on variable costs of $2.34 per ton and average net back of $50.85 (as of March 1974) variable manufacturing costs = 4.602% of average per ton net back. Consequently, 0.265% of $50.84 = 5.757% of $2.34 and 0.270% of $50.84 = 5.865% of $2.34. Full manufacturing costs (budgeted 1974) were $28.89 per ton and percentages based on this figure were calculated in a manner similar to the percentages based on average net back per ton.

Fixed over the relevant range of inventory levels.

Calculated on the basis of tons of shrinkage as a percent of average inventory in tons. Applied to full manufacturing costs as a surrogate for variable manufacturing costs plus transportation and adjusted to corresponding percentage based on net back and variable costs per ton.
TABLE 18

INVENTORY CARRYING COSTS FOR PRODUCT LMN

<table>
<thead>
<tr>
<th></th>
<th>Percentage Based on Average Net Back per Ton</th>
<th>Percentage Based on Budgeted Full Manufacturing Costs per Ton</th>
<th>Percentage Based on Variable Costs per Ton</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>I. Capital Costs</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Capital Cost (minimum acceptable rate of return = 20% after taxes - 40% before taxes)</td>
<td>8.188(^a)</td>
<td>23.227(^b)</td>
<td>40.000</td>
</tr>
<tr>
<td><strong>II. Inventory Service Costs</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Insurance</td>
<td>0.265</td>
<td>0.752</td>
<td>0.988</td>
</tr>
<tr>
<td>- Taxes (vary with location --平均)</td>
<td>0.274</td>
<td>0.777</td>
<td>1.022</td>
</tr>
<tr>
<td><strong>III. Storage Space Costs</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>IV. Inventory Risk Costs</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Obsolescence</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Pilferage (Shrinkage)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Damage</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Relocation Costs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>TOTAL (before taxes)</strong></td>
<td>11.947</td>
<td>33.893</td>
<td>57.745</td>
</tr>
</tbody>
</table>

\(^a\) Capital cost (minimum acceptable rate of return = 20% after taxes - 40% before taxes)

\(^b\) Total manufacturing cost per ton

\(^c\) No data provided
TABLE 18 (continued)

| Variable costs per ton of $80.43 per ton and average net back per ton of $393 (December 1, 1974), variable costs = 20.47% of average net back per ton. Therefore Capital Costs = $0.2047 \times 40\% = 8.188\% of average net back per ton. |
| Budgeted full manufacturing costs for 1974 were $138.51. Variable costs as a percentage of full manufacturing costs = 58.068\%. Therefore Capital Costs = \(0.58068 \times 40\% = 23.227\%\). |
| Fixed over the relevant range of inventory levels. |
### TABLE 19

ADDITIONAL ANNUAL INVENTORY CARRYING COST DUE TO EACH TERMINAL

<table>
<thead>
<tr>
<th>Average Inventory in Tons</th>
<th>City A 1850</th>
<th>City B 1850</th>
<th>City C 950</th>
<th>City D 1850</th>
<th>City E 950</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freight Costs per Ton</td>
<td>$16.80</td>
<td>$16.80</td>
<td>$16.80</td>
<td>$16.80</td>
<td>$16.80</td>
</tr>
<tr>
<td>Variable Manufacturing Cost per Ton</td>
<td>2.34</td>
<td>2.34</td>
<td>2.34</td>
<td>2.34</td>
<td>2.34</td>
</tr>
<tr>
<td>Total Variable Cost of Inventory</td>
<td>35,409</td>
<td>35,409</td>
<td>18,183</td>
<td>35,409</td>
<td>18,183</td>
</tr>
<tr>
<td>Total Inventory Value Based on Aver</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(67.474% of Variable Cost) (^a)</td>
<td>94,054</td>
<td>94,054</td>
<td>48,298</td>
<td>94,054</td>
<td>48,298</td>
</tr>
<tr>
<td>Inventory Carrying Cost</td>
<td>$23,892</td>
<td>$23,892</td>
<td>$12,269</td>
<td>$23,892</td>
<td>$12,269</td>
</tr>
</tbody>
</table>

\(^a\)See Table 17.
### TABLE 20

**TERMINAL REQUIREMENTS FOR THE PROPOSED EXPANSION—**
**1975 ESTIMATED COSTS**

<table>
<thead>
<tr>
<th>Cost Categories</th>
<th>Possible Sites</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>City A</td>
</tr>
<tr>
<td>Freight Savings</td>
<td>$141,680</td>
</tr>
<tr>
<td>Terminal Costs</td>
<td>205,800</td>
</tr>
<tr>
<td>Inventory Carrying Costs&lt;sup&gt;b&lt;/sup&gt;</td>
<td>23,892</td>
</tr>
<tr>
<td><strong>Net Increase</strong></td>
<td>$88,012</td>
</tr>
</tbody>
</table>

<sup>a</sup>Figures other than inventory carrying costs were taken from a previous company memo.

<sup>b</sup>See Table 19.
APPENDIX F

CARRYING COST PERCENTAGES USED BY THE
COMPANIES PRIOR TO THIS RESEARCH
METHOD USED AT COMPANY A

The inventory carrying cost percentage quoted at Company A was 9.5 percent after taxes, or 19.0 percent before taxes.

A meeting with the controller revealed that there was not an established procedure for calculating inventory carrying costs. He said that it had been some time since he had made the calculation and was not aware that the number was still being used. Although he could not remember specifically which costs had been included, he believed that the following expenses had been considered:

1. Taxes (on inventory);
2. Insurance (on inventory);
3. Public Warehouses (about 3% - total public warehousing costs over factory sales though public warehouses valued at full factory cost);
4. Plant overhead (some fixed items such as taxes and insurance);
5. Cost of money (10% from the parent company).

The cost of capital (10%) was applied to inventory valued at full factory cost.

Total 19.0% before taxes

9.5% after taxes
METHOD USED AT COMPANY B

In the past the inventory carrying cost figure that had been used in distribution studies was 15 percent before taxes. The Manager of Distribution Research said that to his knowledge this percentage had not been documented. Recently, after reading a publication concerned with the issue of inventory carrying costs, the figure was changed to 25 percent on the assumption that the 15 percent was too low.

The percentage was applied to inventory valued at variable standard cost delivered to the customer. This value was a weighted average for all products considering the distribution center used and the method of shipment to each customer. However, for the purposes of applying the company's cost of money to the value of inventory, only the weighted average standard variable cost at the distribution centers should be used since inventory is held only at these locations.
METHOD USED AT COMPANY C

Although the company did not have a documented inventory carrying cost percentage, these costs had been considered both implicitly and explicitly in prior distribution decisions. For example, management concern about the number of inventory turns is an implicit measure of inventory carrying costs that assumes holding inventory has a high cost associated with it.

The Manager of Distribution Development and Control had been using a 20 percent before tax figure for distribution system analysis. He said that the number was "purely arbitrary" and was composed of a 10 percent cost of money plus 10 percent to cover other associated costs. The percentage was applied to inventory valued at actual variable costs of production.
METHOD USED AT COMPANY D

Although the company did not have a documented carrying cost figure, these costs had been considered both implicitly and explicitly in a number of past decisions. For example, management concern about the number of inventory turns is an implicit consideration of inventory carrying costs. The assumption, in such instances, is that maintaining inventory has a high cost attached to it.

The Manager of Transportation Services said that an explicit carrying cost figure had been used in "some plan: expansion proposals." He was not sure about the exact percentage used but he thought that the cost of money at that time had been applied to the full manufactured cost of the inventory.
METHOD USED AT COMPANY E

Although the company did not have a documented inventory carrying cost percentage, these costs had been considered both implicitly and explicitly in prior distribution decisions. For example, management concern about the number of inventory turns and the inclusion of inventory as part of the required assets when establishing the rate of return on new investments are both implicit considerations of the costs associated with holding inventory. The former assumes that maintaining inventory has a very high cost attached to it. On the other hand, the latter approach ignores all components of inventory carrying costs with the exception of the cost of money. Although capital costs may represent the largest single component of the cost of carrying inventory, the exact proportion should be determined. In addition, these capital costs should only be applied to the variable costs (direct out-of-pocket costs) associated with the inventory which makes the method of inventory valuation very important.
In a May 1974 study of "Warehouse Space Requirements" by the Inventory Planning Manager, an explicit measure of 25 percent was used for inventory carrying costs. This was simply the textbook figure and had not been documented.
METHOD USED AT COMPANY F

Although the company did not appear to have a documented inventory carrying cost figure, these costs had been considered both implicitly and explicitly in a number of past decisions. For example, management concern about the number of inventory turns is an implicit consideration of inventory carrying costs. The assumption, in such instances, is that maintaining inventory has a high cost attached to it.

Inventory carrying costs were considered explicitly, at least in part, in recent studies in which the costs of money (at about 9%), handling, and storage were used to determine product line profitability. As a general rule an inventory carrying cost of 15 percent of product cost was being used. This number was "extrapolated from historical storage costs and industry averages."
APPENDIX G

AN INCORRECT APPLICATION OF

INVENTORY CARRYING COSTS
AN INCORRECT APPLICATION OF INVENTORY CARRYING COSTS
(FOOD PRODUCTS MANUFACTURER)

Using Current Inventory Carrying Cost of 19.0%, Should Columbus, Ohio, Warehouse be Closed?

<table>
<thead>
<tr>
<th></th>
<th>Plant to Warehouse Expense</th>
<th>Warehouse Expense</th>
<th>Freight to Customer Expense</th>
<th>Inventory Carrying Costs</th>
<th>Total System Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Close</td>
<td>$34,705</td>
<td>$22,529</td>
<td>$93,285</td>
<td>$ -0-</td>
<td>$150,514</td>
</tr>
<tr>
<td>Leave Open</td>
<td>38,084</td>
<td>18,774</td>
<td>41,469</td>
<td>11,972</td>
<td>110,294</td>
</tr>
<tr>
<td>Columbus Saves</td>
<td>($3,379)</td>
<td>$3,755</td>
<td>$51,816</td>
<td>($11,972)</td>
<td>$40,220</td>
</tr>
</tbody>
</table>

The factory cost of the inventory change (should Columbus warehouse be closed) is $63,007. The carrying cost is 19.0% or $11,972.

R.O.I. = \[\frac{\text{Saving by being open}}{\text{Additional inventory required}} \times 100\%

\[\frac{40,220}{63,007} \times 100\% = 63.84\% \text{ before taxes}

\[63.84\% \times 0.69 = 41.92\% \text{ after taxes}

which implies leaving Columbus open (since R.O.I. is greater than 20% after taxes).

\[a\] Assumes constant Customer Service Levels and Lot Quantity Costs.

\[b\] Next closest warehouse will be used.
BIBLIOGRAPHY
BIBLIOGRAPHY

Books


183


**Articles**


Parker, Donald D., "Improved Efficiency and Reduced Cost in Marketing," *Journal of Marketing*, April, 1962.


Special Publications

Accounting and Auditing Approaches to Inventories and Three Nations, Accountants International Study Group, 1968.


Foster, Ronald S. "What Does It Cost to Carry Inventory?" Washington, D.C., National Association of Wholesalers.


Magee and Company, Inc. "Basic Research on Inventory Turnover and Management for the Wholesale and Chain Grocery Inventory."

Steel Service Center Institute, "We Could Save You a Few Thousand Bucks."


