This is to certify that the

thesis entitled

THE DEVELOPMENT OF PACKAGING COSTING
METHODOLOGY AND THE OPTIMIZATION OF
PACKAGING COST MODEL

presented by

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has been accepted towards fulfillment
of the requirements for

M.S. degree in PACKAGING

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Date May 20, 1982

O-7639

# ABSTRACT

## THE DEVELOPMENT OF PACKAGING COSTING METHODOLOGY AND THE OPTIMIZATION OF PACKAGING COST MODEL

by

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Packaging cost, the cost associated with a packaged product cost, is comprised of a number of cost elements and represents one of the highest costs in physical distribution. The magnitude of this cost and the fact that packaged inventory levels are influenced by the configuration of the physical distribution system design demonstrates the need for an accurate calculation of packaging cost if appropriate trade-offs are to be made within the firm. Currently, managers who recognize the valuation packaging cost use estimates or conventional industry benchmarks. Essentially, an accurate calculation of packaging cost needs as a guideline a normative model of packaging cost. This research develops the optimization of packaging cost model for determining the annual optimum units of items for each type of package to be manufactured in order to economically minimize total packaging cost. The contribution of the model is for purposes of production and marketing planning.

ACKNOWLEDGEMENTS

Professor Paul Bankit, Chairman of my Thesis Committee, and my advisor deserves special recognition not only for his many contributions to this thesis but also for his high standard of professional competence which he consistently displayed. His patience and direction were helpful in getting me to the level of understanding which was necessary to achieve the objectives of this thesis.

I would like to express my sincere appreciation to the other members of the Thesis Committee, Professor Hugh Lockhart, and Jay Sterling for their valuable suggestions. Without their support I could not have graduated, I am deeply grateful.

This thesis could not have been possible without the presence of some who merit my special thanks - Poon and Somporn Kongcharoenkiat, Robert Adams, Shohei Yoneda and Claire Furutani, for their assistance in preparing this thesis.

Mrs. Beverly Lantis must be recognized for her role in typing. She gave generously of her time, a fact that contributed significantly to the completion of this thesis within the deadlines to which I was committed.

Finally, I would like to express my gratitude to my elder brother, Chanchai, for his encouragement throughout my period of study.

To my Mom: Siang Tan
and the Kanapanishkasem
and especially my eldest brother
Kitti Kanapanishkasem
for their support throughout
the period of my study.

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# CHAPTER I

# INTRODUCTION

Every package specification is the end result of a development, and it will ultimately be succeeded by another specification. As such, each specific type of package has a beginning, a time of active use, and an end. It must justify its "life" by contributing the maximum of value in relation to its cost. Costs are incurred from the very conception of a package, and continue until the final liquidation of last inventories, while value is received only during the "active use" period.(1)

PACKAGING COST. No other area of packaging is so disputed and so misunderstood as that of costs. Many companies determine the cost of the package itself but not the cost of the packaging system in relation to other marketing costs. Some programs are aimed at reducing the cost of the package rather than how the package affects all other parts of the marketing system. Even companies with a good value analysis program are guilty of this practice.(2)

In some companies, package costs are now being shared by production and marketing. This seems sensible; if marketing

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[1]Edmund A. Leonard, Introduction to Economics of Packaging, 1st Edition, 1968, p. 7.

[2]Harold J. Raphael, David L. Olsson, Package Production Management, 2nd Edition, (Westport, Connecticut: The Avi Publishing Company, Inc., 1976), pp. 156-158.

wants a more expensive package and can justify it, the additional cost should come from their budget rather than from production. Perhaps part of the package cost should also come from advertising, if it is used for this purpose.(3)

Packaging costs, such as materials and supplies, and packaging operations, such as labor, speed, overhead, utilities, and so forth are easy to substantiate and are easily understood. Of equal importance, and often ignored, are package development and distribution costs. The three areas of development, production, and marketing should be studied together if true packaging cost is to be arrived at.(4)

Currently, most managers who consider packaging cost use estimates or traditional cost-data benchmarks. In fact, many corporations do not consider packaging cost even though this cost is both real and substantial.

Although some authors have addressed the types of cost that should be considered as typical inputs for the packaging cost model, there is no generally accepted methodology for determining each element of packaging cost.

The thrust of this reasearch is to develop a packaging cost methodology, based on existing accounting, marketing and

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3 & 4 Harold J. Raphael, David L. Olsson, Package Production Management, 2nd Edition, (Westport, Connecticut: The Avi Publishing Company, Inc., 1976), pp. 156-158.

production literature that can be used to determine elements of packaging cost. Finally, the elements of packaging cost will be used as inputs to validate the optimization of a packaging cost model.

BACKGROUND

Packaging is a part of the total physical distribution system can be regarded as a means of minimizing the cost of delivery while maximizing sales. Reduction of packaging cost may not necessarily increase overall profitability if there is increased damage of the product or increased downtime on the packaging line.[5]

Total packaging cost is not just the price per thousand paid for corrugated packaging. The majority of total packaging costs accrue after the container has been paid for; labor costs, transportation costs, distribution costs, merchandising costs, warehousing costs, and many other hidden expenses.[6]

In order to optimize packaging cost, the total distribution system must be examined so that all costs can be taken into account and the particular weighting must be defined for each exercise. The stages and processes involved in the production and distribution system for each package required must be analyzed and then the various cost elements of packaging taken into consideration.[7] Unfortunately, the final package

[5] R.R.Goddard and F.A.Paine, Optimizing the Packaging Cost, Paper presented at the 2nd International Packaging Conference, Munich, 9-11 June 1976, pp. 307-320.

[6] James Turner, Canadian Packaging, June 1975, p.23

[7] R.R.Goddard and F.A.Paine, Optimizing the Packaging Cost, Paper presented at the 2nd International Packaging Conference, Munich, 9-11 June 1976, pp. 307-320.

is often based on production and marketing considerations at the expense of logistical requirements.(7) However, the knowledgeable corporate executive realizes that the success of physical distribution systems particularly hinge on the quality of the packaging cost data available for the decision making process and control.

## PROBLEM

The problem addressed in this research will be the development of packaging costing methodology to be used as a basis in the process of allocating the elements of packaging cost in terms of cost per unit package. Then the Optimization of Packaging Cost Model, i.e. Linear Programming Model which involves a linear function of elements of packaging cost variables subject to a set of linear constraints will be formulated.

However, the elements of packaging cost will be arbitrarily assumed and used as inputs to validate the model. Finally, the model consists mainly of quantitative elements of packaging cost which are subject to certain assumptions. It is necessary to obtain the final feasible solution (the annual optimum units of items for each type of package to be produced).

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[8] Donald J. Bowersox, Logistical Management, 2nd Edition (New York: Macmillan Publishing Co., Inc., 1978), p. 191.

## THE RESEARCH PURPOSE

The purpose of this research was to develop a methodological framework which determines the specific cost elements that should be included in calculating the total packaging cost. This framework can be used by management to develop packaging cost percentages.

## RESEARCH OBJECTIVES

The specific objectives of the research were as follows:

1. To identify the key cost elements involved in determining the total cost of packaging.

2. To develop from these cost elements a normative model or general methodological framework for determining the total cost of packaging.

3. To formulate the optimization of packaging cost model from those elements of packaging cost.

4. To test the model using the arbitrarily assumed inputs-elements of packaging costs.

## ASSUMPTIONS AND LIMITATIONS

The specific assumptions of the research were as follows:

1. For each element of packaging cost, there are time-horizon differences to accomplish certain activities for each package.

2. For certain elements of packaging cost, there are two components making up the cost. These are the fixed components and the variable components.

3. Each element of packaging cost can be allocated as a cost per unit package.

4. The packaging line has the capacity to handle the annual optimum units of items for each type of package to be produced.

5. Each element of packaging cost, for each type of package, is known and constant.

6. An annual budgeted expense of each element of packaging cost is known and constant.

7. Forecasted annual demand of items for each type of package is known and constant.

8. A forecasted annual demand of items for each type of package will be used as the basis in allocating an annual budgeted expense for each element of packaging cost.

9. A change-over in machinery of the packaging line, can be made satisfactorily to meet the desired level of production.

10. Any changes/alterations made on the package in order to change packaging functions, (e.g. to prolong shelf-life), will result in incremental packaging process costs.

11. The attainment of minimum annual budgeted expense for each element of packaging cost is the criterion of optimality.

## POTENTIAL CONTRIBUTIONS

The major contribution that will result from this research is a methodology that managers can use to develop packaging system cost figures for the company. Another contribution is the utilization of the optimization of packaging cost model as a tool for both production and marketing in determining the annual optimum units of items for each type of package produced.

# CHAPTER II

## REVIEW OF THE LITERATURE

The literature review is divided into the following sections:

1. The elements of packaging cost.
2. Typical input for packaging cost model - The production line.
   2.1 Fixed costs (established on an annual basis)
   2.2 Variable costs (established on a weekly or monthly basis)
3. The estimation of product cost.
   3.1 Cost accounting.
   3.2 Financial accounting.
4. Summary

The section on the elements of packaging cost presents a review of previous studies on packaging cost as well as literature in the areas of logistics, marketing, production and packaging. This section is used as a basis for determining the elements that should be included in calculating the total packaging cost.

The section on input for the packaging cost model presents a review of selected packaging cost literature. This section is used both as a basis to identify the cost elements as either variable or fixed costs and as a basis for determining the elements that should be included in calculating the total packaging cost.

The section on product cost estimating presents a review of selected cost accounting, financial accounting and managerial accounting literature to provide the necessary background for establishing the figure to be used as the cost elements per unit package.

The final section presents a summary of the literature to be used in formulation of the methodological framework and the optimization of the packaging cost model.

## THE ELEMENTS OF PACKAGING COST

A literature search revealed that there are few expositions in the area of estimating the annual cost of packaging as a percentage of the average production cost, or of the physical distribution cost. However, a publication, published by Packaging Council of Australia(9), had estimated the annual cost of*packaging/storage as the percentage of total physical distribution cost. These estimates are summarized in Table 1.

TABLE 1
ESTIMATES OF PHYSICAL DISTRIBUTION COSTS IN AUSTRALIA

| Component | % of Total | $Million |
|---|---|---|
| Transport | 17.9 | 1,100 |
| Inventory | 25.7 | 1,580 |
| Order processing | 14.9 | 920 |
| Warehousing | 12.7 | 780 |
| *Packaging/storage | 11.9 | 730 |
| Receiving and dispatch | 10.0 | 610 |
| Administration | 7.0 | 430 |
| Total physical distribution cost | | 6,150 |

Source: Productivity Promotion Council of Australia. Figures are for 1974.

9 Mike Kettle, Packaging Today (Melbourne, Australia: Packaging Council of Australia, 1979) September/October.

Another publication, by R. M. Fiedler(10), is the conceptual model which includes three major factors in determining total cost of packed goods:

1. The cost of manufacturing the product.
2. The cost of protective packaging.
3. The cost of damage resulting from inadequate protective packaging.

The author states that no one segment of these three related factors can be optimized without considering the other two. Moreover, it was recognized that without the ability to measure and quantify each component of the model, one can't use the model in a meaningful way.

Robert L. Glazier(11) proposes the method in calculating the total manufacturing cost by using a standard cost data, Figure 1, which includes the cost of packaging, ingredient (beer), labor, production and distribution.

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10 R. M. Fiedler of MTS Corporation, Proceedings of the May 1975 meeting of the National Safe Transit Association.

11 Robert L. Glazier, Package Development & Systems (New York: Scarborough Publishing Co., Ltd., 1971) March/April.

Plant________________ Eff. Date__________ Costing Unit__________

Product No.______________ Description__________ Std. Volume__________

| | | | | Stndard Cost Per Unit | | |
|---|---|---|---|---|---|---|
| | | Quantity | Unit | | | |
| BEER | | Per Unit | Price | Fixed | Variable | Total |
| Finished Beer | | | | | | |
| | | | TOTAL | | | |
| PACKAGING | | | | | | |
| a. Materials | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | TOTAL | | | |
| b. LINE LABOR: | Cost Centers | | | | | |
| Crew | | | | | | |
| Labor Rate | | | | | | |
| Std. Crew Cost | | | | | | |
| Cases/Hour | | | | | | |
| Cost Per Unit | | | | | | |
| Depalletizing | | | | | | |
| Scheduling % | | | | | | |
| | | | TOTAL | | | |
| c. SERVICE LABOR & EXPENSES: | | | | | | |
| Cost/Line Hour | | | | | | |
| Cases/Hour | | | | | | |
| Total Cost/Unit | | | | | | |
| Receiving Mtl. | | | | | | |
| Proc./Prod.Serv. | | | | | | |
| Service Mtce. | | | | | | |
| Depalletizing | | | | | | |
| Bldg.Clean/Lub. | | | | | | |
| Unloading | | | | | | |
| Administration | | | | | | |
| Own Expense | | | | | | |
| Scheduling % | | | | | | |
| | | | TOTAL | | | |
| d.PROCESS LOSS: | | | | | | |
| Beer | | | | | | |
| | | | TOTAL | | | |
| | | | PACKAGING COST | | | |
| PALLETIZING | | | | | | |
| a. Palletizing labor | | | | | | |
| b. Service Labor and Expenses | | | TOTAL | | | |
| | | | TOTAL MANUFACTURING COST | | | |

FIGURE 1

STANDARD COST SHEET

According to Jack Milgrom and Aaron Brody(12):

For accounting purposes, many companies often include packaging costs (packaging, materials cost, equipment cost, allocating space in the packager's plant, inventory, capital, and manpower) in the general manufacturing costs of a product. Some surveys have attempted to indicate ranges of total packaging cost, based on the percent of manufacturer's selling price to the distributor. For example, some packaging "costs" as of 1971 were:

> Motor oil in a metal can - 26%;
> Motor oil in a composite can - 10%;
> Beer in tinplate can - 43%;
> and beer in a one-way bottle - 36%.

The National Commission on Food Marketing(13), in the mid-1960's, investigated the packaging cost for breakfast cereal, and cookies and crackers. The result indicated that in 1964 total packaging cost for the breakfast cereal industries were:

> 17.4% of net manufacturer's sales; materials amounted to 80.5% of that figure or 14% of net sales, and labor amounted to almost 3% of net sales. A category entitled "other packaging costs" amounted to 2.5% packaging costs, or about 0.004% of net sales. Packaging costs were second to ingredient and process costs in 1964. When expressed in terms of the consumer's purchase price in 1964, total packaging costs represented 13.0%.

The cookie and cracker industry presented a statistically different but fundamentally similar picture. Packaging costs in 1964 were:

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[12] Jack Milgrom and Aaron Brody, Packaging In Perspective, (Cambridge, Mass.,: Arthur D. Little, Inc., 1974), pp. 82-83.

[13] Jack Milgrom and Aaron Brody, Packaging in Perspective, (Washington, D. C.: National Commission on Food Marketing, 1960)

18.8% of manufacturer's selling price, which ranked it also as the second highest cost incurred.

It is also pointed out that these data indicate that packaging costs represent major costs to the food producer.

Table 2 is a recent unpublished data by several of the country's major packagers providing information on the total costs of packaging. Packaging materials generally account for the major portion of the packaging costs shown in this table:

TABLE 2

COST OF PACKAGING OF SELECTED PRODUCTS TO THE CONSUMER (1973)

| Product | | Percentage of the consumer price |
|---|---|---|
| Roasted and ground coffee in 1-lb cans | | 10 |
| Margarine - stick form | | 6 |
| - tub form | | 16 |
| Refrigerated dough | Less than | 20 |
| Fruit-flavored drink mix | | 50 |
| Frozen boil-in-bag vegetables | | 7 |
| Canned corn | | 24 |
| Frankfurters - 1-lb. | Less than | 5 |
| Bacon - 1-lb. | Less than | 5 |
| Granular drain cleanser | Less than | 20 |
| Powdered cleanser | | 13 |

Source: Arthur D. Little, Inc.

Another example is the one-half gallon plastic-coated paper board carton, which costs about 2.25¢ and represents about 50% of the total packaging cost. At the end of the high-volume filling line, the filled container costs about 5¢ exclusive of the milk. A filled one-half gallon all-plastic milk container costs about the same amount. Total packaging cost for the one-gallon milk container (including materials, investment, and labor) are 6 to 8¢ each and the packaging materials costs account for about 60%, whether paperboard or plastic containers are used. (Assuming high-volume production)[14]

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[14] Ibid., p. 83.

A publication by M. J. Jackson[15], covers the most important elements which make up the total packaging cost associated with a product, as shown in Table 3.

TABLE 3

ELEMENTS MAKE UP THE TOTAL PRODUCT'S PACKAGING COST

| | |
|---|---|
| 1. MARKETING | - consumer research<br>- national advertising program<br>- artwork<br>- legality of packs |
| 2. TECHNICAL | - carry out laboratory trials-physical/ chemical<br>- storage/shelf life test<br>- production development trials<br>- occupancy/storage and transit trial<br>- preparation of technical specifications |
| 3. PURCHASING | - performance<br>- price<br>- supplier selection<br>- future availability |
| 4. PRODUCTION | - performance<br>- consistent quality of material<br>- service support |
| 5. DISTRIBUTION/ WAREHOUSING | - handling<br>- transporting<br>- storage of goods |
| 6. RETAILING | |

Source: M. J. Jackson, Elements of Total Distribution Costs, 1978

Another approach to the calculation of packaging costs is presented by Edmund A. Leonard[16]. The elements in the total cost of a package are shown in Table 4.

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[15] M. J. Jackson, Elementsof Total Distribution Costs, Paper presented at the Institute of Packaging Conference in London on 2 Nov., 1978, 6 pp.

[16] Edmund A. Leonard, Introduction to Economics of Packaging, 1st Edition, 1968, p. 3

## TABLE 4

## ELEMENTS OF PACKAGING COST

1. DEVELOPMENT COSTS
    a. Identification of package criteria
    b. Concept search
    c. Design
    d. Models
    e. Sample tooling and samples
    f. Sample evaluation - technical and customer research
    g. Costing and specifications
    h. Tooling and materials for test market
    i. Test market pack and evaluation
    j. Specification refinement and purchasing
    k. Tooling for production
    l. Quality control program implementation
    m. Start-up

2. ONE-TIME COSTS
    a. All of the above, principally tooling for production, which includes,
    b. Supplier molds or dies, printing plates, dies, or cylinders
    c. Packing-line equipment or change parts
    d. Installation

3. MATERIALS COSTS
    a. Basic package unit price
    b. Special packing for inbound shipment
    c. Inbound freight
    d. Packaging materials storage and handling
    e. Shrinkage of packaging materials from damages, loss, cost of overages
    f. Sampling and inspection costs

4. PACKAGING MACHINERY COSTS, Other than ONE-TIME
    a. Rental or leases
    b. Service and maintenance
    c. Amortization per unit package
    d. Power and utilities

5. PACKING PROCESS COSTS
    a. Direct labor
    b. Indirect labor
    c. Overhead
    d. Incidental materials

6. DISTRIBUTION COSTS
    a. Storage and warehousing, including special handling and materials
    b. Outbound freight

7. WRITEOFF OF TERMINAL INVENTORIES.

Source: Edmund A. Leonard, Introduction to Economics of Packaging, 1968.

Another 1980's publication by Edmund A. Leonard[17]:

- Many elements of cost are constant (or reasonably so) as to percentage for a given process - e.g. shrinkage losses, tolerances of overage or underage in ordering when a packaging process remains constant, the quantities of materials it consumes to yield a target volume of packed goods are predictable.
- The steps in packaging development do not change; therefore the packaging development cost is constant
- Percentage differentials for specifications that differ from bases quoted tend to be constant; e.g. volume differentials for number of colors printed.
- Bases on which prices are quoted rarely changes: glass prices traditionally include re-shippers and delivery; cans are quoted palletized, one end attached, plus delivery; plastic bottles in bulk master shipper f.o.b. supplier's plant, etc.

Guidelines for projection of the price movements of packaging materials, based on current trend:

- The inflation rate of the Consumer Price Index will average eight to ten percent per year for all of the 1980's.
- Due to intensive energy requirements, prices for glass and aluminium will probably escalate two percent faster than the Consumer Price Index.
- No important packaging materials will escalate in price at rates less than the general inflation rate for any length of time. Temporary exceptions, if they occur, will arise from over capacity in some industry segments.
- Plastic materials, mostly made from petroleum, natural gas, and coal, will escalate in step with the costs for energy.
- The price relationships among packaging materials will not change significantly if the kinds and intensities of current inflationary forces to not change. In the long run, glass, aluminium, and the more exotic plastics will be the most expensive packaging materials, with steel packaging next, followed by the customary plastics, and with paper and paperboard packaging the least expensive.[18].

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[17] Edmund A. Leonard, Packaging Economics (New York: Book for Industry, Division of Magazines for Industry, Inc., 1980).

[18] Ibid.

Knowing present prices, one can project crudely forward in time with the above guidelines. Possibly a better way of doing this would be to use statistical data published by the U. S. Department of Commerce in "Container and Packaging Quarterly." Each issue includes a table entitled "Comparison of Wholesale Price Indexes for Selected Containers and Container Materials."

In a 1960 publication by Delmar W. Karger[19], it was suggested that the cost elements of the new product should include several cost categories listed under fifteen general headings (shown in Table 5). It is important to note that the purpose of this exposition was in the pricing of the new product. Consequently, mamy of the costs can only apply to the company that is trying to determine the product unit cost. These costs cannot be used for accounting purposes. Some elements of the cost (selling expenses, purchased materials cost - the cost of raw materials to produce the product) that are included are not relevant to packaging cost.

TABLE 5

THE COST ELEMENTS OF THE NEW PRODUCT

1. PRE-PRODUCTION ENGINEERING
    1. Engineering labor to generally investigate the problem.
    2. Junior engineer and/or technician labor to support the engineering investigation through lab work, library research, etc.

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[19]Delmar W. Karger, The New Product, 1st Edition 2nd Printing (New York: The Industrial Press, 1960), pp. 40, 41-58.

TABLE 5 (Continued)

3. Drafting labor to make preliminary and final drawing.
4. Packaging engineering costs to design the package and shipping carton.
5. Specification engineering costs involved in integrating the special new product specifications into the established company standards.
6. Model maker, assembly, or other similar labor costs to manufacture working models.
7. Chemical engineering labor where this group provides consulting service.
8. Technical publication costs, such as for writers, illustrators, etc. where one or more technical publications are needed in the marketing of the product.
9. Engineering that may be contracted to another firm.
10. Engineering material-raw, semi-finished, finished-which may be needed for any of the above labor classifications.
11. Engineering overhead on the labor.
12. Procurement and transportation costs that may be chargeable against the material purchased.
13. Travel of engineering personnel caused directly by the project.
14. Equipment cost associated with the pre-production engineering such as special machines, test equipments, etc.
15. Miscellaneous expenses. This category provides for coverage of the more unusual costs such as: outside laboratory service, consulting expense, patient license fees, and associated legal expense.

2. PRODUCTION SUPPORT ENGINEERING

These are engineering costs that will be incurred during the production of the product on the factory floor.

3. FACILITY COST

The cost associated with the establishment of any required new buildings, work benches, stock racks, pallets, and other general items that could have a future use on other products.

4. EQUIPMENT COST

A valuable function principally related to design parameters, the maximum anticipated run rate and the minimum anticipated life span of the new product.

5. TOOL, JIG, FIXTURE, AND MISCELLANEOUS MATERIALS HANDLING EQUIPMENT COSTS.

1. Vendor cost.
2. Internal company cost.

6. PURCHASED MATERIAL COST

1. Special tool cost.
2. Price or material selling price.

TABLE 5 (Continued)

7. DIRECT LABOR COST.

8. SHRINKAGE.
   The ordinary material losses, over-buys, over-shipments accepted, etc.

9. SCRAP.
   Cost involved under shrinkage.

10. TRANSPORTATION.
   The expenses of transporting required materials to manufacturing plant.

11. OVERHEAD
   The indirect manufacturing costs.

12. SELLING EXPENSE.

13. GENERAL AND ADMINISTRATIVE EXPENSE.

14. PATENT LICENSE COST.

15. SPECIAL TAXES.
   A storage sales tax.

Source: Delmar W. Karger, The New Product, The Industrial Press, 1960.

The elements of packaging cost, as presented by Edmund A. Leonard, should be extensively investigated in order to indentify any probable sub-element costs which might contribute to the elements.

1. Development costs.

As presented by Roger C. Griffin, Jr., and Stanley Sacharow(20): the amount of effort expended in a development project in packaging

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[20]Roger C. Griffin, Jr. and Stanley Sacharow, Principles of Package Development, (Westport, Connecticut: The Avi Publishing Co., Inc., 1972) pp. 10, 12, 13.

depends upon the type of development required. There are several types which may be categorized as follows:

1. Modification of an existing package for an existing product in order to improve package.

2. Expansion of a product line through use of a well-tried and proven package.

3. Development of a new package concept for a proven product to improve sales.

4. Development of a new package concept for a new and untried product.

It was pointed out that the package development path comprises the following steps[21]:

1. Definition of the product properties as they relate to package technical requirements;

2. Definition of package technical and functional requirements;

3. Definition of package styling and design requirements;

4. Identification of legal or other restrictions;

5. Selection of possible package design and materials;

6. Estimation of probable cost of development;

7. Decision whether to proceed;

8. Package preparation and testing for performance:
   a. Technical performance,
   b. Consumer preference,
   c. Economic feasibility, and

9. Decision whether to proceed for market test.

The development path may be follow through step 6 at little cost, but after step 7, (the decision to proceed), the developmental cost will become significantly larger.

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[21]Ibid., p. 12.

According to Philip Kotler[22]: Developing the package for a new product requires a large number of decisions. The first task is to establish the packaging concept. The packaging concept is a definition of what the package should basically be or do for the particular product. A further decision must be made on the component elements of package design - size, shape, materials, color, text, and brand mark. After the packaging is designed, it must be put through a number of tests:

- Engineering tests are conducted to insure that the packaging stands up under normal conditions;
- Visual test, to insure that the script is legible and the colors harmonious;
- Dealer test, to insure that dealers find the packages attractive and easy to handle; and
- Consumer tests, to insure favorable consumer response.

According to Joseph G. Fernandes[23]: The process of development, either for a new package or redesigning current packaging, is separated into three parts, as shown in Table 6:

1. Research
2. Development
3. Finalization

Essentially, in each phase, time units are established to insure that the project will be completed on schedule and

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[22] Philip Kotler, Marketing Management, 4th Edition (Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1980), pp. 333-334.

[23] Joseph G. Fernandes, Packaging Development & Systems, (New York: Scarborough Publishing Co., Ltd., 1978) July/ August, pp. 16-18.

the expenses involved can be determined. The time units vary depending on the nature of the project, for example a week, month, two months.

TABLE 6

THE PROCESS OF PACKAGE DEVELOPMENT

1. RESEARCH
   - marketing plan
   - product position statement
   - gather competitive packages
   - investigate materials
   - investigate equipment concept
   - screen existing containers

2. DEVELOPMENT
   - design concepts in 2-dimensions vs. 3-dimensions
   - preliminary testing and evaluation
   - narrow equipment concept
   - inter phase with graphic concepts
   - interview supplier and sampling
   - intermediate marketing presentation
   - coordinate with other departments
   - final prototypes
   - concept cost analysis
   - final development presentation

3 FINALIZATION
   - final prototype refinement
   - vendor coordination
   - die strike approval
   - final graphic
   - final specs and support documents
   - participate in start up

Source: John G. Fernandes, Principles of Package Development, The Avi Publishing Company, Inc., 1972.

2. One-time costs

According to the article written by William M. Peragine[24], entitled "Packaging equipment specification - the machinery users

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[24] William M. Peragine, Package Development & Systems, (New York: Scarborough Publishing Co., Ltd. 1977) November/December, pp. 19-20.

view, part II:

Installation of the machine: "If the machinery's buyer provides the manpower, the air, the electrical connection, etc., how many hours will it take to install the machine and what will the installation cost be?." The author presented the part of the contract showing in details the work, expenses and understanding that must be accomplished by supplier and user:

> V. Installation: Buyer shall pay the services of seller's engineer for a period up to...hours at the rate of $.... per hour, straight time and $... per hour overtime plus reasonable and necessary travel and living expenses.
>
> VI. Spare parts: Seller shall submit to Buyer, Seller's recommended list of spar parts and sub-assemblies along with quantities and itemized prices(25)...

Another article written by Richard C. Wheeler, presented Job Description for a packaging machinery development engineer, in which one of his/her functions pertaining to tooling for production: engineering and maintenance - to coordinate plant level engineering activities in reference to new packages, including change of parts, supply test, start-up problems, etc.(26)

3. Packaging material costs

According to the governmental statistics, value of selected containers and packaging materials consumed by selected SIC

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[25] Ibid.

[26] Richard C. Wheeler, Package Development & Systems (New York: Scarborough Publishing Co., Ltd., 1978), March/April, p. 17.

Industry for years 1958, 1963 and 1967 [27]:

1. Food. The packaging cost for food as a percentage of manufacturer's costs is among the highest in the list, because the value of the content is so low. For example, the percentage for the canned food specialty industries was 19.5% in 1967, followed by canned fruit and vegetables at 17.1%. However, the packaging costs for other food items, such as frozen fruits and vegetables (8.4%) and cereal preparation (6.6%) were below 10%. These costs are computed on the basis of manufacturer's costs.

2. Non-Food. This category includes a very broad range of smaller industries and, therefore, can not be described concisely. The products are far more stable than those made by the food industries, have a much lower turnover per unit time and, concequently, are purchased in lesser quantities. As a result, product values tend to be higher, and packaging can be more sophisticated and higher cost. A major non-food item is toiletries and cosmetics. This industry is the second largest gross user of packaging materials. The third largest user of packaging materials is the pharmaceutical industry. Another non-food users of packaging materials are:
    - soap and detergents
    - polishes, paints, coating, etc.
    - petroleum product
    - paper goods industries
    - cigarette and tobacco

   It is evident that the range of non-food products being packed is far wider than the range of food products and the range of requirements stemming from distribution and product need is far greater. In spite of the high cost of packaging materials for some of these products, packaging materials cost as a percentage of manufacturer's costs are relatively low, as shown in Table 7.

3. Industrial Packaging. Industrial packaging is that employed for commodities and products designed for remanufacturer, and can vary in size from bulk carrier that are not integral parts of vehicles (For example,

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[27] Jack Milgrom and Aaron Brody, Packaging in Perspective, (Washington, D. C.: Bureau of the Consensus, U. S. Department of Commerce).

large machines are often crated in large wood frames and boxes) to 50-lb polethylene bags that are used to package plastic resin or tobacco. Because the quantity of industrial products contained in a package is so high, the cost of packaging per unit of product contained is almost always extremely low, for example, the cost of packaging materials for plastic resins represent about 1% of the manufacturer's cost. The packaging materials costsfor chemicals are similar, and those for synthetic rubber accounted for 0.7% of the manufacturer's cost in 1967.

Dr. Jack Milgrom and Dr. Aaron Brody[28] have estimated that about $277 billion was spent on finished packed goods by U. S. consumers in 1971, based on this value, the value of packaging materials in 1971 ($19.5 billion) was about 7%. They estimate that this percentage is about the same today.

TABLE 7

COST OF PACKAGING MATERIALS AS A PERCENTAGE OF MANUFACTURER'S COST FOR SELECTED PRODUCTS (1967)

| SIC Code No. | Product | Packaging Materials % (Value) |
|---|---|---|
| 2841 | Soap and other detergents | 8.9 |
| 2842 | Polishes and sanitation goods | 9.9 |
| 2844 | Toilet preparations | 12.7 |
| 2834 | Pharmaceutical preparations | 4.8 |
| 2111 | Cigarettes | 2.7 |

Source: U. S. Dept. of Commerce

28 Jack Milgrom and Aaron Brody, Packaging in Perspective, (Cambridge, Mass.,: Arthur D. Little, Inc., 1974), p. 173.

4. Packaging machinery costs (other than One-time)

As presented by Edmund A. Leonard[29]: A packer need not own all the equipment in his packing lines, since lease and rental arrangements are available on many kinds of machines. Suppliers service and maintenance contracts are available to go with the machinery.

Another exposition, presented by Joseph Hanlon[30], shows the following: Before purchasing any equipment for the packaging line, it is necessary to make the financial analysis to see whether the expenditure will be justified. This entails an anlysis of all the expenses included, balanced against the savings that will accrue by the elimination of hand labor. An important decision that will have to be made is the length of time to be allowed for amortizing the cost of the equipment. This varies with different companies and different situations; the average length of time for most companies is about 3 years. If the product is a new one, and the chance of survival in the market place is questionable, it might be safer to figure on a 1-year payback in order to justify the expense of a new piece of equipment. On the other hand, if the product is well established and there is little likelihood change would make the equipment obsolete, it might be reasonable to amortize the cost over a 5 or 10 year period.

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[29] Edmund A. Leonard, Introduction to Economics of Packaging, 1st Edition, 1968, p. 10.

[30] Joseph F. Hanlon, Handbook of Package Engineering (New York: McGraw-Hill Book Co., 1971) pp. 20-25.

There are several ways to evaluate proposals for new equipment:

Payback - a method for measuring the time required to recover the original investment;

Return on Investment (ROI) - either the return on gross investment or the return on average investment;

Discounted Cash Flow (DCF) - on this basis, an investment must generate enough additional profit or saving to recover the original capital plus a certain minimum earning.

<u>Buy or Lease</u>: There are many companies, both large and small, that prefer to lease packaging machinery rather buy it. If the product is standard and is expected to have a good future, outright purchase is undoubtedly the best choice. The tax benefit and the opportunity to make alterations to the equipment weigh heavily in favor of outright purchase. In some special cases, it is more prudent to rent a piece of machinery or even a whole production line. The condition which favor leasing include:

1. A product of uncertain future.
2. New and unproven machines.
3. One-time promotion or other short-term situations.
4. Supplemental equipment for seasonal or peak demand.
5. Government contract which allows full write-off of the rental cost.
6. Shortage of capital or lack of approval by top management.

Some companies use a rule of thumb that when the purchase price of equipment is less than the cost of a 5-year lease, it will be bought outright. Otherwise, a rental arrangement is favored.

Repair service must also be considered. The availability and terms of service can be part of the purchase contract.

Training of personnel may also be part of the agreement, as well as the initiation of maintenance programs.

In order to obtain a thorough understanding of the behavior of sub-element costs as paid for the packaging machinery cost, a number of packaging publications and accounting literature were reviewed.

Investment in assets. The cost of capital should be applied to the investment in physical assets(31). A precise definition of the cost of capital is elusive; however, Sam R. 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.(32).

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[31] Douglas M. Lambert, The Development of an Inventory Costing Methodology, Ph. D. Dissertation, The Ohio State University, 1975, p. 61.

[32] Sam R. Goodman, Financial Manager's Manual and Guide, (Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1973, p.219

James C. T. Mao[33] examined the concept of hurdle rate. This is the rate at which projects will be accepted - as it pertains to a perfect capital market and to capital rationing.

> 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 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 acquired and that, because of capital rationing, is currently turning down marginal investment promissing annual return 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 investment foregone by the firm, rather than by the price at which the funds were originally acquired. Of course, the 15 percent hurdle rate could be designated as the cost of capital to the firm, if this firm is interpreted generically.[34].

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33 James C.T. Mao, Quantitative Analysis of Financial Decisions, (Toronto, Canada: Collier-Macmillan Canada, Ltd., 1969), p. 393.

34 Ibid.

*IRR is an Internal Rate of Return

Accounting for the consumption of capital assets, as introduced by H. G. Thuesen, W. J. Fabrycky and G. T. Theusen[35], reads:

> An asset such as a machine is a unit of capital. Such a unit of capital loses value over a period of time in which it is used in carrying on the productive activities of a business. This loss of value of an asset represents actual piece meal consumption or expenditure of capital.
>
> An understanding of the concept of depreciation is complicated by the fact that there are two aspects to be considered. One is the actual lessening in value of an asset with use and the passage of time, and the other is the accounting for this lessening in value.
>
> The accounting concept of depreciation views the cost of an asset as a prepaid operating expense that is to be charged against the profits over the life of the asset. Rather than charging the entire cost as an expense at the time the asset is purchased, the accountant attempts, in a systematic way, to spread the anticipated loss in value over the life of the asset. This concept of amortizing the cost of an asset so that the profit and loss statement is a more accurate reflection of capital consumption is basic to financial reporting and income tax calculation.
>
> A second aim in depreciating account is to have, continuously, a monetary measure of the value of an enterprise's unexpected physical capital, both collectively and by individual units such as specific machines. This value can only be approximated with the accuracy with which the future life of the asset and the effect of deterioration can be estimated.
>
> A third aim is to arrive at the physical expenditure of physical capital, in monetary terms, that has been incurred by each unit of goods as it is produced. In any enterprise, physical capital in the form of machines, buildings, and the like is used in carrying on production

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[35] H. G. Thuesen, W. J. Fabrycky and G. J. Thuesen, Engineering Economy, 5th Edition (Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1977), pp. 329-330.

> activities. As the machines wear out in productive activities, physical capitals are converted to value in the product. Thus, the capital that is lost in wear my machines is recovered in the product processed on them. This lost capital needs to be accounted for in order to determine production cost.

Another concept of amortizing the cost of an asset is defined by Douglas Greenwald and Associates[(36)]:

> Amortization of fixed assets is a method of depreciating the original investment in equipment, or plants over the estimated average service life of an asset. Mortalities or retirement occuring before the average life has been attained are not accounted for by this method. Short-lived items that wear out before the end of the average life continue to be depreciated as if they were still present. Depreciation is terminated altogether when the average life has been attained.

The concept of depreciation, depletion, and amortization, as presented by Earl A. Spiller, Jr.,[(37)]:

> Each term refers to the estimated cost of the services of a long-lived asset consumed during the period. Every productive resource acquired represents a bundle of service potential to be realized over time. Whether it is consumed rapidly or over a long time span, for most resources the service life is limited. Consequently, it becomes necessary to allocate the cost of an asset to the accounting periods in which it is used.
>
> "Depreciation" is the name given to the process of allocating the cost of plant assets over their useful service lives.
>
> "Depletion" and "Amortization" are the names given to the cost allocation processes for natural resources (wasting assets) and intangibles, respectively.

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[36]Douglas Greenwald & Associates, <u>The McGraw-HillDictionary of Modern Economics</u>, 2nd Edition (New York: McGraw-Hill, Inc., 1973), p. 20.

[37]Earl A. Spiller, Jr., <u>Financial Accounting</u>, 3rd Edition (Homewood, Illinois: Richard D. Irwin, Inc., 1977), pp.300-301.

> Depreciation is a systematic and rational process of cost allocation reflecting the expiration of asset services. In establishing a procedure for allocating the cost of non-current assets, accountants encounter two problems. They must first estimate the useful service life of the asset and then devise a systematic and rational way to spread the* depreciation base over this service life. The useful life of the asset is its period of service to the particular business entity, not necessarily its total conceivable life.

The average service life of an asset can be equivalently interpreted as the economic life of an asset as the concept presented by H. G. Thuesen, W. J. Fabrycky and G. J. Thuesen[38]:

> The economic life of an asset is the time interval that minimizes the assets total equivalent annual costs or maximizes its equivalent annual income.
>
> The economic life is also referred to as the minimum cost life or the optimum replacement interval. In addition, one of the important determinants of an asset's economic life is the pattern of costs incurred by operating and maintenance (O & M) activities. This relationship can be observed in the discussion of sporadic, constant, and increasing O & M costs, in Appendix A.

Operation and maintenance costs. According to W. J. Thuesen, W. J. Fabrycky and G. J. Thuesen[39]:

> Operation and maintenance costs will ordinarily be made up of several items such as power, supplies, spare parts, and labor. Each of these items is estimated on the basis of the number of units of product that it is estimated are to be processed per year.

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*Depreciation base = Acquisition Cost-Net Residual Value
Cost of using asset = Original investment - portion of cost recovered or to be recovered at the end of asset's useful life.

[38] H. G. Thusesen, W. J.Fabrycky and G. J. Thuesen, Engineering Economy, 5th Edition (Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1977), p. 412.

[39] Ibid., p. 412.

F. C. Jelen[40] suggested an estimate of maintenance cost:

> Maintenance cost as percentage of investment per year ranges from 10% from a complex plant with severe corrosive conditions to 3% for a relatively simple plant with mild, non-corrosive conditions.
>
> Generally, maintenance can be taken as 60% labor cost and 40% materials cost when a unit is operating at 75% capacity, maintenance cost will be about 85% of the maintenance cost at 100% capacity. When operating at 50% capacity, maintenance cost will be about 75% of maintenance cost of 100% capacity.
>
> Maintenance cost is known to increase with the age of equipment, but the estimator must use an average figure (average value of depreciation).
>
> <u>Power and utilities costs</u>
>
> Electric rates may be obtained from the utilities. Utilities prices can be obtained from company cost records for nominal utility increments. Otherwise, they will have to be made by inquiry from outside sources or a study of the company-owned system, if the utility is self-generated.[41]

5. <u>Packaging process costs or</u>
   <u>Packaging operation costs</u>

The Packaging Institute, USA, & Packaging Machinery Manufacturers' Institute[42] defines "packaging operation" as:

1. Packaging method or way of operating or functioning.

2. Any phase of a practical packaging function, whether encompassing the entire activity or a single small activity involved in the function.

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[40] F. C. Jelen, <u>Cost and Optimization Engineering</u>, (New York: McGraw-Hill Book Company, 1970), p. 348.

[41] <u>Ibid</u>., p. 345.

[42] The Packaging Institute, USA, & Packaging Machinery Manufacturers' Institute, <u>Glossary of Packaging Terms</u>, 5th Edition, p. 116.

F. J. Jelen[43] defines "operating cost" or "manufacturing cost" as:

> The expense involved in keeping a project, operation, or a piece of equipment running and producing.
>
> Operating costs are commonly calculated on one of three bases, daily, unit-of-product, or annual basis. Operating costs fall into two major classifications, direct and indirect. Direct costs tend to be proportional to throughput, such as raw materials, and are called also variable costs. Indirect costs tend to be independent of throughput, such as local property taxes, and are called also fixed costs.[44]

Table 8, describes manufacturing cost checklist.

Table 9, describes preliminary operating-cost estimate.

Direct labor. Edmund J. Obremski[45] offered the formula in calculating direct labor cost, based on three elements:

- line speed;
- crew size; and
- fatigue and downtime factor

as shown in Appendix A.

A further investigation was undertaken in the area of production to identify the probable sub-element costs that contribute to packaging process costs. These sub-element costs are:

- Set-up cost or operation start-up costs, or production preparation costs.
- Lost capacity costs (lost capacity due to changeover cost).

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43 F. C. Jelen, Cost and Optiomization Engineering (New York: McGraw-Hill Book Company, 1970) p. 338.

44 Ibid, p. 340.

45 Edmund J. Obremski, Package Development & Systems, (New York: Scarborough Publishing Co., Ltd., 1978), July/August, pp. 24-25.

TABLE 8

## MANUFACTURING COST CHECKLIST

1. DIRECT PRODUCTION COSTS
    a. Raw material and fuel costs
    b. Utilities
        1. Electricity
        2. Steam
        3. Water
        4. Others
    c. Labor
        1. Operating labor
        2. Repair Labor
        3. Supervision
        4. Indirect payroll cost
    d. Supplies and miscellaneous
        1. Operating supplies
        2. Repair supplies
        3. Laboratory
        4. Other
        5. Contingencies

2. FIXED COSTS
    a. Factory overhead including taxes and insurance - general work expense
    b. Depreciation

3. DISTRIBUTION COSTS - LOADING, PACKING AND SHIPPING
    a. Materials
    b. Labor
    c. Overhead

Source: F. C. Jelen, Cost and Optimization Engineering, New York: McGraw-Hill Book Company, 1970.

TABLE 9

PRELIMINARY OPERATING-COST ESTIMATE

A. DIRECT PRODUCTION COSTS
   1. Materials
      a. Raw materials - estimate from price list
      b. By-product and scrap credit - estimate from price lists
   2. Utilities - from literature or from similar operation
   3. Labor - from literature or from similar operations
   4. Supervision - 10 to 25% of labor
   5. Payroll charges - 15 to 25% of labor plus supervision
   6. Maintenance - 3 to 6% of investment per year
   7. Operating supplies - 015 to 1% of investment per year.
   8. Laboratory - 20% of labor
   9. Royalties - 1 to 5% of sales
   10. Contingencies - 2 to 10% of direct costs

B. INDIRECT COSTS
   1. Depreciation 5-10% of investment per year
   2. Property taxes - 2% of investment
   3. Interest - 6 to 8% of investment
   4. Insurance - 1% of investment
   5. Plant overhead - 40 to 60% of labor or 15 to 30% of direct costs.

C. DISBRIBUTION COSTS
   1. Packaging - estimated from container costs
   2. Labor - from similar operations
   3. Shipping - from carrier or 1 to 3% of sales
   4. Overhead - 50 to 75% of distribution labor cost.

Source: F. C. Jelen, Cost and Optimization Engineering, New York: McGraw-Hill Book Company, 1970.

Set-up costs or Operation start-up costs, or Production preparation costs. According to Richard N. Cardozo(46), changes made in the packaging of the same product is one aspect of modifying existing product line. Marketing managers may alter the functional characteristics or appearance of the package to improve the performance of one or more of the packaging functions (to store the product, to protect it, to facilitate use of it, to help position or reposition it, and to help sell it).

For instance, functional characteristics may be altered to prolong the shelf-life of the product or reduce costs. In some instances, the manufacturers initiated these changes in an attempt to reduce handling and storage costs throughout the entire channel of distribution. Consequently, when package changes are introduced into the production lines, there is assumed to be incremental packaging process costs (this is known as either a "set-up costs" or an "operation start-up costs", or a "production preparation costs") that must be included when calculating packaging process cost.

The term "set-up costs", as presented by Haynes and Henry(47) in the concept of the function of inventory, refers to the physical work incurred in preparing for a production

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[46] Richard N. Cardozo, Product Policy, Cases and Concept, (Reading, Mass.: Addison-Welsley Publishing Company, 1979), pp. 41-42.

[47] W. Warren Haynes and William R. Henry, Managerial Economics, 3rd Edition (Dallas, Texas: Business Publications, Inc., 1974), p. 299.

run (setting up) equipment and adjusting machines and the clerical costs of shop orders, scheduling, and expediting. Set-up costs remain relatively constant regardless of the site of the order.

"Operation start up costs" is presented by F. C. Jelen(48) and refers to costs generally expensed along with other production costs. Included are salaries and wages for start-up supervision and operators, raw materials and finished product that are spoiled or off-grade, maintenance labor and materials, supplies, and general plant expense.

Moreover, operating costs during start-up are generally high and often exceed product market price on a per-unit basis.

The concept used in determining the set-up costs for the year, as presented by H. G. Thuesen, W. J. Fabrycky and G. J. Thuesen(49), is the following:

$$SC = C_s \ (N)$$
$$= C_s \ \frac{(D)}{(Q)}$$

Where SC = set-up cost per year;
Cs = set-up cost per production run;
D = yearly demand for the item;
Q = production quantity;
N = number of production runs per year

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48 F. J. Jelen, Cost and Optimization Engineering, (New York: McGraw-Hill Book Company, 1970), pp. 375-376.

49 H. G. Thuesen, W. J. Fabrycky and G. J. Thuesen, Engineering Economy, 5th Edition (Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1977), p. 520.

According to Douglas M. Lambert (50), production preparation costs are made up of the following costs:

a. Set-up time
b. Inspection
c. Set-up scrap
d. Inefficiency of beginning operation.

It was also pointed out that the production preparation costs and the lost capacity cost are usually available since they are used as inputs to production planning.

6. Distribution costs

According to Edmund A. Leonard(51):

> All expenses concerned with physically moving finished packed goods from the packing plant to the customer are distribution costs.
>
> This includes palletizing, master shipper loading, strapping, warehousing and shipment by all means of transportation. Outbound freight does not apply to those commodities which are sold F.O.B. the packer's plant. Certain products have specialized distribution requirements which add cost.

Patterns for distribution of products and cost elements associated(52):

1. Plant-to-Plant Direct Shipment, e.g. a manufacturer of automobile parts ships directly from his plant to

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[50] Douglas M. Lambert, The Development of an Inventory Costing Methodology, Ph. D., Thesis, The Ohio State University, p. 12.

[51] Edmund A. Leonard, Introduction to the Economics of Packaging, 1st Edition, 1968, pp. 10-11.

[52] Edmund A. Leonard, Packaging Economics (New York: Book for Industry, Division of Magazines for Industry, Inc., 1980), pp. 129-130.

a customer's assembly plant. The costs include:
- labor for loading rail cars or trailers;
- the freight rate multiplied by the gross weight of the shipment (the rate includes the factor for distance);
- the cost of dunnage and its installation;
- labor for unloading, and processing of claims for damage in transit, if any.

Thus, in this distribution pattern, there are at least four cost elements and possibly six.

2. Air Cargo. The cost starts with delivery of the container to the shipper and his loading of it. Then, the truck pick up, the transfer to the plane, the in-flight leg of trip, unloading the plane, trucking to the consignee and finally his labor to unload the container - eight cost elements in all.

3. Piggyback. This dual-mode situation resembles Air cargo, with the exception that air travel is not involved. A truck trailer is loaded by the shipper and driven to a rail terminal, where the trailer is loaded onto a flat car. The trailer travels by rail to a rail terminal in the vicinity of its destination, where it is unloaded from the car and hauled by cab to the consignee. The number of cost elements is the same as for air cargo.

Jack Milgrom and Aaron Brody(53) presented the concept of economics of physical distribution as follows:

> The costs of physical distribution function can be estimated only when one defines the beginning and end of the function.
>
> The distribution by the packer to the wholesaler/retailer's warehouse, typically involves two or three movements, and then the wholesaler/retailer uses about four movements to move the packaged product to the consumer.

The National Association of Food Chains(54) has indicated that:

> Generally the cost of moving products from the warehouse to the super market is between $145 and $160 per ton. For example, a can of soft drink that sells for 10¢,

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[53] Jack Milgrom and Aaron Brody, Packaging in Perspective (Cambridge, Mass.: Arthur D. Little, Inc., 1974), p. 95.

[54] Ibid., p. 95.

the distribution cost for the wholsesaler/retailer amounts to about 11% of the retail sales prices of the can. These costs include warehousing, inventory interest, transport from the warehouse to the store, and store lab or (including check out).

The average costs of distribution of all products in the super market are about 20%. But these costs represent only part of the physical distribution. The cost to the packager/producer of moving the product from his manufacturing facility to the customer's warehouse represents about 5-6% of wholesale price for most food products, and 7-85 for items such as household chemicals. These costs include warehousing and transportation; most is attributed to transportation.

A total physical distribution cost is given by the expression: $D = T + FW + VW + S$[55]

Where D = total distribution cost of proposed system
T = total freight cost of proposed system;
FW = total fixed warehouse cost of proposed system;
VW = total variable warehouse cost (including inventory) of proposed system;
S = total cost of lost sales due to average delivery delay under proposed system.

Besides the sub-element costs presented by Edmund A. Leonard:

a. Storage and warehousing
b. Outbound freight

the probable sub-element cost that contributes and will be included in calculating packaging distribution cost is the inventory carrying cost.

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[55] Philip Kotler, Marketing Management, 4th Edition (Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1980), pp. 453-454.

Douglas M. Lambert proposed the four basic cost categories must be considered when calculating inventory carrying cost[56], as shown in Table 10.

Thomas S. Dudick and Ross Cornel[57] suggested that for operation costs component, in calculating inventory carrying cost, breakage and obsolescence costs allowances are based on historical data. When practical, obsolescence allowances take into account the anticipated life cycle of the product; otherwise past experience is used.

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[56]Douglas M. Lambert, The Development of Inventory Costing Methodology, Ph. D. Dissertation, The Ohio State University, 1975, p. 57.

[57]Thomas S. Dudick and Ross Cornel, Inventory Control for the Financial Executive (New York: Ronald Press Co., 1979) p. 46.

TABLE 10

THE COMPONENTS OF INVENTORY CARRYING COST

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 warehouse
   b. Public warehouse
   c. Rented warehouse
   d. Company owned warehouse

4. INVENTORY RISK COSTS
   a. Obsolescence
   b. Damage
   c. Shrinkage (pilferage)
   d. Relocation costs

Source: Douglas M. Lambert, The Development of Inventory Costing Methodology, 1975.

W. Warren Haynes and William R. Henry[(58)] suggested that for costs due to obsolescence, deterioration, pilferage, the total of these costs is usually obtained by dividing their actual costs, determined by cost accounting, by the average value of inventory.

7. Write-off of terminal inventories.

Edmund A. Leonard[(59)] presents:

> Any time when a package change is decided, there will be packed goods in the channel of distribution, packaging materials in the packer's plant, and raw to finished packaging materials in the supplier's plants and warehouses.

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[58] W. Warren Haynes and William R. Henry, Managerial Economics, 3rd Edition (Dallas, Texas: Business Publications, Inc., 1974), p. 288.

[59] Edmund A. Leonard, Introduction to Economics of Packaging, 1st Edition, 1968, p. 12.

> The change over must be arranged with a view of minimizing the value of old materials in this chain of supply and distribution which have to be discarded.

William J. Bruns, Jr., and Richard F. Vancil (60) recommended that replacement costs can be estimated in the following way:

TABLE 11

ILLUSTRATION OF CONSTRUCTION OF A COST INDEX FOR ONE YEAR TYPE OF ASSET (Base Year is 1972)

| Date | Current Cost of Asset | Cost Index |
|---|---|---|
| 1972 | $250 | (250 ÷ 250) X 100 = 100 |
| 1973 | 295 | (295 ÷ 250) X 100 = 118 |
| 1974 | 345 | (345 ÷ 250) X 100 = 138 |
| 1975 | 400 | (400 ÷ 250) X 100 = 160 |
| 1976 | 475 | (476 ÷ 250) X 100 = 190 |

Source: William J. Bruns, Jr., and Richard F. Vancil, A Primer on Replacement Cost Accounting, 1976

> Where identical assets are currently available for purchase, the cost to buy replacement assets can be estimated by market price. If the asset to be replaced is inventory that has been manufactured by the firm, the cost to manufacture new inventory can be estimated giving consideration to current material, labor and other manufacturing costs.

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60 William J. Bruns, Jr., and Richard F. Vancil, A Primer on Replacement Cost Accounting (President and Fellows of Harvard College Reproduced by permission, 1976), pp. 10.

For many assets, using an index number to estimate replacement cost may be the most objective, easiest and least costly method for estimating replacement cost. An index is the ratio of two prices for the same item at two different points of time.

Usually, an index relates prices for a series of years (or some other period of time) to a single base year. The index at the base year is ususally stated as 100. Table 11 shows how an index is estimated.

Using a cost index to estimate a replacement cost can be illustrated using the index developed in Table 11. Suppose an asset of this type, purchased in 1975 for $800, is sold in 1976. One can calculate the replacement cost of goods sold as follows:

Historical Cost X (1976 Index ÷ 1975 Index) = Replacement Cost

$800 x (190 ÷ 160) = $950

Typical input for packaging cost model - The production line:

Neil C. Robson[61] pointed out that:

On a high speed, capital intensive production line, the allocation of costs per package requires much quantitative and performance data. Nevertheless, such data is normally easy to obtain because it is recorded as a measure of efficiency and cost control.

Typical factors contributing to added value on a packaging line are listed in Table 12. Using date from Table 12, the average packaging cost can be determined per package or per unit volume of product.

There are additional suggestions on how to handle uncertain and quantitative data:

---

[61] Neil C. Robson, Canadian Packaging, March 1978, pp.29-30.

Less accurate information is obtainable concerning the costs of transporting and storage of empty packages. Fortunately, these are relatively minor constituents of the total packaging cost. Transport costs, for example, can safely be based upon an average number of packages per vehicle. Warehousing costs can assume a certain stacking density for each type and size of package. (62).

TABLE 12

TYPICAL FACTORS CONTRIBUTING TO ADDED VALUE ON A PACKAGE LINE.

FIXED COSTS (established on an annual basis)
- packaging equipment depreciation
- allocation of building costs, based on area occupied
- allocation of other plant and service depreciation costs, based on area occupied or on comsumption
- allocation of management costs and burden on value, throughout or other criteria.

VARIABLE COSTS (established on a weekly or monthly basis)
- cost of labor employed on packaging line including overtime, benefits, etc.
- cost of power, heat, light and other services attributable to packaging line
- cost of ancilliary packaging materials - adhesive, ink, etc. (The cost of the basic package, as it arrives at the packaging line, appears elsewhere in the econometric model).
- cost of maintenance and spares attributable to packaging line.

To obtain the added value per unit package, the following additional data is needed:
- actual packaging line output, taking into account efficiency and dow time.
- line wastage, both of product and packaging materials
- average pack content, as some costs are related to throughput of product rather than packaging.

Source: Neil C. Robson, Canadian Packaging, 1978

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[62] Ibid.

The behavior of variable and fixed costs, according to Sidney Davidson, James S. Schindler, Clyde P. Stickney and Roman L. Weil(63), can be described as follows:

> Variable costs change as the volume of activity changes and are zero when production is zero. In accounting, variable costs are usually assumed to be linear and typically means a cost that is constant per unit of activity or one that is strictly proportional to output.
>
> Fixed costs remain constant during an accounting period within a reasonable range of activity. Costs quoted as a price per unit of time.

Hiroyuki Iwashimizu(64) defined the packaging system cost model as:

> The description of the whole system of packaging with respect to cost. By showing the whole system in higher levels (Figure 2), the idea of the packaging system mechanism is shown. Going into details of each system unit, the cost which comes from each component (lower level) of the system unit will be identified.

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[63] Sidney Davidson, James S. Schindler, Clyde P. Stickney and Roman L. Weil, Managerial Accounting (Hinsdale, Illinois: The Dryden Press, 1978), pp. 99-100.

[64] Hiroyuki Iwashimizu, Packaging System Cost Model, Unpublished report, School of Packaging, Michigan State University, 1976, pp. 2-6.

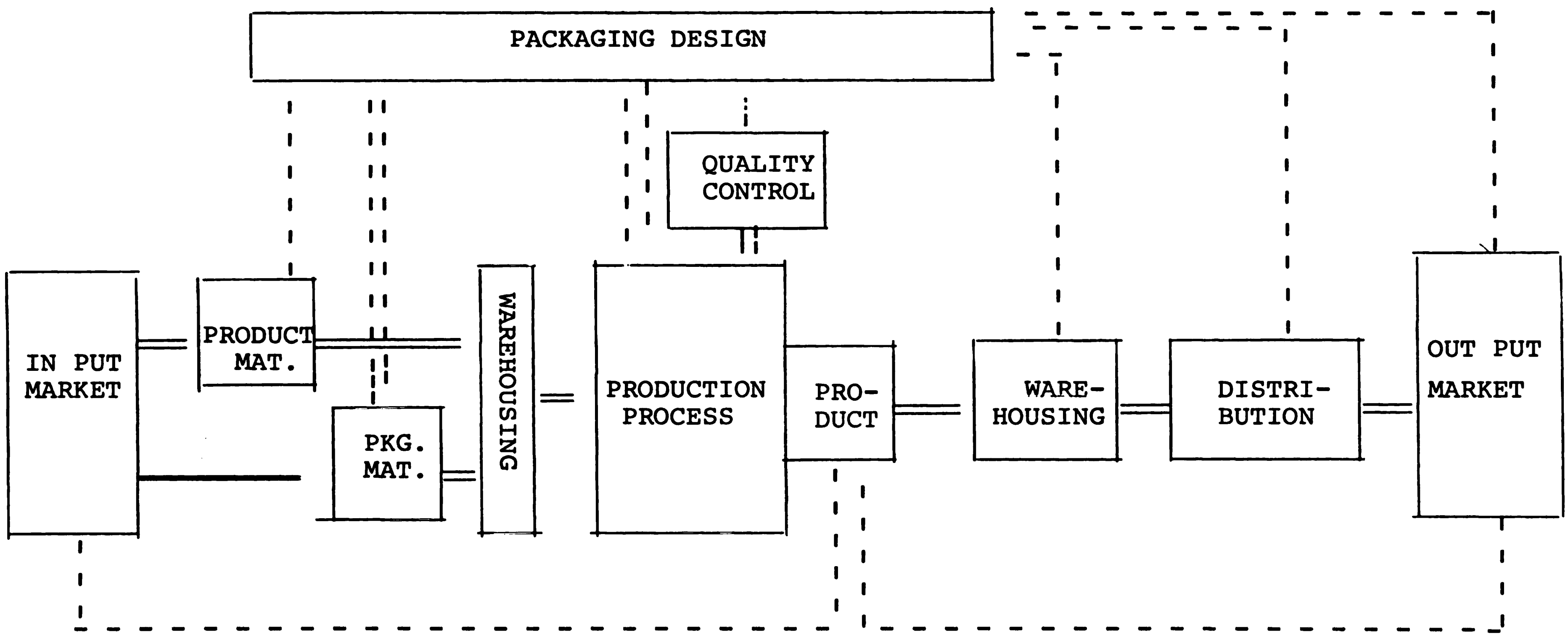


FIGURE 2.

PACKAGING SYSTEM COST MODEL

- - - Information flow

═══ Material or Product Flow

TABLE 13

SYSTEM UNITS AND THEIR COMPONENTS LIST

1. INPUT MARKET
    a. Supplier of material
    b. Natural resources limitation
    c. Regulation
    d. Others

2. PACKAGING DESIGN (COST)
    a. Graphic design (cost)
    b. Structual design (cost)
    c. Testing (cost)
        1) Material test
        2) Performance test

    These may be divided into two parts;
        1) Consumer packages
        2) Shipping containers
    d. Labor (cost
    e. Equipment (cost)

3. PRODUCT MATERIALS (COST)
    a. Product material cost

4. PACKAGE MATERIALS
    a. Consumer package material cost
    b. Shipping container material cost

5. PRODUCTION PROCESS (COST)
    a. Machinery cost
    b. Labor cost
    c. Material handling cost
    d. Running cost
    e. Maintenance cost
    f. Yield (loss)

6. QUALITY CONTROL (COST)
    a. Equipment cost
    b. Labor cost

7. WAREHOUSING (COST)
    a. Material handling cost
    b. Labor cost
    c. Space cost
    d. Damage (loss)

8. DISTRIBUTION (COST)
    a. Vehicle (cost)
    b. Material handling (cost)
    c. Labor (cost)

TABLE 13 (Continued)

9. OUTPUT MARKET
   a. Consumer
   b. Consumer demand
   c. Retailer
   d. Wholesaler
   e. Others

Source: Hiroyuki Iwashimizu, Packaging System Cost Model, 1976.

It was pointed out that each system unit has its components which explain the cost component of it.

> Excluding input market, output market, each system unit can be followed by the work "cost", for example, product material cost, packaging design cost, distribution cost and the like.(65)

The system units and their components are shown in Table 13.

## THE ESTIMATION OF PRODUCT COST
## COST ACCOUNTING

H. G. Thuesen, W. J. Fabrycky and G. J. Theusen(66) defined cost accounting as:

> A branch of general accounting adopted to registering the costs for labor, material, and overhead on an item-by-item basis as means of determining the cost of production.

It was pointed out that the costs that are incurred to produce and sell an item of product are commonly classified as:

---

[65] Ibid.

[66] H. G. Thuesen, W. J. Fabrycky and G. J. Thuesen, Engineering Economy, 5th Edition (Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1979) pp. 311-314.

- DIRECT MATERIAL. Ordinarily, the cost of principal items of material required to make a product are charged to it as direct material cost.

- DIRECT LABOR. Direct labor is labor whose cost is charged directly to the product. The labor of personnel engaged in such activities as inspection, testing, or moving the product from machine to machine or in picking, pointing, or washing the product is often charged in this way. Items as social security, pensions, and insurance costs that are nearly proportional to direct wages are sometimes included in arriving at direct labor costs.

- FACTORY OVERHEAD. Factory overhead is also classified as factory expense, shop expense, burden, indirect cost, Factory overhead embraces all expenses incurred in factory production which are not directly charged to product as direct material or direct labor.

- FACTORY COST. The factory cost of a product is the sum of direct material, direct labor, and factory overhead.

- ADMINISTRATIVE COST. Administrative costs arises from expenditures for such items as salaries of executive, clerical, and technical, and auditing services that are necessary to direct the enterprise as a whole as distinct from its production and selling activities.

  For administrative costs, in most cases it is not practical to relate administrative costs directly to specific products. The usual practice is to allocate administrative cost to the product as a percentage of the product's factory costs.

- SELLING COSTS. The selling cost of a product arises from expenditures incurred in disposing of the products and service produced. This class of expense includes such items as salaries, commissions, office space, office supplies, rental and depreciation, operation of office equipment and automobiles, travel, market surveys, entertainment of customers, displays and sales space.

  In many cases, it is considered adequate to allocate selling expense to the product as a percentage of their production cost. (67)

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[67] _Ibid._

## FINANCIAL ACCOUNTING

Sidney Davidson, James S. Schindler, Clyde P. Stickney, and Roman L. Weil(68) defined financial accounting as:

> Typically refers to the preparation of general purpose reports for use by personnel outside, or external to a firm.
>
> Financial accounting makes an important distinction between a product cost and a period expense. Cost incurred in changing the physical form of goods being manufactured are product costs. These costs are included in the valuation of inventory and until the goods are sold, are shown on the balance sheet as assets. When the inventory items are sold, these products become expenses of the period of sale. Period expenses, on the other hand, are treated as expenses in the same period in which the costs are incurred. (for example, selling and administrative expenses). Thus, period expenses do not become part of the cost of product being manufactured.
>
> Generally accepted accounting principles and the income tax law specify the types of costs that are to be treated as product costs.
>
> According to financial accounting practice, product cost is composed of three elements:
> 1. Direct material
> 2. Indirect labor, and
> 3. Manufacturing overhead.(69)

A further study was undertaken in the area of packaging cost analysis to reinforce the concept in per-unit package costing process. According to Mike Mcdermott(70):

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[68] Sidney Davidson, James S. Schindler, Clyde P. Stickney and Roman L. Weil, Managerial Accounting (Hinsdale, Illinois: The Dryden Press, 1978), p. 1.

[69] *Ibid*., p. 283-284.

[70] Mike Mcdermott, Rexham Booth Computer Does Cost Analysis (Food & Drug Packaging, Volume 44, No. 6, March 19, 1981, pp. 3, 25).

Rexham researchers have developed a computer program that compares the per-unit packaging cost of 303 x 406 cans to a comparably sized retort pouch. Taken into account are such factors as labor, electricity, thermal energy, transportation, material and storage labor costs.

First, can packaging cost data is punched into the computer. This includes per-hour labor costs, including fringe benefits; the number of workers on line multiplied by number of shifts; the number of annual hours per direct worker; the number of clean up workers multiplied by number of shifts; the number of indirect workers, and annual can production.

Next, inbound shipping costs are computed using average miles per load, number of loads to ship in empty cans, cost per mile excluding fuel and fuel cost per mile. Outbound shipping costs are determined from similar data.

After labor and shipping costs are determined, the computer adds the cost of storage, electricity, thermal energy, containers and cases and computes the per-unit cost of each can produced.

Per-unit cost per pouch is then determined using the same or similar criteria, and the computer compares the two sets of data category by category and by overall costs.

## SUMMARY

There have been a number of publications that have produced the types of costs that should be included in packaging cost, but none have addressed the problems of how to operationalize the collection of such costs.

From the literature cited previously, the evidence supports the contention that both selling costs and administrative costs should not be included in the calculating of total packaging cost.

The costs that should be included in the cost of packaging production will depend upon to a certain extent, the use to be made of the figure. Fox example, both selling costs and administrative costs included in Table 5 are relevant only if the purpose of the use is to the costing of the product. These selling and administrative costs should not be included in calculating the packaging cost of the packed good.

From the literature review concerning the elements of packaging cost, the total packaging cost was determined to be the following costs:

1. Package development costs.
    a. on research process
    b. on development process
    c. on finalization process

2. One-time costs
    a. Engineering tooling for production
    b. Packing-line equipment and change parts
    c. Installation

3. Packaging materials costs
    a. Basic package unit price
    b. Special packing for inbound shipment
    c. Inbound freight
    d. Storage and handling
    e. Shrinkage (damage, loss, cost of overages)
    f. Sampling and inspection costs

4. Packaging machinery costs, other than one-time
    a. Amortization per unit package
    b. Operational service and maintenance
    c. Power and utilities

5. Packaging process costs
    a. Direct labor
    b. Factory overhead
    c. Production preparation
    d. The lost capacity (due to changeover)
    e. Down-time
    f. Incidental materials

6. Distribution costs
    a. Inventory carrying costs
        1. Capital costs
            - on inventory investment
            - on investment in assets required by inventory

        2. Inventory service costs
            - insurance
            - taxes

        3. Storage space costs
            - plant warehouse
            - public warehouse
            - rented warehouse
            - company owned warehouse

        4. Inventory risk costs
            - obsolescence
            - damage
            - shrinkage (pilferage)
            - relocation

    b. Outbound freight

7. Writeoff of terminal inventories
    a. on packed goods
    b. on packaging materials

# CHAPTER III

# RESEARCH DESIGN

The purpose of this chapter is to present the methodology that was developed on the basis of the literature reviewed in Chapter II and to structure the remaining research design so that the methodological framework can be tested using the arbitrarily assumed inputs (elements of packaging cost).

Completed research design is presented in 3 sections:

- Development of the packaging cost model;
- Formulation of the optimization of packaging cost model;
- Validation of the optimization of packaging cost model.

## DEVELOPMENT OF THE MODEL

The literature review was used as the basis for the development of the methodological framework to be used to determine packaging cost.

The following seven basic cost categories must be considered when calculating total packaging cost:

1. Package development costs
2. One-time costs
3. Packaging materials costs
4. Packaging machinery costs, other than One-time

5. Packaging process costs

6. Distribution costs

7. Writeoff of terminal inventories.

1. Package development costs

The package development costs used in this research is the concept presented by Edmund A. Leonard (71) that "Package development costs" are the expenses for all those activities that lead up to and include the issuance of specifications for packaging materials, on the basis of which purchase orders can be placed.

Following are sub-elemental package development costs:

a. Research process cost. This is to determine the need. Early collection of all pertinent data and orientation to marketing strategy is critical. With such information, one can develop a problem statement and, establish parameters for the package. Next, is to develop initial concepts for package which once analyzed to determine what additional information one needs to gather. Activities in research process which incurred the costs are:

- marketing planning
- product position statement and identification of package criteria
- gathering competitive packages
- investigating materials
- investigating equipment concept
- screening existing package

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[71] Edmund A. Leonard, Introduction to Economics of Packaging, 1st Edition, 1968, p. 7.

b. Development process cost. During this process, various design concepts in two and three dimensions are developed. This will be followed with an analysis of these options, and working with marketing, select the best alternatives. Included activities which incurred the cost are:

- models
- sampling tooling and samples
- sample evaluation
    technical: engineering test
    customer research: dealer test, customer test
- costing and specifications

c. Finalization process cost. Following the selection of the best design, one is ready to prepare the final prototype, final support documents, and implementation of the program. Included activities which incurred the cost are:

- tooling and materials for test market
- test market pack and evaluation
- specification refinement and purchasing
- tooling for production
- quality control program implementation

It is rare that all of these costs can be recovered during the first year of production. One practical way of calculating package development costs, so as to obtain recovery of package development costs, is to amortize the charge over a period of several years (usually 2 to 5 years).

2. <u>One-time costs</u>

The one-time costs used in this research is the concept presented by Edmund A. Leonard that "One-time costs" are all those expenditures which will not have to be repeated during the "life" or active use of a package specification.

One-time costs are made up of:

a. <u>Engineering tooling for production cost</u>. This cost incurred from coordinating plant-level-engineering activities in reference to new packages, including supply test, start-up problems, etc., also included:

b. <u>Packing-line equipment and change part cost</u>. Generally speaking, suppliers do not charge for replacement of original tooling which is required by wear-out, such as plastic or glass molds or dies or printing plates. However, the packer must bear his own replacement costs on packaging machinery and parts (as noted in the category of packaging machinery costs).

c. <u>Installation of machinery cost</u>. This cost covers the expenses for supplier's engineer and/or technicians crew, such as straight time and over time ($ per hour) plus reasonable and travel and living expenses.

3. <u>Packaging materials costs</u>

Following are elements made up of packaging materials costs:

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[72] Edmund A. Leonard, <u>Introduction to Economics of Packaging</u>, 1st Edition, 1968, p. 6.

a. Basic unit cost. This is the quoted price. For example, price per thousand containers (can: or cartons or repeats or jars).

b. Special packing cost. Most materials are assumed to be deliverable in accordance with certain accepted trade practices. If packer wishes something different, he incurs some cost premium.

c. Inbound freight cost. There is cost involved to ship packaging materials from the supplier to the packer. Practices in delivery and freight charging differ greatly among segments of the packaging materials industry.

d. Packaging, materials storage and handling cost. There are three possible ways to handle the situation:

   - the supplier stores against the packer's release for delivery;
   - the packer buys outside storage service, usually a public warehouse;
   - the packer stores in his own storehouse.

However done, the service has a cost - the cost of the storage space and labor.

e. Shrinkage (Damage, Loss, Overages) cost. The term "shrinkage" refers to quantity rather than size. Specifically, this means "the loss of all reasons that account for the diffent between units of packaging material received and units of packed goods shipped."

f. Sampling and inspection cost. Most packers audit the quality of incoming packaging materials. In general, the more complex the package, the more the cost of sampling and testing. The value of the contained product and the hazards of its spoilage will also influence the amount of expenditure on packaging material quality inspection.

4. Packaging machinery costs, other than One-Time

Before purchasing any machinery for the packaging line, it is necessary to make a financial analysis to determine whether the expenditure will be justified. There are several ways to evaluate investment proposals for new machinery:

- Payback period;
- Return on investment (ROI);

and - Discounted cash flow (DCF).

Whichever method is used to determine the cost of machinery, it is necessary to combine the capital costs and operating costs to determine full cost of ownership.

The cost of capital used in this research is the hurdle rate concept presented by James C.T. Mao.[73] 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 packaging machinery should be expected to earn a rate competitive with marketable securities and/or other liquid investments of the firm.

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[73] James C. T. Mao, Op. Cit., p. 173.

Buy or Lease. Many companies prefer to lease packaging machinery rather than buy it. If the product is standard and is expected to have a good future, outright purchase is undoubtedly the best choice. In some cases, it is more prudent to rent a piece of machinery, or even a whole production line. A rule of thumb that might be served as the guidelines, when the purchase price of machinery is less than the cost of a 5-year lease, it will be bought out right. Otherwise, a rental arrangement is favored.

Packaging machinery costs are made up of:

a. Amortization per unit package[(74)] The amortization, the cost of an asset used in this research, is the concept as presented by Douglas Greenwald and Associates.

In allocating the original investment in packaging machinery to total packaging cost, the economic life of an asset (the average service life of an asset) must be determined as the approach suggested by H. G. Thuesen, W. J. Fabrycky and G. J. Thuesen.[(75)] Essentially, one of the important determinants of an asset's economic life is the pattern of costs incurred by operating and maintenance (O & M) activities. Additionally, a full understanding of the concept of depreciation is necessary to understand the methods and be able to depreciate the original investment for packaging machinery.

---

74, 75 The full treatment is in Appendix A.

b. Operational service and maintenance. Costs included are salaries and wages for start-up supervision and operators, raw materials and finished product that are spoiled or off-grade, maintenance labor and materials, supplies.

The availability and terms for operational service cost and maintenance cost can be arranged as part of the packaging machinery purchase contract. Training of personnel cost, also available from the contract, must be included in calculating operational service and maintenance cost.

c. Power and Utilities. Electric rates may be obtained from the utilities. Utilities prices can be obtained from company cost records for nominal utility increment.

5. Packaging process costs.

Packaging process costs are made up of:

a. Direct labor.[76] This is the cost of labor of personnel engaged on packaging lines, in such activities as moving product from machine to machine, or in pickling, or inspection and testing. Such items as overtime, benefits that are nearly proportional to direct wages are sometimes included in arriving at direct labor costs.

b. Factory overhead. Factory overhead costs embrace all expenses incurred in factory production which are not directly charged to products as direct material or

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76 The full treatment is in Appendix A.

direct labor. Factory overhead is also designated by such items as factory expense, shop expense, burden and indirect cost. Typically, the following items are factory overhead:

- allocation of building costs, e.g. building maintenance based on area occupied
- allocation of other plant and services depreciation costs, based on area occupied or on consumption
- allocation of management costs and burden based on value, throughput or other criteria
- allocation of taxes, insurance, power, heat, etc., either on area occupied, or on its employment relative to plant total.

c. <u>Production preparation</u>. The production preparation cost concept used in this research stems from Haynes and Henry which refers to the physical work incurred in preparing for a production run (setting up and/or adjusting machinery/equipment so that different types of packages can be processed) and clerical costs of shop order, scheduling, and expediting.

Production preparation costs remain relatively constant regardless of the size of the production run.

According to Douglas M. Lambert,[77] production preparation costs are made up of the following costs:

- set-up time

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Production preparation costs are equivalent to set-up costs (SC)

$$SC = C_s(N) = Cs\frac{(D)}{(Q)}$$

Where SC = set-up costs per year;
Cs = set-up costs per production run;
N = number of production runs per year;
D = yearly demand for the item;
Q = production quantity

[77] Douglas M. Lambert, Op. Cit., p. 12

- inspection

- set-up scrap

- inefficiency of beginning operation

d. The lost capacity (due to changeover)

e. Down-time

Both the lost capacity (due to changeover) and down-time costs can be approximated by taking the costs incurred at different levels of activity and dividing by the increment in volume.

f. Incidental materials. Incidental materials cost is usually inclusive of glue and stream and gas, etc. which may be required for packaging process. Their total monthly costs, divided by unit packed, will identify a cost per unit for such materials.

6. Distribution costs.

The distribution costs used in this research is the concept by Edmund A. Leonard that all expenses concerned with physically moving finished packed goods from the packing plant to the customer are distribution costs.

The distribution costs are made up of:

a. Inventory carrying costs. The following four basic cost categories must be considered when calculating inventory carrying costs(78):

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78 Douglas M. Lambert, The Development of an Inventory Costing Methodology, Ph. D. Dissertation, the Ohio State University, 1975, pp. 60-67.

7. Capital costs. The cost of capital used in this research is the hurdle rate concept as presented by James C.T. Mao. There are two types of capital costs that should be considered:

   a. Inventory investment. The cost of capital should only be applied to the out-of-pocket investment in finished packed goods inventory. Although most companies use some variation of absorption costing for inventory valuation, only variable packaging manufacturing costs are relevant. The minimum acceptable rate of return *(MARR) on new investments should be applied only to the variable costs directly associated with the investment in finished packed goods inventory.

   b. Investment in assets. The cost of capital also should be applied to the investment in physical assets, such as materials handling equipment. This is done if the amount of investment varies directly with the volume of finished packed goods inventory held and not the quantity of the inventory shipped.

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* MARR is the rate of which the firm can always invest since it has a large number of opportunities that yield such a return.

2. Inventory service costs. The inventory service costs consist of:

a. Taxes. Taxes varies depending on the state in which inventories are held. 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 caluculated by using the actual taxes paid during the previous year over the average inventory value during that year.

b. Insurance. Although insurance rates are not strictly proportional to inventory levels (since insurance is usually purchased for a specific 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.

3. Storage space costs. There are four types of facilities that should be considered and the treatment is quite different for each one:

a. 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 products.

b. Public warehouses. Space in a public warehouse 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 rented cost should be considered in carrying cost.

The capital costs associated with holding inventory in public warehouses must be included in finished packed inventory carrying costs. These costs are equal to the variable manufacturing costs plus variable distribution costs multiplied by the *opportunity cost of capital.

c. Rented (Leased) warehouses. The amount of space rented is based on the maximum amount needed for the period of the contract.

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* Minimum acceptable rate of return which is the hurdle rate.

Thus, the rate of incurring warehouse rental charges does not fluctuate from day to day with changes in the inventory level. Though 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 costs may vary with the inventory level.

However, operating costs that are not variable with the level of inventory held should not be included in carrying costs.

d. 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. Inventory risk costs vary from company to company and include charges for obsolescence, damages, pilferage and relocation of inventory.

a. Obsolescence. The cost of obsolescence is the cost of each unit which must be disposed of at a loss because it became obsolete. It is the difference between the original cost of the unit and its salvage value.

b. 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 carrier.

c. Pilferage. Inventory theft, in the view of many authorities, is a more serious problem than cash embezzlement. Shrinkage may be more closely related to company security measures than inventory levels, although it will definitely vary with the number of warehouse locations.

d. Relocation costs. Relocation costs are associated with transhipment of inventory from one stocking location to another. In most cases, they are the result of tradeoff 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.

b. Outbound freight. Outbound freight does not apply to those commodities which are sold F.O.B. the packer's plant. Certain products have specialized distribution requirements which add costs. The costs of shipper and shipping are determinable by reference to rules of the rail and trucking industries' Freight Classification Boards. A large and growing volume which they published is known by the name of Rule 41. This states the minimum requirements for a shipping container to hold almost any conceivable commodity so as to enjoy the coverage of a common carrier's insurance against damage in shipment.

Freight rates by common carrier are also fixed by commodity. The factors which are considered in rate-setting include the value of the commodity, the average density in pounds per cubic foot as shipped, and the distance. Light-weight products have higher rates than dense ones, for the reason that to meet his costs, the carrier must receive at least a break-even revenue per truck or railcar employed.

For the case of containerization, the total transportation cost[79] will be:

$$C_{trp} = C_{trp,\ truck} + C_{trp,\ container} + C_{trp,railroad}.$$

The transportation cost considered when selecting container dimensions must be based on the transportation modes used. This means that the selection will depend on how much railroad, truck and ISO-freight in container.

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[79]Gunilla Johnson, Lecutre: Technical Economic Calculation on non-returnable and Unit Load Container for Transportation by Road, Rail, Sea and Air, Swedish Packaging Research Institute, 1979.

7. <u>Writeoff of terminal inventories</u>.

Any time a changeover from one package to another is decided upon, there will be costs incurred, i.e. the write off of terminal inventories costs. As there will be packed goods in the channel of distribution, packaging materials in the supplier's plants and warehouse. Of course, the write-off of terminal inventories costs (for both finished packed goods and packaging materials) must be included in calculating total packaging cost.

The approach used in calculating this cost element in this research is the "Estimating Replacement Costs" concept as presented by William J. Bruns, Jr., and Richard F. Vance.[80]

The methodology has been summarized in Figure 3 which, in addition to illustrating an interpretation of the elements of packaging cost date (input) required to adequately assess the total packaging cost, shows the perceived availability of such data.

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[80] William J. Bruns, Jr. and Richard F. Vance, Op. Cit., p. 70.

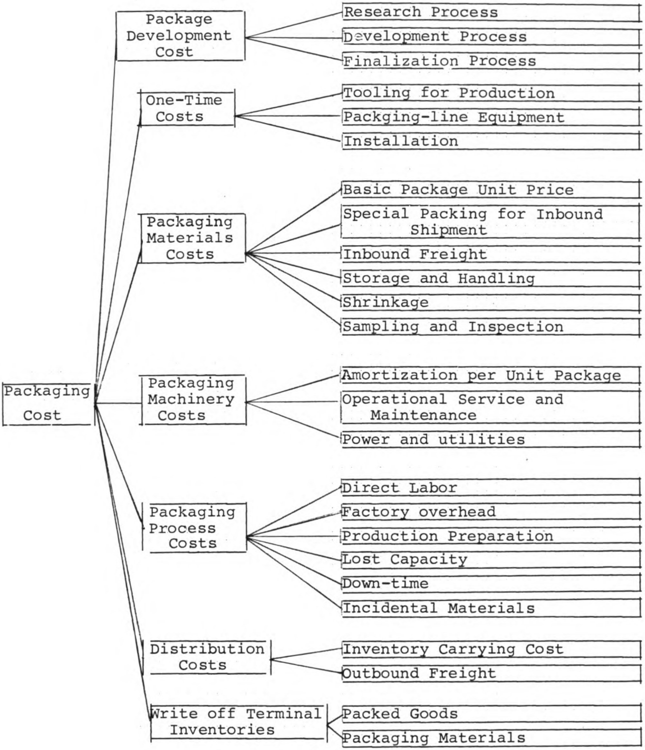


FIGURE 3. NORMATIVE MODEL OF PACKAGING COST METHODOLOGY

## FORMULATION OF THE OPTIMIZATION OF PACKAGING COST MODEL.

### DESCRIPTION OF THE MODEL.

Linear programming (LP) is without doubt one of the most used methods of operation research (OR) today. Problems from almost every phase of industry have been formulated successfully as linear programming models.[81]

The objective of the model in this research is to minimize the total packaging cost. To achieve the objective, Linear Programming (LP) will be used as a device to determine the annual optimum units of items for each type of package to be manufactured.

The following assumptions and limitations are made:

1. For each element of packaging cost, there are time-horizon differences to accomplish certain activities for each package type.
2. For certain elements of packaging cost, there are two components making up the cost. These are the fixed components and the variable components.
3. Each element of packaging cost can be allocated as a cost per unit package.
4. The packaging line has the capacity to handle the annual optimum units of items for each type of package to be manufactured.
5. Each element of packaging cost, for each type of package is known and constant.
6. An annual budgeted expense of each element of packaging cost is known and constant.

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[81]Billy E. Gillett, Introduction to Operation Research, (New York: McGraw-Hill, Inc., 1976), p. 68.

7. Forecasted annual demand of items for each type of package is known and constant.

8. A forecasted annual demand of items for each type of package will be used as the basis in allocating an annual budgeted expense for each element of packaging cost.

9. A change-over in machinery of the packaging line, can be made satisfactorily to meet the desired level of production.

10. Any changes/alterations made on the package in order to change packaging functions (e.g. to prolong shelf-life) will result in incremental packaging process costs.

11. The attainment of minimum annual budgeted expense for each element of packaging cost is the criterion of optimality.

PACKAGING COST

The following listed elements are used as input for the optimization of packaging cost model:

1. Package development costs - fixed costs;
2. One-time costs - fixed costs;
3. Packaging materials costs - fixed costs + variable costs;
4. Packaging machinery costs - Fixed costs + variable costs.
5. Packaging process costs - Fixed costs + variable costs;
6. Distribution costs - fixed costs + variable costs;
7. Writeoff of terminal inventories costs - fixed cost.

These factors, which state the behavior of elements of packaging cost in the treatment of sub-element costs (for example: research process costs in package development costs) will either develop them to be variable or fixed. It also dependts to a certain extent upon the use of elements of package cost in the model. In this research certain elements of packaging cost, (e.g. package development cost will be considered fixed because the steps in package development to not change). On the other hand, certain elements of packaging cost, e. g. packaging materials costs will be considered comprising two components: variable and fixed costs.

The following notations are being adopted:

$Q_k$ - Annual optimum units of items to be manufactured;

$DV_k$ - Annual budgeted development expenses;

$OT_k$ - Annual budgeted one-time expenses;

$MA_1$ - Annual budgeted packaging machinery expenses;

$PR_k^{fixed}$ - Annual budgeted packaging process expenses;

$DT_k^{fixed}$ - Annual budgeted distribution expesnes;

$WI_k$ - Annual budgeted writeoff of terminal inventories;

$FC_k$ - Total fixed packaging cost;

$q_k$ - Forecasted annual demand of items;

$vc_k$ - Variable packaging cost per unit item;

$mt_k$ - Variable materials cost per unit item;

$r_k$ - Variable power and utilities cost per unit item;

$pr_k$ - Variable packaging process cost per unit item;

$dt_k$ - Variable distribution cost per unit item;

*$a_k$ - Selling price of finished packed goods per unit item;

m - Number of types of package.

* The unit selling price of finished packed goods is known and constant.

Table 14 summarizes the package cost elements and unit selling price of finished packed goods that will be required a the cost coefficient to formulate the optimization of packaging.

TABLE 14

SUMMARY OF PACKAGING COST ELEMENTS AND UNIT SELLING PRICE

| Package Type | Selling Price per unit item, $a_k$ | Variable Cost per unit item, $vc_k$ | Fixed Costs $FC_k$ |
|---|---|---|---|
| 1 | $a_1$ | $vc_1$ | $FC_1$ |
| 2 | $a_2$ | $vc_2$ | $FC_2$ |
| 3 | $a_3$ | $vc_3$ | $FC_3$ |
| : | : | : | : |
| : | $a_k$ | $vc_k$ | $FC_k$ |

Then

$$FC_1 = DV_1 + OT_1 + MA_1 + PR_1^{Fixed} + DT_1^{fixed} + WI_1$$

$$FC_2 = DV_2 + OT_2 + MA_2 + PR_2^{Fixed} + DT_2^{fixed} + WI_2$$

$$FC_3 = DV_3 + OT_3 + MA_3 + PR_3^{Fixed} + DT_3^{fixed} + WI_3$$

$$\cdots\cdots\cdots\cdots\cdots\cdots\cdots$$

$$FC_k = DV_k + OT_k + MA_k + PR_k^{fixed} + DT_k^{fixed} + WI_k$$

and $vc_1 = mt_1 + r_1 + pr_1 + dt_1$

$$vc_2 = mt_2 + r_2 + pr_2 + dt_2$$

$$vc_3 = mt_3 + r_3 + pr_3 + dt_3$$

$$\cdots\cdots\cdots\cdots\cdots$$

$$vc_k = mt_k + r_k + pr_k + dt_k$$

Elements of packaging cost estimation, is in Appendix B.

The Optimization of Packaging Cost Model

The objective function must represent total variable and fixed costs and can be written as:

$$\text{Minimize } vc_1Q_1 + vc_2Q_2 + vc_3Q_3 + \ldots + vc_kQ_k = (FC_1 + FC_2 + FC_3 + \ldots FC_k)$$

$$\text{Or Minimize } \sum_{k=1}^{m} vc_kQ_k + \sum_{k=1}^{m} FC_k$$

Since the $(FC_1 + FC_2 + FC_3 + \ldots + FC_4)$ fixed cost is independent of the decision variables, it can be omitted from the objective function, yielding

$$\text{Minimize } \sum_{k=1}^{m} vc_kQ_k$$

The first constrain forces the total revenue to equal to total packaging cost and can be stated as:

$$a_1Q_1 + a_2Q_2 + a_3Q_3 + \ldots + a_kQ_k = vc_1Q_1 + vc_2Q_2 + vc_3Q_3 + \ldots$$
$$+ vc_kQ_k + (FC_1 + FC_2 + FC_3 + \ldots + FC_k)$$

$$(a_1 - vc_1)Q_1 + (a_2 - vc_2)Q_2 + (a_3 - vc_3)Q_3 + \ldots + (a_k - vc_k)Q_k =$$
$$(FC_1 + FC_2 + FC_3 + \ldots + FC_k)$$

$$\sum_{k=1}^{m} (a_k - vc_k)\ Q_k = \sum_{k=1}^{m} FC_k$$

The other constraints reflecting the forecasted annual demand limitations are expressed as:

$$\begin{array}{lll} Q_1 & \leq & q_1 \\ Q_2 & \leq & q_2 \\ Q_3 & \leq & q_3 \\ \vdots & & \vdots \\ q_m & \leq & q_m \end{array}$$

The complete model with non-negativity conditions is thus:

$$\text{Minimize} \quad \sum_{k=1}^{m} vc_k Q_k$$

$$\text{Subject to} \quad \sum_{k=1}^{m} (a_k - vc_k) Q_k = \sum_{k=1}^{m} FC_k$$

$$Q_k \leq q_k$$

$$Q_k \geq 0$$

To solve this optimization of packaging cost model, which is a linear programming problem, the Gomory's cutting-plane algorithm for which a computer program is accessible as a package will be used to obtain the optimal solution. The optimal solution to be obtained, for this research, is the annual optimum units of itmes for each type of package to be manufactured.

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* This set up can solve small all-integral LP problems (maximum of 15 constraints and 15 variables in the original problem). The user can supply an upper limit on the number of cuts that will be tolerated, or if an upper limit is not supplied, the program will stop if an optimal integer solution has not been obtained after 15 cuts.

Validation of the Optimization of Packaging Cost Model.

The following data is arbitrarily assumed for a finished packed goods which is packed into three different types of package:

Elements of packaging budgeted expense those are fixed, $FC_k$:

$DV_1 = \$10,000$
$DV_2 = 30,000$
$DV_3 = 20,000$
$OT_1 = \$5,000$
$OT_2 = 10,000$
$OT_3 = 8,000$

$MA_1 = \$100,000$
$MA_2 = 100,000$
$MA_3 = 100,000$

$PR_1^{fixed} = \$7,000$
$PR_2^{fixed} = 7,000$
$PR_3^{fixed} = 7,000$

$DT_1^{fixed} = \$2,500$

$DT_2^{fixed} = 5,000$
$DT_3^{fixed} = 3,500$

$WI_1 = \$5,000$
$WI_2 = 15,000$
$WI_3 = 10,000$

Then

$$FC_k = DV_k + OT_k + MA_k + PR_k^{fixed} + DT_k^{fixed} + WI_k$$

$$FC_1 = \$(10,000 + 5,000 + 100,000 + 7,000 + 2,500 + 5,000)$$
$$= \$130,500$$

$$FC_2 = \$(30{,}000 + 10{,}000 + 100{,}000 + 7{,}000 + 5{,}000 + 15{,}000)$$

$$= \$167{,}000$$

$$FC_3 = \$(20{,}000 + 8{,}000 + 100{,}000 + 7{,}000 + 3{,}500 + 10{,}000)$$
$$= \$148{,}500$$

$$\sum_{k=1}^{m} FC_k = FC_1 + FC_2 + FC_3$$
$$= \$(130{,}500 + 167{,}000 + 148{,}500)$$
$$= \$446{,}000$$

<u>Variable cost per unit package</u>, $vc_k$:

$mt_1 = \$.10$

$mt_2 = .15$

$mt_3 = .12$

$r_1 = \$.10$

$r_2 = .20$

$r_3 = .15$

$pr_1 = \$.04$

$pr_2 = .05$

$pr_3 = .04$

$dt_1 = \$.10$

$dt_2 = .20$

$dt_3 = .20$

Then

$$vc_k = mt_k + r_k + pr_k + dt_k$$
$$vc_1 = \$(.10 + .10 + .04 + .10)$$
$$= \$.34$$
$$vc_2 = \$(.15 + .20 + .05 + .20)$$
$$= \$.60$$
$$vc_3 = \$(.12 + .15 + .04 + .20)$$
$$= \$.51$$

Selling price per unit item, $a_k$:

$a_1 = \$1.50$

$a_2 = 2.00$

$a_3 = 1.80$

Number of types of package, m

$m = 3$

TABLE 15

SUMMARY OF THE DATA REQUIRED AS COST COEFFICIENT FOR THE MODEL

| Package type | Selling price per unit item, $a_k$ | Variable cost per unit item, $vc_k$ | Fixed costs $FC_k$ | $(a_k - vc_k)$ |
|---|---|---|---|---|
| 1 | \$1.50 | \$.34 | \$130,500 | 1.16 |
| 2 | 2.00 | .60 | 167,000 | 1.40 |
| 3 | 1.80 | .51 | 148,500 | 1.29 |
| | | | $\sum_{k=1}^{m} FC_k = 446,000$ | |

Thus, Minimize $.34Q + .60Q_2 + .51\,Q_3$

$$\begin{aligned} \text{Subject to } 1.16Q_1 + 1.40\,Q_2 + 1.29\,Q_3 &= 446,000 \\ Q_1 &\leq 200,000 \\ Q_2 &\leq 200,000 \\ Q_3 &\leq 200,000 \end{aligned}$$

$$Q_1, Q_2, Q_3 \geq 0$$

The computer program for Gomory's cutting-plane algorithm yield the following results:

Minimum value of the objective function = \$152,605

| Package type | Annual optimum units of items to be manufactured |
|---|---|
| 1 | 200,000 |
| 2 | 0 |
| 3 | 165,892 |

# CHAPTER IV

# SUMMARY AND CONCLUSIONS

The purpose of Chapter IV 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. The following sections are comprised of the major conclusions, amplifications of the normative model of packaging cost methodology, and implications for businessmen and academicians. The chapter closes with a section that contains some suggestion for future research.

## SUMMARY OF RESEARCH PURPOSE AND DESIGN

The purpose of this research was to develop a methodology for determining the cost of packaging. A search of the appropriate literature in the areas of packaging, production, marketing, physical distribution and accounting was required in order to establish which costs should be included in packaging cost. The next step was to formulate the optimization of packaging cost model from those elements of packaging cost variables. The final step was to validate the model using the arbitrarily assumed data.

The following research objectives have already been successfully achieved:

1. The identification of key cost elements in determining packaging cost.
2. The development of a normative model of packaging cost from the key cost elements.
3. The formulation of the optimization of packaging cost model from those elements of packaging cost.
4. The validation of the optimization of packaging cost model using the arbitarily assumed data - elements of packaging cost.

MAJOR CONCLUSIONS

The major conclusions and amplifications of the research are presented in this section. The assumptions and limitations listed in Chapter I have halped focus the research for this optimization model and lead to the conclusions listed below:

1. The major contribution of this research is the methodology that was developed in Chapter III. The existing accounting literature was utilized and distilled into a methodology that can be applied in a packaged goods business setting. The framework is conceptually sound and represent an improvement over most previous attempts to quantify this packaging cost figure. This framework was based on existing knowledge in the fields of packaging, production, marketing, distribution, finance and accounting. In addition, the

methodology addressed the issue of packaging valuation and as such represents a unique contribution to the literature. Since the packaging cost percentage has to be applied to a production figure the determination of an accurate packaging value is a critical factor. The cost of money only should be applied to the direct variable costs associated with the packaging manufacturer and distribution of the finished packed goods to the storage location. Any costs that are not variable with the number of units manufactured and distributed should be treated as period costs (period expenses) and not built into the packaging value.

2. The second conclusion of the study is that packaging cost is necessary input to a number of crucial management decisions in the area of production, distribution and marketing, as well as management control applications). The potential specific uses were as input to:

(1) Physical distribution system design;

(2) The setting of customer service objectives and service levels;

(3) Production schedules;

(4) Determinating inventory level; and

(5) The analysis of finished packed goods profitability.

3. The third conclusion of the research is that the methodology and the optimization model developed can be used by managers to determine total packaging cost specifically geared to their company and this can be achieved at a low cost.

4. The fourth conclusion is that it is crucial for each company to determine its own packaging cost. It was established that packaging cost, for a packaged goods manufacturer, do have the ability to change a management decision if the wrong number is used. There is also considerable variation in the figures that are calculated for each of the companies.

Not only are the company generated figures not accurate, but in all of the companies the percentages is not applied to the correct value of packaging and in some instances the concept was improperly applied.

5. The fifth conclusion is concerned with the number of packaging cost percentages that each company must calculate. That is, in the case of a company with a relatively homogeneous product line, 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 certain elements of packaging cost, insurance and taxes become available. However, for companies with heterogeneous products, it seems to be necessary to calculate packaging cost figures for each product.

6. The sixth conclusion is concerned with the application of the optimization of packaging cost model. This linear programming model can be applied, for either different types

or different sized packages, which behave consistently packaging function (containment, protection, performance and communication), of the identical product contained. The model also can be applied for heterogeneous products like which have different types of package (for example, different types of packaging materials used) processed on the packaging line that will be able to changeover.

AMPLIFICATION OF THE NORMATIVE MODEL OF PACKAGING COST METHODOLOGY.

Although no problems were anticipated in applying the methodology in the finished packed goods manufactured, each of the companies has reasonably sophisticated data base from which to work. However, in some companies it is conceivable that a substantial expenditure may be required to develop a reporting system that will provide accurate data.

In addition, some-changes in the methodology and in updating procedures 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 elements and the hurdle rate.

Furthermore, if budgeted costs are available, they may promide a more current input to the packaging cost percentage than actual costs from the previous fiscal year.

If management wanted to implement the accuracy some of the cost elements, regression analysis could be used as a means of determining the relationship between the units of finished packed goods manufactured and cost elements such as variable packaging process costs, variable distribution 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 canned packed industry. The product must be packed when the raw materials 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 both packaging lines operations and the finished packed inventory investment and loan is repaid as inventory is liquidated. Consequently, the short-term rate of interest paid by the company is relevant cost of money since the hurdle rate concept assumes that long-term financing is being used.

For a further amplification of the model, managers may want to determine the effects of changes in such factors as product mix, transportation mode, and shrinkage on packaging cost percentage and the resulting tradeoff analysis.

## IMPLICATIONS

The research has a number of implications for businessmen and academicians. Conceivably, it would seem prudent for managers to use packaging cost as an element in a number of distribution, marketing and production decisions. Packaging cost should be generated internally for each company on an annual basis.

Once obtained, packaging cost will be a vital component in the analysis to establish the company's distribution policies. Discovering the company's actual packaging cost also could result in changes in ordering quantities, manufacturing quantities, and even in the product manufactured and sold. Many companies may use the methodology to calculate finished packed product cost.

Potential uses of packaging cost which have implications for management decision making are outlined briefly. One possible application that shows particular promise is an input to the estimation of the potential profitability of new products. Packaging cost 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 packaging cost percentage in retailing and wholesaling, include department and product profitability analysis.

The fact that an incorrect packaging 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.

## SUGGESTIONS FOR FUTURE RESEARCH

This paragraph addresses the possible directions of future research in the area of optimizing packaging cost. First, since this study was only concerned with a general model, future research should be broadened into specific categories of products, e.g. industrial goods, and consumer goods manufacturing. Secondly, it should be possible to obtain a statistically valid sample of companies and allow them to apply the methodology and the model themselves, to obtain information and data for specific firms. The problem of implementation, if any, the results and perceived uses for the model could then be recorded by surveying these firms. Then each special case could be examined in an attempt to remedy the problem of generality if the general model researched here can not be applied. Finally, an additional area to consider would be the development of a methodology to be added to the model to perform sensitivity analyses of the factors and variable elements.

# APPENDICES

# APPENDIX A

A1. The average service life of an asset - the economic life.

A2. Depreciation methods.

A3. Direct labor calculation.

A1. *THE AVERAGE SERVICE LIFE OF AN ASSET - THE ECONOMIC LIFE.

Sporadic maintenance costs. Assume that a machine is purchased for $400 and that its salvage value is zero at any state at which it may be retired. Assume that the interest rate is zero.

TABLE a
ECONOMIC HISTORY OF A MACHINE WITH SPORADIC MAINTENANCE COSTS.

| End of Year Number | Maintenance Cost of End of Year Given | Summation of Maintenance Costs, B | Average Cost of Maintenance Through Year Given, C ÷ A | Average Capital Cost if Retired at Year End Given, $400 ÷ A | Average Total Cost Through Year Given, D + E |
|---|---|---|---|---|---|
| A | B | C | D | E | F |
| 1 | $100 | $100 | $100 | $400 | $500 |
| 2 | 100 | 200 | 100 | 200 | 300 |
| 3 | 300 | 500 | 167 | 133 | 300 |
| 4 | 100 | 600 | 150 | 100 | 250 |
| 5 | 100 | 700 | 140 | 80 | 220 |
| 6 | 100 | 800 | 133 | 67 | 200 |
| 7 | 100 | 900 | 129 | 57 | 186 |
| 8 | 300 | 1,200 | 150 | 50 | 200 |
| 9 | 100 | 1,300 | 144 | 44 | 188 |
| 10 | 100 | 1,400 | 140 | 40 | 180 |

This table brings out the fact that capital costs increase in some inverse proportion to the length of life. This is always true for interest rates other than zero and for any pattern of of salvage value. The fact that maintenance costs are averaged

* From H. G. Thuesen, W. J. Fabrycky and G. J. Thuesen, Engineering Economy, 5th Edition (Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1977) pp. 225-231.

(in Column D) tends to smooth out the effect of sporadic large maintenance costs. It is clear that if replacmenet is to be made, it is desirable to do so immediately prior to a large expenditure for maintenance.

<u>Constant maintenance costs.</u> When neither interest nor salvage value is involved, an equation for the average cost of a year of service can be written as follows:

$$C = \frac{P}{n} + M$$

Where

C = average annual cost of capital recovery and maintenance;

P = Initial cost of asset;

F = Salvage value of asset;

M = Constant yearly cost of maintenance;

n = Life of asset in years.

When interest and salvage value are involved:

$$C = (P - F)\left(A/p\ i, n\right) + Fi + M$$

Where

F = salvage value;

i = interest rate;

$(A/p\ i,n)$ = interest factor.

<u>Constant increasing maintenance costs</u>. Assumed that a machine has been purchased for $800, that its salvage value is zero at any age and that its maintenance cost is zero the first year and rises at a constant rate of $100 per year thereafter. If it is assumed that the interest rate is zero, the fact concerning the machine may be represented by Table b.

As there is a rising trend in maintenance cost, there will be a minimum average total cost at some point in the life of the asset. This point occured in the fourth year in the example presented. The average annual cost for an asset with increasing O & M cost may be expressed as follows:

$$C = \frac{P}{n} + Q + (n-1)\frac{m}{2}$$

TABLE b

ECONOMIC HISTORY OF A MACHINE WITH CONSTANTLY INCREASING MAINTENANCE COSTS

| End of Year Number | Maintenance Cost for End of Year Given | Summation of Maintenance Costs B | Average Cost of Maintenance Through Year Given C ÷ A | Average Capital Cost if Retired at Year End Given \$800 ÷ A | Average Total Cost Through Year Given D + E |
|---|---|---|---|---|---|
| A | B | C | D | E | F |
| 1 | \$ 0 | \$ 0 | \$ 0 | \$800 | \$800 |
| 2 | 100 | 100 | 50 | 400 | 450 |
| 3 | 200 | 300 | 100 | 267 | 367 |
| 4 | 300 | 600 | 150 | 200 | 350 |
| 5 | 400 | 1,000 | 200 | 160 | 360 |
| 6 | 500 | 1,500 | 250 | 133 | 383 |

Where

C = average annual cost;

P = initial cost of asset;

Q = annual constant portion of operating cost of asset (is equal to first year operation cost, of which maintenance is a part);

m = the amount by which maintenance costs increase each year;

n = life of asset in years.

This expression, if differentiated with respect to n, set equal to zero, and solved for n, results in the following:

$$n = \frac{2P}{m}$$

For example presented in Table b, P = \$800, Q = 0, and m = \$100. Therefore, the minimum cost life is:

$$n = \frac{2(\$800)}{\$100} = 4 \text{ years}$$

Figure b graphically depict the trade-offs between the increasing maintenance costs and the decreasing costs of capital recovery that produces a minimum cost life for the asset.

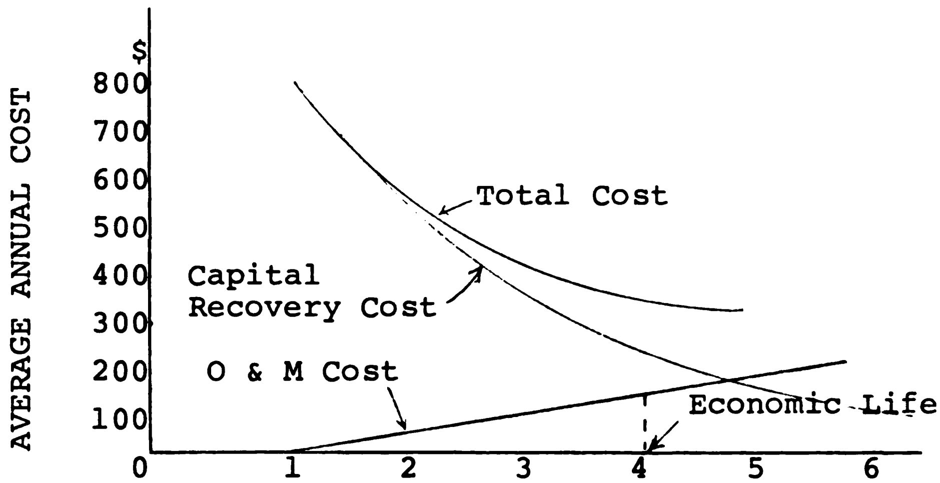


Figure a. ECONOMIC LIFE OF AN ASSET

<u>Finding the economic life of an asset</u>. The application of this approach is demonstrated by the following example.

The economic history of an asset whose first cost is \$5,000, whose salvage value at any time is zero, and whose cost of maintenance is zero the first year and increases at a constant rate of \$100 for an interest rate of 6% is shown in Table c. The minimum equivalent annual cost occurs when the cost of extending an asset's life one more year exceeds the equivalent annual cost to date. Since the salvage value is zero at any time the incremental cost of one additional year's operation is reflected in Column B. The incremental cost of providing service for year 12 ($1,100) exceeds the equivalent annual cost for 11 years ($1,076) and therefore the economic life of the asset is 11 years.

Table c illustrates a method for determining the equivalent annual cost of maintenance and the equivalent annual cost of capital recovery with return for lives ranging from 1 to 14 years. The sum of these costs is a minimum for a life of 11 years. The quanitites in Column G, H, and I have been plotted to reveal trends in Figure C.

Study of the total equivalent annual cost curve reveals that it im rather flat in the region of the minimum. It may, therefore, be concluded that a deviation of one or two years from the maximum cost life will result in relatively small increases in total equivalent annual cost.

The mathematical model for determining the economic life of an an asset assumes an interest rate of zero. For the example of Table C, with an interest rate of zero, the minimum cost life is

$$n = \frac{2P}{m} = \frac{2(\$5,000)}{\$100} = 10 \text{ years}$$

TABLE c.

EQUIVALENT ANNUAL COST OF MAINTENANCE PLUS CAPITAL RECOVERY WITH A RETURN OF AN ASSET FOR CONSTANTLY INCREASING MAINTENANCE

| End of Year Number<br>A | Maintenance Cost at End of Year Designated<br>B | Present-Worth Factor for Year Designated<br>C | Present-Worth as of Beginning of year No.1 of Maintenance for Year Designated. B X C<br>D | Summation of Present Worths of Maintenance Through Year Designa-ted. D<br>E | Capital-Recovery Factor for Year Designated (A/P 1,n)<br>F | Equivalent Annual Cost of Maintenance Through Year Designated. E X F<br>G | Equivalent Annual Cost of Capital Recovery and Return Through Year Designated. F X $5,000<br>H | Total Equivalent Annual Cost Through Year Designated. G + H<br>I |
|---|---|---|---|---|---|---|---|---|
| 1 | $ 0 | 0.9434 | $ 0 | $ 0 | 1.06000 | $ 0 | $5,300 | $5,300 |
| 2 | 100 | 0.8900 | 89 | 89 | 0.54544 | 48 | 2,727 | 2,775 |
| 3 | 200 | 0.8396 | 167 | 256 | 0.37411 | 96 | 1,870 | 1,966 |
| 4 | 300 | 0.7921 | 237 | 493 | 0.28859 | 142 | 1,442 | 1,585 |
| 5 | 400 | 0.7473 | 298 | 791 | 0.23740 | 188 | 1,187 | 1,375 |
| 6 | 500 | 0.7050 | 352 | 1,143 | 0.20336 | 233 | 1,016 | 1,249 |
| 7 | 600 | 0.6651 | 399 | 1,542 | 0.17914 | 276 | 895 | 1,172 |
| 8 | 700 | 0.6274 | 439 | 1,984 | 0.16104 | 319 | 805 | 1,124 |
| 9 | 800 | 0.5919 | 473 | 2,457 | 0.14702 | 361 | 735 | 1,096 |
| 10 | 900 | 0.5584 | 502 | 2,960 | 0.13587 | 402 | 679 | 1,081 |
| 11 | 1,000 | 0.5268 | 526 | 3,487 | 0.12679 | 442 | 633 | 1,076 |
| 12 | 1,100 | 0.4970 | 546 | 4,033 | 0.11928 | 481 | 596 | 1,077 |
| 13 | 1,200 | 0.4688 | 560 | 4,588 | 0.11296 | 518 | 564 | 1,083 |
| 14 | 1,300 | 0.4423 | 574 | 5,162 | 0.10758 | 556 | 537 | 1,094 |

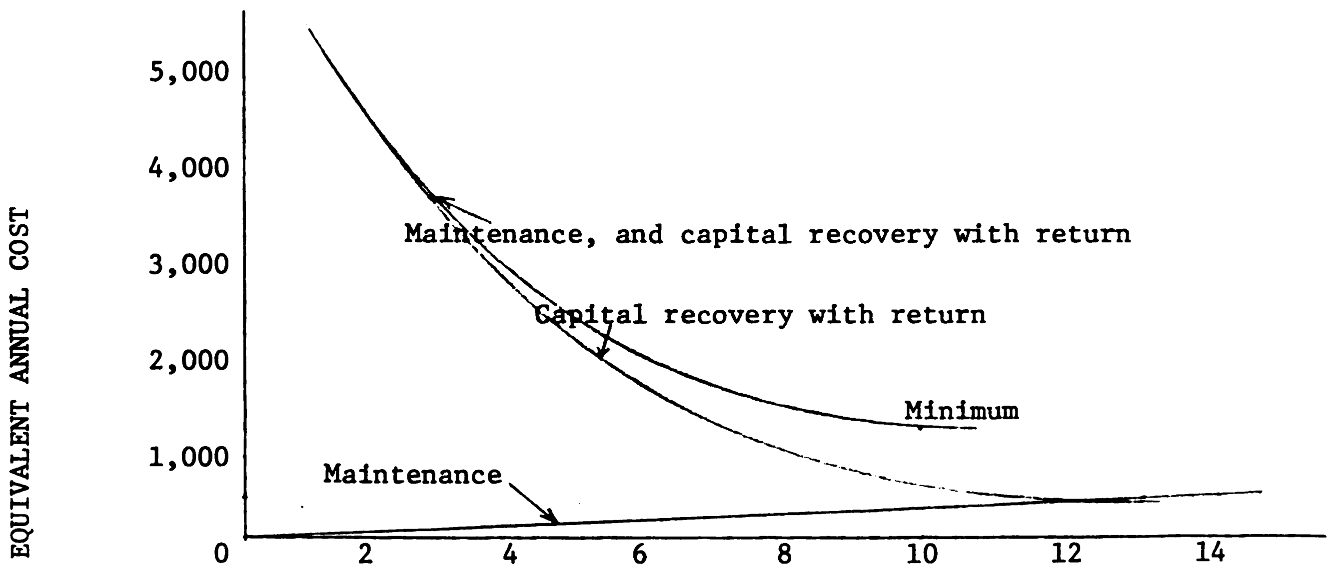


FIGURE b. MINIMUM COST LIFE OF AN ASSET.

Therefore, this equation may be used to approximate the economic life of an asset for cases involving interest.

In addition to the general procedure just discussed, there are two special situations for which the economic life can be discovered without lengthy calculations.

1. One of these situations occurs whever the annual costs of an asset remain constant over its life while the asset's present salvage and its future salvage values remain the same. As previously shown for the case where maintenance costs remain constant, the minimum cost action is to retain the asset as long as possible. In many cases an existing old asset has a zero salvage value with no expectation of a change in its future salvage. Thus, there are many real world situations that meet these requirements and as a result, the economic life for such assets is equal to the service life. That is, the longer the asset is in service, the lower its equivalent annual costs.
2. Another special situation developes if the present and future salvage values always equal each other and the annual operating and maintenance costs are always increasing. For this set of circumstances, the economic life is the shortest possible life, namely, one year (or one period depending upon the frequency of the replacement studies). This fact is evident from the relationship describing the total costs of the asset for any year.

Total equivalent annual cost = capital recovery with return + equivalent annual operating costs.

The capital recovery portion of total costs will be constant for any asset for which P = F no matter how long the asset is in serv ice.

$$\text{Capital recovery with return} = (P-F)\ (^{A/Pi,n}) + Fi.$$

The equivalent annual operating cost for an asset will be ever increasing as long as each year's operating expense is greater than the proceeding year's expense. Thus, for these two conditions the total equivalent annual cost will be minimized for the shortest time the asset might be reasonably retained. In this appendix this time will be considered to be the time between the present and the next time replacement would be reconsidered: one year.

A2.*DEPRECIATION METHODS.

1. Uniform charge per period - straight line method:

$$D_t = \frac{P-F}{n}$$

$$B_t = P - + \left(\frac{P-F}{n}\right)$$

TABLE d

GENERAL EXPRESSIONS FOR THE STRAIGHT-LINE METHOD

| End of Year 1 | Depreciation Charge During Year 1 | Book Value at End of Year t |
|---|---|---|
| 0 | -- | $P$ |
| 1 | $\frac{P - F}{n}$ | $P - \left(\frac{P - F}{n}\right)$ |
| 2 | $\frac{P - F}{n}$ | $P - 2\left(\frac{P - F}{n}\right)$ |
| 3 | $\frac{P - F}{n}$ | $P - 3\left(\frac{P - F}{n}\right)$ |
| 1 | $\frac{P - F}{n}$ | $P - 1\left(\frac{P - F}{N}\right)$ |
| n | $\frac{P - F}{n}$ | $P - n\left(\frac{P - F}{n}\right)$ |

2. Decreasing charge per period:

a. Sum-of-the-year-digits method

$$D_t = \frac{n - t + 1}{M\ (n+1)/2} \quad (P - F)$$

$$B_t = \frac{P - (P - F)}{n(n+1)/2} \left[ \sum_{j = n-t+1}^{n} j \right]$$

* From H. G. Thuesen, W. J. Fabrycky and G. J. Thuesen, Engineering Economy, 5th Edition (Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1977), pp. 331-339.

The generated expressions for the depreciation amount in each year and the book value at the end of year year are presented in Table e.

TABLE e

GENERAL EXPRESSIONS FOR THE SUM-OF-THE-YEARS DIGITS METHOD OF DEPRECIATION

| End of Year 1 | Depreciation charge during year 1 | Book value at the end of year t |
|---|---|---|
| 0 | -- | P |
| 1 | $\frac{n}{mn - 1)/2}$ (P - F) | $P - \frac{(P - F)}{n(n + 1)/2} n$ |
| 2 | $\frac{(n - 1)}{mn - 1)/2}$ (P - F) | $P - \frac{(P - F)}{n(n + 1)/2} (n+(n-1))$ |
| 3 | $\frac{n - 2}{m(n + 1)/2}$ (P - F) | $P - \frac{(P - F)}{n(n + 1)/2} (n+(n-1) + (n - 2))$ |
| t | $\frac{n - t + 1}{n(n + 1)/2}$ (P - F) | $P - \frac{(P - F)}{n(n + 1)/2} \left[\sum_{j=n-t+1}^{n} j\right]$ |
| n | $\frac{i}{n(n + 1)/2}$ (P - F) | $P - \frac{(P - F)}{n(n + 1)/2} \left[\sum_{j=1}^{n} j\right]$ |

The first cost of the asset is P, while its estimated salvage value and estimated life are F and n, respectively. Thus, the depreciation charge in any year can be expressed as

$$D_t = \frac{n - t + 1}{N(n + 1)/2} (P - F).$$

And the book value at the end of any ear t is:

$$B_t = P - \frac{P - F}{n(n + 1)/2} \left[\sum_{j=n-t+1}^{n} j\right]$$

However, the expression for book value can be simplified when it is seen that

$$\sum_{j=n-t+1}^{n} j = \sum_{j=1}^{n} j - \sum_{j=1}^{n-t}$$

In other words, if n = 6, t = 4, and n - t + 1 = 3, then

3 + 4 + 5 + 6 = 1 + 2 + 3 + 4 + 5 + 6 - (1 + 2).

Since it is known that $\sum_{j=1}^{n} j = n(n+1)/2$ it follows that

$$\sum_{j=n-t+1}^{n} j = \frac{m(n + 1)}{2} - \frac{(n - t)\ (n-t) + 11}{2}$$

b. Declining-balance method:

$$D_t = R\ B_{t-1}$$

$$= R(1-R)^{t-1}\ P.$$

$$B_t = B_{t-1} - D_t$$

TABLE f

GENERAL EXPRESSIONS FOR THE DECLINING BALANCE METHOD OF DEPRECIATION

| End of Year t | Depreciation charge during year t | Book value at end of year t |
|---|---|---|
| 0 | -- | P |
| 1 | $R \times B_0 = R(P)$ | $(1 - R)B_0 = (1 - R)P$ |
| 2 | $R \times B_1 = R(1 - R)P$ | $(1 - R)B_1 = (1 - R)^2P$ |
| 3 | $R \times B_2 = R(1 - R)^2P$ | $(1 - R)B_2 = (1 - R)^3P$ |
| 4 | $R \times B_{t-1} = R(1-R) t-1P$ | $(1 - R)B_{t-1} = (1-R)^tP$ |
| n | $R \times B_{n-1} = R(1-R)^{n-1}P$ | $(1 - R)B_{n-1} = ( - R)^nP$ |

C. <u>Sinking fund method</u>:

$$D_t = (P-F)\ (^{A/F\ i,n})\quad H\quad i(^{F/A\ i,\ t-1})$$

$$= (P-F)\ (^{A/F\ i,\ n})\ (^{F/P\ i,\ t-1})$$

$$B_t = P = (P-F)\ (^{A/F\ i/n})\ (^{F/A\ i,t}).$$

NOTATION:

$P$ = First cost of the asset;
$F$ = estimated salvage value;
$B_t$ = book value at end of year t;

$D_t$ = depreciation charge during year t.

$n$ = estimated life of the asset.

TABLE g

GENERAL EXPRESSIONS FOR THE SINKING-FUND METHOD OF DEPRECIATION

| End of Year 1 | Depreciation Charge at end of year 1 | Book value at end of year t |
|---|---|---|
| 0 | -- | P |
| 1 | $(P - F)(^{A/F\ i,n}) + i(0)$ | $P-(P-F)(^{A/Fi,n})(^{F/Ai,1})$ |
| 2 | $(P-F)\ (^{A/F\ i,\ n})+i\ (P-F)(^{A/Fi,n})(^{F/Ai,1}L$ | $P-(P-F)(^{A/F\ i,n})(^{F/Ai,2})$ |
| 3 | $(P-F)(^{A/F\ i,n})+\ i\ (P-F)(^{A/Fi,n})(^{F/Ai,2})$ | $P-(p-F)(^{A/Fi,n})(^{F/Ai,t})$ |
| t | $(P-F)(^{A/Fi,n})+\ i\ (P-F)(^{A/Fi,n})(^{F/Ai,t-1})$ | $P-(P-F)(^{A/Fi,n})(^{F/Ai,t})$ |
| n | $(P-F)(^{A/Fi,n})+\ i\ (P-F)(^{A/Fi,n})(^{F/Ai,n-1})$ | $P-(P-F)(^{A/Fi,n})(^{F/Ai,n})$ |

## A3.*DIRECT LABOR CALCULATION

The formula in calculating direct labor cost, based on these elements:

- line speed;

- crew size;

and - fatigue and downtime factor.

Assumed that the production day is determined by three factors:

1. Not pay for lunch break so employees work a full eight-hour day;

2. Two ten-minute breaks;

3. A five-minutes wash up time.

This brings the actual work time per employee to 455 minutes per day.

4. An arbitrary lost time factor is 15%.

Then apply this formula as follows:

1. 85% lost time factor relates directly to 115%. As an applied factor to productivity on the line.

2. The second factor is 455 minutes theorotical day.

3. A dozen count base is the third factor.

4. Individual line speed (which may vary for different products on the same line, or as speeds differ on different lines) is the fourth factor.

By combining these four factors, the formula has developed:

$$\text{Doz/Day} = \frac{\text{Line speed} \times 455}{1.15 \times 12}$$

$\frac{\text{Hours/Day}}{\text{Doz/Day}} =$ Hours/Dozen. This is the direct labor standard. which is used as the basis in estimating the direct labor cost.

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* From Edmund J. Obremski, Package Development & Systems, July/August (New York: Scarborough Publishing Co., Ltd. 1979) pp. 24-25.

B1. THE GENERAL FORM OF LINEAR PROGRAMMING (LP) MODEL.

The general form will be

Maximize (or minimize): $Z = c_1X_1 + c_2X_2 + \ldots + c_kX_k$

Subject to: $a_{11}X_1 + a_{12}X_2 + a_{13}X_3 + \ldots a_{1k}X_k\,(*) \quad b_1$

$a_{21}X_2 + a_{22}X_2 + a_{23}X_3 + \ldots + a_{2k}X_k\,(*) \quad b_2$

$\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$

$a_{m1}X_1 + a_{m2}X_2 + a_{m3}X_3 + \ldots = a_{mk}X_k \quad (*) \quad bm$

All $X_k \geq 0$

Where

$c_k$ is a known "cost" coefficient of $X_k$;

$X_k$ is an unknown variable;

$a_{mk}$ is a known constant;

$b_m$ is a known constant,

and (*) means $\geq$, = or $\leq$ for each constraint.

* From Billy E. Gillett, Introduction to Operations Research, (New York: McGraw-Hill, Inc., 1976) pp. 69.

# APPENDIX B

B1. The general form of linear programming (LP) model.

B2. Cost estimation.

B3. Computer print-out (the validation of the optimization of packaging cost model using the arbitrarily assumed data).

## B2.*COST ESTIMATION

The purpose of cost estimation is to estimate the fixed cost amount and the variable cost amount for various types of total costs (for example, raw materials, labor, utilities, insurance). Some costs, such as rent and insurance, will have only a fixed component. Others, such as raw materials and direct labor, will have only a variab le component. Many costs, however, are mixed, having both fixed and variable components.

The total cost of an item can be expressed as

| Total Cost During Period | = | Fixed Cost During Period | + | Variable Cost Per Unit of Activity | X | Units of Activity Carried Out During Period |
|---|---|---|---|---|---|---|

or using standard notation,

$$TC = a+bx$$

Where a is total fixed cost;

b is variable cost per unit of activity;

and x is the number of units of activity carried out.

The activity represented by x is called the independent variable and the amount of total costs is the dependent variable.

In some sophisticated analyses, more than one activity or independent variable is presumed to influence total cost

The symbolic representation of such a relation might be

$$TC = a + bx_1 + cx_2 + \text{etc.}$$

There are two basic approaches to estimating cost*:

1. Engineering Method of Estimating Costs.
2. Estimation of Costs Using Historical Data.

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* For the full treatment of document, see Sidney Davidson, James S. Schindler, Clyde P. Stickney and Roman L. Weil, Managerial Accounting, (Hinsdale, Illinois: The Dryden Press, 1978), pp. 124-136.

## B3. COMPUTER PRINT-OUT

```
MPOS VERSION 4.0         NORTHWESTERN UNIVERSITY

      ***********************************
      *                                 *
      *              M P O S            *
      *                                 *
      *            VERSION 4.0          *
      *                                 *
      * MULTI-PURPOSE OPTIMIZATION SYSTEM *
      *                                 *
      ***********************************

***** PROBLEM NUMBER  1 *****

     REGULAR
     VARIABLES
     Q1 Q2 Q3
     MINIMIZE
     .34Q1 + .60Q2 +.51Q3
     CONSTRAINTS
 1.  1.16Q1 + 1.4Q2 + 1.23Q3 = 446000
     BOUNDS
     Q1 .LE. 200000
     Q2 .LE. 200000
     Q3 .LE. 200000
     OPTIMIZE


MPOS VERSION 4.0         NORTHWESTERN UNIVERSITY

********************
* PROBLEM NUMBER  1 *
********************

USING REGULAR

                                PROBLEM INPUT SUMMARY

  CONSTRAINTS   VARIABLES     NON-ZEROS          PARAMETERS        BOUNDS
  -----------   ----------    --------------     --------------    ----------
  EQS=     1    INT=     0    NUMBER=      3     TOL=  .100E-08
  LES=     0    TOTAL=     3  PERCENT=100.00     EPS=DEFAULT
  GES=     0    NOUB=    3                       LIMIT=DEFAULT
  TOTAL=     1  NOLB=    0                       RSCALE=  .100E+01


MPOS VERSION 4.0         NORTHWESTERN UNIVERSITY

********************
* PROBLEM NUMBER  1 *
********************

USING REGULAR


                        SUMMARY OF RESULTS

VAR  VAR        ROW STATUS        ACTIVITY       OPPORTUNITY      LOWER          UPPER
 NO  NAME        NO                 LEVEL           COST          BOUND          BOUND
  1  Q1          --     UB    200000.0000000     -.1186047      0.0000   200000.0000
  2  Q2          --     LB         0.0000000     -.0465116      0.0000   200000.0000
  3  Q3          --     B     165891.4728682     0.0000000      0.0000   200000.0000
  4  ARTIF-- 0-   1     LB         0.0000000      .3953488      0.0000           INF

   MINIMUM VALUE OF THE OBJECTIVE FUNCTION =      152604.651163

   CALCULATION TIME WAS     .0050 SECONDS FOR   6 ITERATIONS.

   DATA STORAGE MEMORY =000433(OCTAL) TOTAL MEMORY = 050000(OCTAL)


TOTAL TIME FOR THIS PROBLEM WAS   .052 SECONDS
```

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