COST-VOLUME RELATIONSHIP FOR PACKING APPLES IN MICHIGAN

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This is to certify that the

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ABSTRACT

COST-VOLUME RELATIONSHIPS FOR
PACKING APPLES IN MICHIGAN

by Hoy Fred Carman

This study originated with requests by members of the Michigan apple packing industry for information on cost-volume relationships in apple packing. Many small volume apple packers must decide if they are going to continue operating at their present scale, expand their operations, sell their apples field-run, or combine operations with other packers. This study provides information that should be useful to Michigan apple packers in choosing among these alternatives.

The principal objective of this study was to determine the cost-volume relationships in synthetically constructed apple packing plants operating under conditions representative of those found in Michigan. Intermediate objectives included the determination of industry structure, least cost packing methods, and labor requirements for the jobs in apple packing plants.

The economic-engineering method of cost analysis was used in this study. Labor utilization and equipment data for the analysis were obtained from observations taken in 14 Michigan apple packing plants. Other data were obtained from manufacturers, previous studies, and packing firm suppliers. Data concerning the industry structure were obtained through an industry survey.

Fixed and variable costs are given by plant stages for capacity rates of operation of 100, 200, 300, 400, and 500 cartons per hour. Least cost methods of operation for the individual stages were determined. Planning equations which indicate estimated total season costs in relation to size of plant and length of operating season were developed for each operating stage and non-stage cost component. These stage and component cost estimates were then added together to derive estimated total season costs for each of the five plant sizes.

Based on the total plant cost equations developed in this study, average packing costs decrease with increases in plant capacity. The majority of this decrease is realized by the time capacity reaches 300 cartons per hour output. Average costs, however, continue to decline within the range of plant sizes studied.

Increasing the length of the packing season also results in a significant decrease in average costs of packing. A sharp decrease in average costs occurs when increasing length of season from 400 to 800 hours. Average costs continue to decrease as length of packing season increases.

Short-run cost curves were derived for the five plant sizes considered. These curves demonstrate that average costs increase significantly when operating apple packing plants at less than planned capacity. Maintaining excess capacity in order to be flexible enough to pack unusually large orders or seasonal production is costly.

COST-VOLUME RELATIONSHIPS FOR PACKING APPLES IN MICHIGAN

By

Hoy Fred Carman

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Throughout the course of the study, valuable counsel and guidance were given by Harold M. Riley, Carleton C. Dennis, and Dennis L. Oldenstadt. Thanks are expressed to these individuals as well as the candidate's guidance committee members: James H. Stapleton, Boris P. Pesek, Linley E. Juers, William J. E. Crissy, and James T. Bonnen.

Thanks are due to the Department of Agricultural Economics and the Economic Research Service of the U. S. Department of Agriculture for the funds invested in this research and in the author's graduate program.

The high value placed on education by the author's parents led to the completion of an undergraduate degree. Special recognition must be expressed to them and to the author's wife, Pat, whose patience and constant encouragement contributed to the completion of this study.

Hoy Fred Carman

TABLE OF CONTENTS

Chapter | Page

Chapter | Page

LIST OF TABLES

Table		Page

LIST OF FIGURES

Figure		Page

LIST OF APPENDIX TABLES

CHAPTER I

INTRODUCTION

Apples are produced commercially in 35 states, but over 60 percent of the average annual crop is produced in five states. Washington, with 20 percent of the U. S. apple crop, is the leading producer. New York produces 16 percent, Michigan produces 10 percent, and Virginia and California each produce about 8 percent of the total crop.

Apples are becoming more important to the Michigan farm economy and Michigan is gaining stature in the total apple industry. Comparison of changes in production over the past 18 years for the five leading states shows that Michigan's increase was greatest in both real and percentage terms (Table 1). Michigan's apple production was over 4-1/2 million bushels (61 percent) greater in the period 1955-63 than in the period 1946-54.

Table 1. Average Annual Production of Apples in the Five Leading Apple Producing States, 1946-54 and 1955-63

State	Annual Production			
	1946-54 Average	1955-63 Average	Change Actual	Change Percent
	1,000 bushels			
Washington	27,633	24,161	-3,472	-12.6
New York	15,490	19,533	4,043	26.1
Virginia	9,538	9,506	-32	-0.3
California	8,247	9,610	1,363	16.5
Michigan	7,415	11,956	4,541	61.2

Source: U. S. Department of Agriculture, "Agricultural Statistics," 1948-63.

The growth in Michigan production has been reflected in increased utilization of apples by both the fresh and processed markets (Figure 1). The 1962 value of Michigan apples utilized in fresh and processed forms was slightly more than 24 million dollars at point of first sale.[1] Of this total value, fresh apples accounted for slightly more than 19 million dollars while processing apple sales made up the difference of almost five million dollars.

While the 1949-62 trend in fresh apple utilization in Michigan has been upward, the surge in fresh use occurred between 1954 and 1956. This surge in fresh use is partially explained by a sharp increase in production during the 1954-56 period. Since 1956, annual fresh utilization of apple production has leveled off at about 8 million bushels.

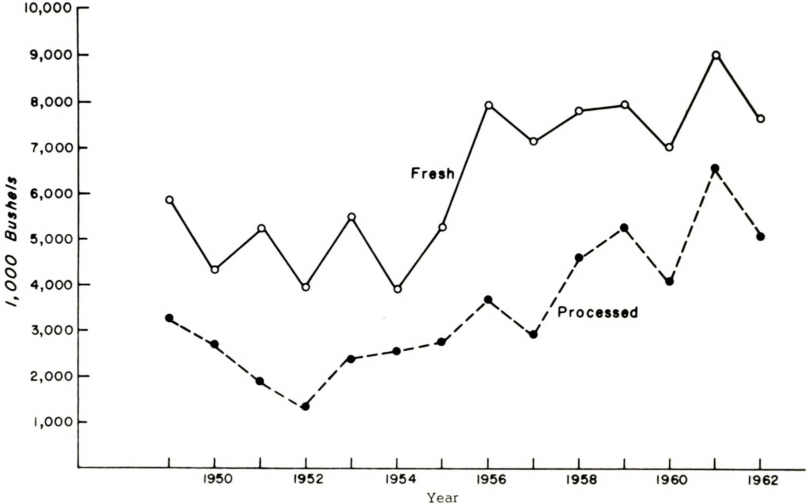
Problem Situation

In addition to expanded production and utilization of fresh apples in Michigan, there have been changes in handling methods, sorting and packing technology, package use, storage facilities, and sales outlets.

There has been a pronounced movement toward fewer and larger apple packing firms in Michigan during the last 7-10 years. During the 1963-64 packing season, there were approximately 180 firms packing apples in Michigan as compared to over 400 firms which were packing apples during the 1956-57 packing season.[2] Thus, Michigan has experienced a 55 percent

[1] Michigan Department of Agriculture and U. S. Department of Agriculture, Michigan Agricultural Statistics (July 1963), p. 23.

[2] Information on changes in plant numbers, package use, and handling are discussed and documented in Chapter III of this study.



Source: Michigan Agricultural Statistics, Micnigan Department of Agriculture, 1950-63.

Figure 1. Utilization of Michigan Commercial Apple Production, 1949-62

reduction in apple packing plant numbers during this seven year period.

Since the total pack of the present 180 firms is larger than that of 400 firms seven years ago, it is obvious that the average size of pack has increased sharply.

Even after this abrupt change in numbers and size distribution, there are still a large number of small firms. A firm packing under 40,000 bushels per year is small when compared to firms in Michigan and in other states which have an annual pack of more than 200,000 bushels. Over 69 percent of the respondents to a Michigan apple packing industry survey stated that they packed less than 40,000 bushels of apples in 1962-63.

Apple packing in Michigan differs from other regions because of the more rapid adoption of two recent innovations. They are the packaging of apples in polyethylene bags and bulk handling of apples from orchard to packing line.

The packing of apples in poly bags has increased from 13 percent of the volume 10 years ago to about 65 percent today. Contrast this with less than 20 percent of Washington's pack being bagged and less than 25 percent of the Appalachian pack in bags. The once popular open returnable crates and bushel baskets are used very little by Michigan apple packers. A combination of the two containers accounted for only 6 percent of the pack in 1962-63 as contrasted to 63 percent 10 years ago.

It was estimated that during the 1958 season about five million bushels of Michigan grown apples were handled in bulk boxes. This was equivalent

to 39 percent of the 1958 crop. A similar estimate for the 1962 crop indicates that 77 percent of the volume was handled in bulk boxes. Available information reveals that few other producing areas have adopted bulk handling to this extent. The costs of bulk handling of apples in well-organized bagging operations has not been studied. It appears that the combination of bulk handling and specialization in bagging apples may offer significant economies for large scale apple packing. The lengthening of the packing season by controlled atmosphere storage is another potential source of economies in packing. This study will analyze the cost relationships between scale of plant and per unit packing costs when using bulk handling, packaging in poly bags, and lengthened packing seasons.

In addition to problems of economies of scale in apple packing, there are also problems of efficient handling methods, equipment, and plant layout. The need for work on these problems was outlined by the Horticultural Crops Research Advisory Committee at its first meeting in Washington, D.C., on February 10-14, 1964. They concluded that:

> The increasing scarcity and cost of labor for handling, storing, and packing horticultural crops coupled with the increased rate of arrival at the packing house due to partial mechanization of harvesting and field handling has focused attention on the problem of lowering costs in handling, storage, and packing. Many of our present packing houses contain antiquated equipment, are poorly arranged, and have insufficient holding areas for present-day volumes and quality requirements.[3]

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[3]Horticultural Crops Research Advisory Committee, Report and Recommendations (Washington: U.S.D.A., E.R.S., February 10-14, 1964), p. 13.

to 39 percent of the 1958 crop. A similar estimate for the 1960 crop indicates that 77 percent

Purpose of the Study

This study is the outgrowth of requests by members of the Michigan apple packing industry for information on the relationships between per unit costs of packing apples and volume packed. Many apple packers in the small size categories (less than 40,000 bushels per year) must decide on one of several alternative plans to follow during the next several years. These include: continuing to pack their own fruit at their present scale, selling their fruit field-run to other packers, expanding the scale of their packing facilities either on their own or through combination with other packers, or becoming a stockholder in an established cooperative or corporation which already packs on a large scale. The data presented in this study with the accompanying analysis will provide information for plant owners to use in deciding among the above alternatives.

The objectives of this study are fourfold. The first three objectives are intermediate in achieving the fourth objective. They are:

1. To ascertain the present structure of the Michigan apple packing industry. Structural characteristics considered include the number, size, location, and legal organization of packing firms. Where appropriate, comparisons are made with past studies.
2. To find least cost methods for packing apples for different stages in the apple packing operation. Costs for various methods and types of equipment will be calculated and compared.
3. To develop labor requirements for the various jobs being done in

Michigan apple packing plants. These requirements will be compared and supplemented with labor requirements for the same jobs which have been developed in other studies.

4. To determine the cost-volume relationships in synthetically constructed Michigan apple packing plants. The costs developed for the plants in this study are not necessarily the same as the costs of existing plants. However, being developed from observed labor and equipment performance, they represent cost levels that are attainable in efficient, well-organized, Michigan apple packing plants.

Scope of the Study

The computation of costs in this study is limited to those costs directly attributable to the apple packing operations. Apple packing includes all operations beginning with the movement of fruit from storage or the receiving area to the dumping station and ending with loading the packed fruit on vehicles for shipment to market. Costs of harvesting, assembly, storage, distribution, and advertising and promotion are not within the scope of this study.

Neither is the development of research methodology an objective of this study. The methodology employed in the analysis has been well developed by other researchers. No attempt is made in the research method section of this study to present a complete discussion of the theory of the firm. Only a few elaborations to conventional theory are noted.

This study was carried out at a point in time. Although it is believed

Michigan apple packing plants. These requirements will be com-

pared and

that the data are reasonably complete and accurate, new technologies are constantly being devised and put into operation. Thus, important alternatives which might be relevant at some future time may not have been considered. In addition, estimates in this study are subject to errors of omission and measurement. An error of omission may arise through failure to include the most efficient possible plant for some scales at which plant costs are measured. Errors in measurement may arise because of the period in which observations are taken in a particular plant or because of individual differences of workers in the sample. It is believed that error has been minimized through inclusion of the major variations in technologies and through dispersion of in-plant observations.

Organization of the Thesis

Chapter II of this thesis includes a discussion of alternative research procedures and of the method employed. Some elaborations to the conventional theory of the firm are noted and briefly discussed. A discussion of data sources follows.

Chapter III is a description of the apple packing industry in Michigan. Characteristics of Michigan apple packing firms are presented and discussed.

The main body of the thesis is contained in Chapters IV and V. Chapter IV contains a description of plant organization and outlines the operating stages in apple packing plants. Each of the plant stages is specified and cost functions are derived. The stages are then combined in Chapter V to derive the total plant cost for different volumes of output. The relationships

between per unit costs of packing and plant size, product mix, length of season, and percent of capacity are analyzed.

Chapter VI contains the summary and conclusions of the study.

CHAPTER II

RESEARCH PROCEDURE

The Research Method

The economic-engineering method of cost analysis is used in this thesis. This method is generally termed the "synthetic" method because the researcher combines or synthesizes the many cost components of plant operations to obtain total plant costs. The synthetic procedure entails the construction of a plant on paper just as architects and engineers do when bidding for contracts. Most of the basic labor utilization and equipment data which are employed in the analysis are obtained through observation of actual plant operations.

It is unfortunate that the economic-engineering method is referred to as the "synthetic" method of cost analysis. While descriptive of the method, the term synthetic carries a connotation of being phony or false and is immediately suspect to many people. Although the naming is unfortunate, the term "synthetic" will be employed in this thesis. This is done purely in the interests of minimizing confusion. It is hoped that a description of the method will dispel any negative biases arising from the name.

Alternative Methods

The researcher who is attempting to derive estimated cost functions for firms has at least two well established approaches at his disposal.

These two approaches are generally referred to as the accounting method and the synthetic method.[1] The accounting method consists of the statistical derivation of cost curves based on accounting data while the synthetic method consists of the statistical derivation of cost curves based on economic-engineering studies.

The Accounting Method

The accounting method consists of an analysis of accounting costs. The analysis is generally summarized in some type of a statistically derived cost curve. There are two general methods of utilizing cost data obtained from plant records. One is to take a cross-section approach. Here each plant is treated as a single observation and cost curves are derived from aggregate cost and volume data. An advantage of this method is that data can generally be collected for fewer research inputs than can synthetic data and the technique can be applied to secondary data.

A real difficulty to the derivation of cost curves from cross-sectional data is the selection and fitting of the proper functional relationship. The true economies of scale curve must lie somewhere below the lowest cost points of the sample plants. The relevant question is "How far below?"

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[1]Dean states that there are three approaches, the statistical, accounting, and engineering, and that they are not always mutually exclusive. See Joel Dean, Managerial Economics (Englewood, N. J.: Prentice-Hall, Inc., 1951), p. 279. Other researchers, however, have combined the statistical and accounting approaches and concentrated on either a cross-section or time series analysis. For a discussion see: Guy Black, "Synthetic Method of Cost Analysis in Agricultural Marketing Firms," Journal of Farm Economics (May 1955), p. 273.

Problems associated with the analysis of cross-section data are discussed in at least two articles.[2]

The second method utilizing accounting data consists of obtaining a historical record of costs and output for a plant which varies output over a range of volumes, but which produces a homogeneous product with essentially constant technology.[3] If applied in a thorough manner, this method can be very costly and time consuming. In addition, data from a single plant theoretically tells us little about an economies-of-scale curve. A single plant typically covers only a small portion of the envelope curve.

The Economic-Engineering Method

As mentioned previously, this method is frequently called the "synthetic" or "building block" approach.[4] The building blocks are the various operations or stages through which the raw material passes in becoming a

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[2]See R. G. Bressler, Jr., "Research Determination of Economies of Scale," Journal of Farm Economics (August 1945), p. 526, and J. F. Stollsteimer, R. G. Bressler, and J. N. Boles, "Cost Functions From Cross-Section Data — Fact or Fantasy?," Agricultural Economics Research, XIII, No. 3 (July 1961).

[3]Dean calls this the statistical approach. Since he believes that this method is superior to any other, he presents a rather detailed discussion. See: Dean, op. cit., p. 279.

[4]Details of the basic synthetic technique are presented in B. C. French, L. L. Sammet, and R. G. Bressler, "Economic Efficiency in Plant Operations with Special Reference to the Marketing of California Pears," Hilgardia, XXIV, No. 19 (Berkeley: California Agricultural Experiment Station, July 1956). A discussion of the synthetic method is presented in Black, op. cit., p. 270, and in L. L. Sammet and B. C. French, "Economic-Engineering Methods in Marketing Research," Journal of Farm Economics (December 1953), p. 924.

Problems associated with the analysis of cross-section data are discussed in at least two articles.

finished product. Plant inputs and outputs are determined through direct observation and through the use of engineering type data from other sources. This permits cost allocations by plant stages. Once the most efficient stages are harmoniously combined, the economies-of-scale curve is easily obtained.

An obvious advantage of the synthetic method is that it can be used where few cost and output records are available. In addition, many more details on the plant organization are available from synthetic studies than from accounting studies. The method is, of course, not without shortcomings. The data collection can be costly and time consuming and the cost curves which are derived are not appropriate for the usual tests of statistical reliability.

Theoretical Elaboration

Because of the nature of fruit packing operations, there are at least four important elaborations which must be made to the conventional marginalist economic theory of production. These elaborations are well presented by French, Sammet, and Bressler in their study of Economic Efficiency in Marketing Pears.[5] They will, therefore, be only briefly discussed here. The elaborations stress (1) the time dimension for output variation, (2) plant segmentation involving the use of many identical machines, (3) discontinuous variation in rates of output, and (4) multiple rather than single stage plants.

[5] French, Sammet, and Bressler, loc. cit.

finished product. Plant inputs and outputs are determined through direct

observation and through

The Time Dimension:[6] If rates of plant output are held constant and total output varied by varying the number of hours worked per day or week, the uniform level of intensification can be expected to produce constant marginal cost. This will be true even though the cost function may be curvilinear in the rate dimension. Failure to distinguish between the time and rate dimentions can lead to much confusion on the nature of the cost curves derived.

Plant Segmentation: This occurs when increases in rates of output and input are associated with the successive addition of workers to perform identical jobs with no real intensification on a fixed factor or changes in the proportions of inputs. Total cost functions from segmented plants will tend to be linear, although discontinuous.

Discontinuities: When output is varied by varying the use of identical machines, the variable cost function for the plant will be discontinuous even though continuous variation is possible for each machine. With fixed proportions between labor and machines, the discontinuities will be even more pronounced.

When the cost function is discontinuous, the condition that profits are maximized where marginal cost equals marginal revenue may no longer apply. With a discontinuous function, the profit maximizing point may be at a "corner" where $MC \neq MR$. This means that total cost and revenue

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[6]Since the following elaborations are based on extensive quotation from French, Sammet, and Bressler, ibid., pp. 548-556, footnotes and quotation marks are omitted.

functions must be examined over their entire range in order to determine maximum profits.

Plant Stages: Apple packing plants consist of a number of different operating stages. A stage has been defined as consisting of all productive services — durable or non-durable — that cooperate in performing a single operation or a group of minor but closely related operations. For example, the main elements of the dumping stage consist of (1) obtaining a container filled with apples, (2) dumping the container, and (3) placing the container aside.

Each of the many stages which in the aggregate form a plant is represented by a cost function much as if it were a plant itself. The total of the stage cost curves, along with certain over-all cost components not associated with specific stages, form the total cost function for the entire plant. The usual theory of production has its most direct application to the individual stage.

The integration and aggregation of plant stages into plant operations leads to the problems of smoothly matching capacities of equipment used at each stage and in choosing the appropriate types of equipment at each stage.

Sources of Data

Several types of data are necessary in order to satisfy the stated objectives of this study. They include: (1) information on the nature of the apple packing industry in Michigan, (2) labor requirements and wage rates

for packing apples, (3) material costs, (4) equipment costs, (5) building construction costs, and (6) overhead charges. Following is a discussion of the sources of these data.

Survey of the Industry

Information on the nature of the apple packing industry in Michigan was gathered through a survey conducted during the winter of 1963-64. Data on the structure of the Michigan apple packing industry as well as handling methods, storage capacities, packages used, and sales outlets were obtained.

In order to survey the industry it was first necessary to obtain a list of apple packers. This was done with the assistance of the Michigan Apple Commission and District Horticultural and Marketing Agents of the Michigan Cooperative Extension Service. A basic list of names was furnished by the Apple Commission and this was supplemented by the District Horticultural and Marketing Agents. A mail questionnaire was sent to all apple packers on the revised list.

Returns were obtained from 132 of the 238 firms listed for a 55 percent response. While carrying out the cost study, the remaining firms were personally contacted and asked to complete the questionnaire. This resulted in a total return of 219 or 92 percent. Of these, 83 or 35 percent reported that they no longer packed apples for the fresh market. Completed questionnaires were obtained from 124 or 80 percent of the 155 firms known to be packing apples in Michigan. The respondent packers accounted for over 70 percent of the 1962-63 fresh pack.

for packing apples , (3) material costs, (4) equipment costs, (5) building construction costs

Results of the industry survey are presented in Chapter III. Where appropriate, comparisons are made with previous studies to show the changes which have been taking place. The changes have, in many cases, been quite pronounced and of real importance to the industry.

In-Plant Work-Sampling

The second phase of the study was concerned with gathering data on equipment and labor utilization in apple packing plants. To obtain this data work-sampling was conducted in a sample of 14 apple packing plants.

Work-sampling, sometimes called ratio delay, is a procedure for sampling workers activities through time. Work-sampling in its simplest form consists of making observations at random intervals of one or more operators or machines and noting whether they are working or idle. Thus, it provides an estimate of the proportion of time spent by various workers or machines working. When related to the total man-hour inputs and the corresponding outputs, it provides estimates of the time requirements for the various jobs. Since this is a sampling procedure, the accuracy of the result is a function of the number of observations taken.[7]

It was necessary to employ three men to help collect observations on plant labor utilization. The men employed were well qualified for working on this study. They all own fruit farms in Western Michigan and were thus

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[7] For a discussion of statistical tests of reliability and analysis of work-sampling estimates, see L. L. Sammet and D. G. Malcolm, "Work Sampling Studies: Guides to Analysis and Accuracy Criteria," The Journal of Industrial Engineering (July 1954), pp. 9-14.

Results of the industry survey are presented in Chapter III. Where ap-
propriate, comparisons

familiar with apple packing operations. In addition, two of the observers were college graduates while the third had completed two years of college.

Prior to the actual in-plant work, it was necessary to train the observers in the technique of work-sampling. This was done with four days of instruction. The instruction consisted of classroom work and practice in apple packing plants. This instruction and practice helped provide the uniformity between plants which is necessary for a study of this type.

The in-plant study consisted of obtaining drawings of the plant layout, a description of the general plant operation, an equipment list, a list of jobs, and a detailed breakdown of the elements in each job.[8] The observers then conducted the work-sampling in each of the 14 sample plants. From six to fifteen visits were made at each of the plants during the period October 16, 1963, to February 24, 1964. Depending on the plant layout and the number of jobs being performed, from 14 to 37 hours were spent observing the jobs in each plant. This permitted the observers to gather 1,500 to 2,000 observations on each job being performed in the plant.

Visiting the plants at various times throughout the packing season permitted observation of different grades, varieties, and packs of apples as well as different rates of output. Since there was no discernable pattern of grades, varieties, or packages, this in effect was a randomization of

[8]For a detailed presentation of the method of work sampling and its application, see: Ralph M. Barnes, Motion and Time Study (4th ed., New York: John Wiley and Sons, Inc., 1958), pp. 498-527, and D. G. Malcolm and L. L. Sammet, "Work Sampling Applications," The Journal of Industrial Engineering (May 1954), p. 4.

observations. Visits to the plants were not strictly random, however, since a random assignment of visits was not made. Average rates of operation ranged from 27 bushels per hour for the smallest plant to 289 bushels per hour for the largest. Peak rates of operation ranged from 33 bushels per hour for the smallest to 336 bushels per hour for the largest.

Labor Production Standards

The data gathered through work-sampling were used to develop labor standards for each of the jobs performed in apple packing plants. These standards are used as a basis for determining labor requirements for the various plant operations. The computed labor standards are considered to be the continuous output rate which a reasonably efficient worker should attain. They do not represent the best output achieved, rather they represent an average of the plants observed. No attempt was made to rate the individual worker observed. Rating requires the judgment of experienced analysts and none were available for this study.[9]

Work-sampling was used whenever applicable to determine the amount of working time required to perform each of the jobs done in Michigan apple packing plants. For most jobs a uniform allowance of 15 percent of total work time was made for non-productive time such as waiting for supply, unavoidable delay, coffee breaks, and personal delay. For the heavy

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[9]Briefly stated, rating is a process whereby the time study analyst compares the performance of the operator under observation with the analyst's own concept of normal performance. For a more complete discussion, see: Barnes, op. cit., p. 364.

observations. Visits to the plants were not strictly random, however,

since a random

lifting jobs, such as manual dumping, a delay allowance of 20 percent was made. The raw time plus the allowance gave the total per unit time from which output per hour was computed. For example, it was found that 1.99 minutes per 12 bag cartons were required to fill poly bags with apples and place the bag inside. With the allowance for non-productive time, the total time per carton is 2.34 minutes. This figure, divided into 60 minutes, gives a work standard of 25 cartons per hour.[10]

Accounting record data supplemented, where appropriate, with data from other studies, were used to determine work standards for those jobs where work-sampling is not well adapted. Jobs in this classification include sorting and utility labor as well as clerical work and management.

The number of workers required for each job when operating at the various output rates was determined on the basis of one worker for each multiple and additional fraction of the applicable job standard. Labor requirements, combined with wage rates paid by Michigan apple packers, provide labor costs for the various apple packing jobs.[11]

Equipment Data

Equipment output capacities were obtained from estimates of plant managers, plant observations, and manufacturer specifications. Installed equipment replacement costs were based on manufacturer quotations.

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[10]Work standards together with descriptions of the jobs performed are presented in Appendix Table A.

[11]Wage rates are presented in Appendix Table B.

Whenever there were price differences for a given piece of equipment, the lowest priced equipment capable of performing the operation with comparable efficiency was used. This is consistent with the objective of determining least cost methods for packing apples for the different stages in the apple packing operation. Data were checked and compared with specifications and costs contained in recent publications.

Other Data

Prices of packing materials were obtained from firms supplying Michigan apple packing plants. These prices are included in the packing stage. Space requirements and building specifications have been well developed in other studies. They were also obtained from the sample plants. These requirements and specifications in combination with construction costs obtained from the Michigan State University Agricultural Engineering Department form the basis for building costs.

Data from other studies together with data from the Michigan State University Agricultural Engineering Department form the basis for estimating overhead and operating charges.

The Sample Plants

The sample plants consisted of a group of 14 apple packing firms located in the principal apple-packing areas of Michigan. To satisfy the objectives of the study, the sample was selected to cover a wide range in plant size, work methods, and equipment types. No attempt was made to design the sample so as to be statistically representative of average

conditions throughout the industry. Several characteristics of the sample plants are summarized in Table 2.

With the exception of Plant D, all of the plants studied are located along the western side of Michigan. This is consistent with the location of apple packing in Michigan. Almost 90 percent of the fresh apple pack is put up on the western side of the state. The concentration of plants facilitated the gathering of observations and also helped to reduce the costs of doing the field work.

The plants observed cover a wide range of sizes. Note that average output per hour ranged from 27 to 267 bushels. All legal forms of organization were represented in the sample. However, most of the sample plants were large corporations and cooperatives. All of the plants observed operate refrigerated storage facilities in conjunction with the packing line. Nine of the plants also operate controlled atmosphere storage facilities.

As noted, the sample plants include a majority of medium and large plants. The sample plants packed approximately 23 percent of the 1962-63 fresh apple pack in Michigan. These plants also packed a higher proportion of their pack in poly bags than did the average Michigan plant. Totaling the figures in Table 2 reveals that the sample plants packed 70 percent of their pack in poly bags, 14 percent in tray packs, 11 percent jumble pack, and 5 percent in other packages. Data for the 1963-64 pack would probably indicate an even higher percentage of the pack in poly bags.

Table 2. General Characteristics of Sample Apple Packing Plants

Plant	1962-63 Fresh Pack (bushels)	Peak Rate of Output (bu. per hr.)	Average Rate of Output (bu. per hr.)	Packout as a Percent of Apples Dumped	Percent of Pack in Various Containers			
					Poly Bags	Tray Pack	Jumble Pack	Other[1]
A	50,000	194	141	68	80	15	5	-
B	207,000	202	158	67	77	7	7	9
C	78,000	262	174	71	75	5	20	-
D	65,000	242	144	81	100	-	-	-
E	124,000	230	182	49	58	1	40	1
F	195,000	214	162	58	60	30	10	-
G	60,000	155	141	69	100	-	-	-
H	17,100	33	27	72	99	-	-	1
I	76,500	281	192	72	90	10	-	-
J	150,000	297	176	75	67	20	13	-
K	130,000	174	130	63	50	15	5	30
L	162,500	336	267	66	65	27	2	6
M	180,000	279	202	69	60	25	5	10
N	263,300	216	188	75	73	2	18	7

[1] Includes apples packed in bushel baskets, gift packs, and shrink film overwraps.

Deriving the Cost-Volume Relationship

Data from all of the sources previously discussed form the basis for estimating total season costs of apple packing plants. Fixed and variable costs are computed by plant cost component for five plants. These plants, which range in size from 100 to 500 cartons per hour, utilize the least-cost work methods and equipment organization presented in this study. Costs are based on operation at planned capacity for stated lengths of season. The range of plant sizes, 100 to 500 cartons per hour, include almost all recently constructed and planned apple packing plants in Michigan. Plant cost components are added to obtain total plant costs for each of the synthetic plants. Cost-volume relationships are then derived and illustrated by average cost curves.

CHAPTER III

DESCRIPTION OF THE MICHIGAN APPLE PACKING INDUSTRY

Industry Structure in the United States

The Michigan apple packing industry is an important part of the total U. S. apple packing industry. As previously noted, Michigan packs about 10 percent of the total U. S. fresh apple pack. A knowledge of the U. S. apple packing industry structure would give an indication as to some of the competitive factors facing Michigan packers. While no analysis of competitive relationships in the apple packing industry are presented in this thesis, they must be borne in mind when discussing proposed changes in a region such as Michigan. For that reason, available data concerning the number and size of apple packing plants in the leading apple producing states are presented. While by no means complete, these data do give an indication of total industry structure. Following is a brief summary of published data on number and size of firms for the leading states.

Washington. During the 1950-51 season, there were 252 packing plants operating in Washington.[1] There seems to have been no substantial change in the number of apple packing plants in Washington since

[1]E. W. Carlsen, D. L. Hunter, R. S. Duerden, and J. F. Herrick, Jr., Apple Handling Methods and Equipment in Pacific Northwest Packing and Storage Houses, U. S. Department of Agriculture Marketing Research Report No. 49 (Washington: U. S. Government Printing Office, June 1953), p. 2.

1950-51.[2] Of these 252 packing plants, 41 are cooperative apple packing plants with an average yearly volume of about 200,000 bushels. The average yearly volume for the other plants would then be around 60,000 bushels per year.

New York recently reported between 235 and 245 apple packing plants in operation.[3] On the basis of number of workers, Kinne classified 66 percent of the plants as small, 21 percent as medium size, and 13 percent as large. On the basis of New York's average annual fresh pack, the average packout per firm would be about 45,000 bushels.

Michigan had approximately 180 firms packing apples during the 1963-64 packing season. Data presented in this chapter show that a majority of the Michigan plants can be classified as small. Details of the Michigan industry are reported in following sections.

California was reported to have about 30 apple packing plants in the mid-1950's.[4] No more recent data on the number and size of plants are available. On the basis of 30 plants, the average annual packout would be about 100,000 bushels per plant.

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[2] Earl Franklin, Extension Marketing Specialist, Washington State University, personal letter, June 2, 1964.

[3] Ivan L. Kinne, "An Analysis of Costs and Economic Efficiency in New York State Apple Packing Houses" (unpublished Ph. D. dissertation, Cornell University, 1960).

[4] B. C. French and D. G. Gillette, Costs of Assembling and Packing Apples as Related to Scale of Operation, Technical Bulletin 272 (East Lansing: Michigan Agricultural Experiment Station, August 1959), p. 6.

Appalachian Area. In 1956-57 a survey was made of the larger apple packing houses in the Appalachian Area between Winchester, Virginia, and Mercersburg, Pennsylvania.[5] Setting a lower limit of 50,000 bushels per season packout, schedules were taken in 36 packing houses: 17 in West Virginia, 8 in Virginia, 4 in Maryland, and 7 in Pennsylvania. No estimate was made of the total number of packing plants in this area.

The U. S. apple packing industry is characterized by a large number of small firms. Thus it is axiomatic that the individual apple packer has little market power. The total market structure is one approaching monopolistic competition on the selling side. The product (apples) is often differentiated by area of production, by variety, or by package. Advertising is used and entry and exit of firms is comparatively easy.

The Function of Apple Packing Plants

The marketing function of an apple packing plant consists of receiving apples from one or more producers, sorting and grading the fruit, receiving and assembling packaging materials, placing apples in various packages and containers, and loading the packed fruit in trucks for shipment to fresh markets or processing plants.

Most apple packing plants in Michigan operate a refrigerated storage in conjunction with the packing line. Many of the packers also handle all sales of their fruit. Neither of these functions are considered in this study.

[5] H. C. Evans and R. S. Marsh, Cost and Mechanical Injury in Handling and Packing Apples, Bulletin 416 (Morgantown: West Virginia Agricultural Experiment Station, June 1958), p. 5.

The hours of operation of Michigan apple packing plants are limited to some extent by the packer's market. Apples are usually packed only after an order is received. Because of the wide use of poly bags and the problems of quality maintenance when refrigerated, packed apples are not stored for any significant length of time. Large packers with well established market outlets are able to operate on a more regular basis than are some smaller firms.

Characteristics of Michigan Apple Packing Plants

Data collected in an industry survey conducted during the winter of 1963-64 permit a rather detailed description of Michigan apple packing plants. Many changes have taken place in the apple packing industry. Whenever past data are available these changes will be noted.

Number of Firms: There are at least 155 firms currently packing fresh apples in Michigan. In addition, it is estimated that there are approximately 25 firms which pack only if the price structure is favorable. Thus, there are at most, 180 packinghouses currently handling the Michigan fresh apple pack.

These firms compare with over 400 in existence in 1956-57 as reported by French and Gillette.[6] This means that the Michigan apple packing industry has experienced a 55 percent decrease in numbers in about seven years. The actual decrease in numbers is even greater in most years since 155 of the 180 firms usually do all the packing.

[6] French and Gillette, op. cit., p. 6.

Geographic Location: The respondent and non-respondent packing plants are geographically located as shown in the following table.[7] Counties included in the five apple-producing areas of Michigan are illustrated in Figure 2.

Table 3. Geographic Location of Respondent and Non-Respondent Fresh Apple Packing Plants in Michigan, 1964

Area[1]	Respondent Plants	Non-Respondent Plants	Total By Area
	- - - - - - - - - number of plants	- - - - - - - - -	
Southwest	41	10	51
West Central	30	6	36
Northwest	18	2	20
Southeast	23	11	34
Other	12	2	14
TOTAL	124	31	155

[1]See Figure 2.

The packing plants are concentrated mainly along the western side of the state, but a sizeable number of plants are located in the southeast near the heavily populated Detroit metropolitan area. This pattern of plant location conforms with the location of production since packing plants tend to be production rather than market oriented.

Most of the apple packing plants in Michigan are in rural locations. Since almost all shipments are by truck, packing plants are located close to all-weather roads. Many of the plants are adjacent to or very close to

[7]Respondent packing plants are composed of those who completed the questionnaire and are actively packing apples.

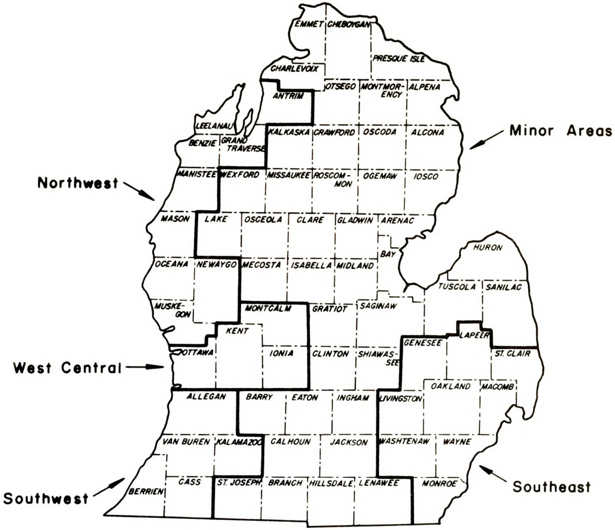

Figure 2. Apple-Producing Areas in Michigan

main highways. Very few packing plants are located on railroad sidings since very few shipments are by rail.

Size of Apple Packing Plants

Plant size can be measured in several ways including physical area, financial assets, volume handled and machine and storage capacity. Physical area, however, is not a very realistic measure of plant size since wide variation can occur in pack depending on type of equipment, length of season and plant layout. Financial assets are difficult to obtain and tend to be non-comparable because of variable depreciation schedules and age of equipment and plant.

This study considers three measures of plant size: the 1962-63 pack in bushels, equipment capacity in bushels per hour, and total refrigerated storage capacity which includes controlled atmosphere facilities.

An important aspect of the 1962-63 pack is the distribution of the pack among the largest packing firms. Data from respondent packers indicated that the five largest firms packed 27 percent of the total 1962-63 fresh pack. The 10 largest firms packed 41 percent while the top 15 firms packed 52 percent of the 1962-63 total pack.[8]

The 1962-63 pack of respondent packing plants ranged from less than 5,000 bushels to more than one-half million bushels. Forty-seven percent of the respondent plants packed 20,000 bushels or less in 1962-63 (Figure 3). Forty-one percent packed between 20,000 and 100,000 bushels, while 12 percent packed over 100,000 bushels in 1962-63.

[8]These data are concerned only with percentages packed. Sales by the top 5, 10, and 15 packing firms would be even greater since some of the large packers act as selling agents for other packers.

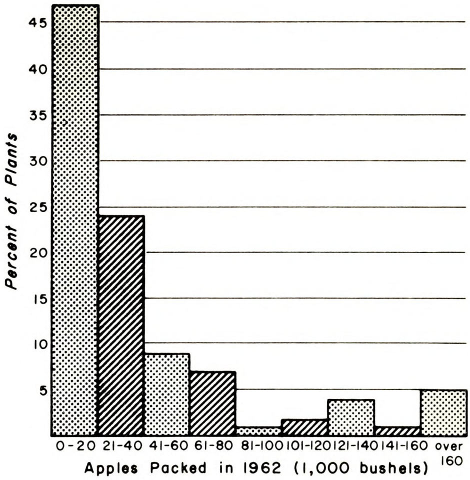

Figure 3. Percentage Distribution of Michigan Apple Packing Plants by Size of Pack, 1962-63

While no previous study of packed volume per plant has been made for all plants in Michigan, 1956 data from a sample of 18 plants show that the pack-out of the largest firm was less than 80,000 bushels.[9]

Data from Figure 1 on size of fresh pack plus information on number of packing firms (Table 3) leads to the obvious conclusion that increased concentration has occurred in Michigan's fresh apple packing industry. Yet it is also important to note that a relatively high percentage of the remaining firms are comparatively small (Figure 3).

An interesting aspect of plant size as shown by the 1962-63 pack is its distribution by producing areas, Table 4.

Table 4. Percentage Distribution of Plant Sizes by Producing Area, Michigan, 1962-63

Bushels Packed in 1962-63	Producing Area[1]					
	S.W.	W.C.	N.W.	S.E.	Minor	State
	percent					
0- 30,000	54	57	44	78	83	60
30- 60,000	22	17	22	18	17	19
60- 90,000	7	10	17	4	--	8
90-120,000	5	--	--	--	--	2
120-150,000	7	3	--	--	--	4
Over 150,000	5	13	11	--	--	7
Total	100	100	100	100	100	100

[1]See Figure 2.

Examination of Table 4 reveals one of the major differences in packing houses by area of the state. Most of the packing houses in the Southeast

[9]D. G. Gillette and B. C. French, "Costs of Packing Apples in Michigan," The Quarterly Bulletin of the Michigan Agricultural Experiment Station, Vol. 40, No. 2 (November 1957), p. 290.

and minor area are small while the large packers are concentrated in the western side of the state. These size differences are due both to volume of production in the areas and to the sales outlets used. Packers in the southeast and minor areas are very close to metropolitan complexes where land values preclude the acquisition of large orchards. In addition, these small packers have a ready outlet for their apples through roadside stands and the produce markets in Detroit. They do not have to produce the output necessary to service a large account.

The second measure of plant size is the capacity of packing equipment in terms of bushels per hour. Equipment capacities of respondent packers ranged from 25 to 400 bushels per hour. The degree of mechanization is related to per hour capacity. A few of the plants with small equipment capacity were mainly hand operations while the larger plants utilized modern sorting, packing, and handling equipment.

The percent of respondent packers in each capacity category is shown in Figure 4.

Intensive study of 15 of the respondent plants indicated that actual output seldom reached the hourly level indicated by the respondent in the survey questionnaire. In fact the actual output during the period studied was only 67 percent of the capacity that plant managers indicated on the questionnaires. Failure to reach full capacity may be due to quality of apples received, type of pack and size of the work crew as well as labor and management efficiency. Plants in the western producing regions tended to have equipment with larger per hour capacities than plants in the southeastern area.

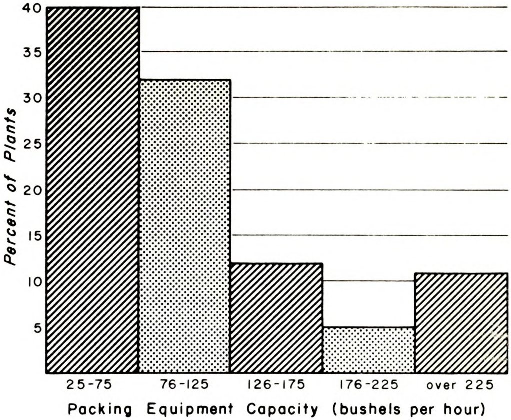

Figure 4. Percentage Distribution of Respondent Michigan Apple Packing Plants by Equipment Capacity (bushels per hour), 1963

Storage capacity is the third measure of plant size obtained in the apple packing plant survey. For purposes of this discussion only refrigerated and controlled atmosphere storages are considered. Common or unrefrigerated storages are not considered, since they are difficult to count and measure and a variety of structures may be used.

The percent of respondent packers in each storage capacity classification is shown in Figure 5.

Figure 5 indicates that over half of the respondent plants had storage capacities of less than 30,000 bushels. Storage will be more fully discussed in a later section.

All three of the measures of plant size discussed above are related in that plants which pack a large annual volume tend to have high capacity packing and handling equipment and large storage facilities. Most of the largest firms by any of the three measures of size used are in the western half of the state. Packing houses in the southeast and minor areas can, with few exceptions, be characterized as small, farm-type operations.

Legal Organization

Accompanying the changes in the number and size of Michigan packing plants have been changes in their legal organization. In at least four cases, individuals who had recently done their own packing formed corporations, acquired one large packing operation, and employed a full-time plant manager. Each of these corporations has from three to ten stockholders.

Storage capacity is the third measure of plant size obtained

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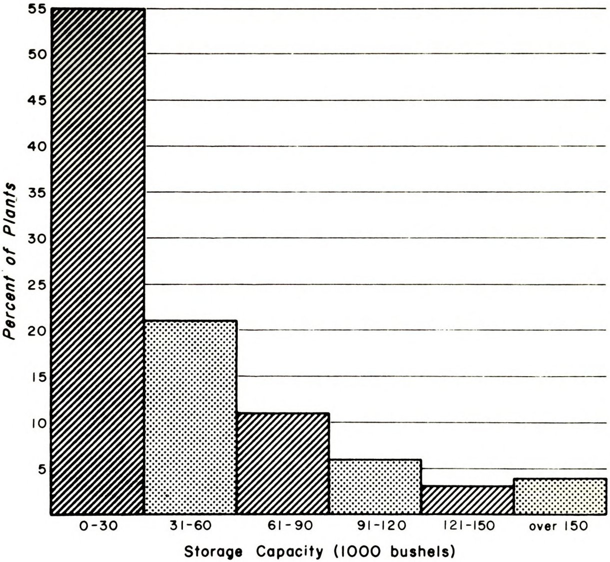

Figure 5. Percentage Distribution of Respondent Michigan Apple Packing Plants by Capacity of Refrigerated and Controlled Atmosphere Storage, 1963

The legal organization of packing plants varies by area. A high percentage of the firms in the southeast and minor areas are either single proprietor or partnerships while most of the corporations are located in the western part of the state. Since size and legal structure are related, there is a tendency for the smaller firms to be organized as single proprietorships and partnerships while the larger firms are incorporated.

The fact that larger firms tend to be organized as corporations is probably best illustrated by data in Table 5, which relates legal organization of firms to their storage capacity.

Table 5. Legal Organization of Respondent Michigan Apple Packing Plants Related to Size of Storage[1], 1962-63

Storage Capacity	Legal Organization			
	Single Proprietor	Partnership	Cooperative	Corporation
1,000 bu.	percent of firms			
0- 30	82	56	50	3
30- 60	16	28	--	27
60- 90	2	13	17	23
90-120	--	3	33	17
120-150	--	--	--	13
over 150	--	--	--	17
Total	100	100	100	100

[1]Includes refrigerated and controlled atmosphere storage.

All of the respondent packing houses with over 120,000 bushel storage capacities were organized as corporations. The corporate structure lends itself to the financial requirements of large storage facilities.[10]

[10]Other studies indicate that storage construction costs range between $1.60 and $2.85 per bushel of capacity. A 150,000 bushel storage facility may thus cost between $240,000 and $427,500.

Coordination Between Growers and Packers

In order to determine the degree of coordination between growers and packers, the respondents were asked to report the quantities of apples grown, purchased, and packed on consignment for the 1962-63 season. Coordination includes vertical integration or the growing of apples by packers and, for purposes of this study, consignment of apples by growers to packers which is one form of a contractual arrangement.

Respondent apple packers indicated that they purchased 19 percent of the apples packed in 1962-63. Fifty-three percent were grown by packer-growers and 26 percent were packed on consignment. Two percent of the 1962-63 apples received by packers were not classified. Thus the degree of packer-grower coordination is high since 79 percent of apple receipts were either grown or packed on consignment. The larger packers, however, tended to buy a larger percentage of their apples and grow smaller quantities relative to the smaller packers.

Receipt of Apples in Bulk Boxes

It was estimated that during the 1958 season almost 5 million bushels of Michigan grown apples or 39 percent of the crop were handled in bulk boxes.[11] During the 1962-63 season, 68 percent of the apples received by respondent fresh apple packers were received in bulk boxes, Table 6.

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[11] H. P. Gaston and J. H. Levin, Handling Apples in Bulk Boxes, Special Bulletin 409 (East Lansing: Michigan Agricultural Experiment Station, revised September 1959), p. 5.

Coordination Between Growers and Packers

In order to determine

packers, the

Table 6. Apples Received by Packers in Bulk and Bushel Containers by Michigan Producing Areas, 1962-1963.

Container	Producing Areas[1]					State
	South-west	West central	North-west	South-east	Minor Areas	
	percent of volume					
Bulk	71	72	82	30	25	68
Bushel	29	28	18	70	75	32
Total	100	100	100	100	100	100

[1]See Figure 2.

The percentage of the total 1962 crop handled in bulk in Michigan would be even higher because most processing plants receive apples in bulk boxes. Industry sources estimate that approximately 90 percent of Michigan's processing apples are handled in bulk boxes. Thus, an estimate of the total use of bulk boxes would place approximately 77 percent of the 1962-63 crop in this container. Total use of bulk containers and bulk handling equipment is increasing yearly.

The percentage of apples handled in bulk boxes varied by producing areas. In the southeast and minor areas the majority of apples are received in bushel crates, Table 6.

Table 7 shows that small packers tend to receive apples in bushel crates while larger packers tend to receive apples in bulk boxes. A Michigan State University study found that cost savings can be realized through the use of bulk containers but only if the grower produces more than 8,000 bushels of apples per year.[12]

[12]Ibid., pp. 16-19.

Table 7. Apples Received by Packers in Bulk and Bushel Containers by Size of Fresh Pack, 1962-1963

Container	Size of 1962 Pack (bushels) 0-30,000	30-60,000	60-90,000	90-120,000	120-150,000	Over 150,000	State
	percent of volume						
Bulk	38	60	67	95	85	80	68
Bushel	62	40	33	5	15	20	32
Total	100	100	100	100	100	100	100

One of the problems associated with bulk handling is the lack of standardization of box size. This creates difficulties in handling, storing, transporting, and payment for picking and selling of apples. Eventual standardization of bulk boxes should reduce these difficulties and result in cost savings.

Storage Facilities of Packing Plants

The Michigan Apple Council reported 2,111,000 bushels of apples in controlled atmosphere storage in Michigan during the fall of 1963.[13] This quantity represents most of the total capacity of controlled atmosphere storages in Michigan. In addition, it is estimated that refrigerated storage facilities could handle another 5 million bushels for a total of more than 7 million bushels.

Survey results indicate that controlled atmosphere facilities maintained by respondent packers totaled 1,719,000 bushels capacity or slightly more than 81 percent of the total. Respondent packers reported

[13]The Michigan Apple Council is the grower service division of the Michigan State Apple Commission.

3.5 million bushels capacity of refrigerated storage or about 70 percent of the total.

More than 94 percent of the respondent apple packers in the state have their own refrigerated or controlled atmosphere storage facilities. It is interesting to note that packers not having storage facilities were all located in the southwest area of the state. While this aspect was not fully investigated, it might be assumed that these packers used public cold storage facilities or packed apples directly from the orchards.

Table 8 shows that most of the larger apple storage facilities are located in the western half of the state. It also shows that the capacities of storage facilities in the southeastern and minor areas of the state are all smaller than 90,000 bushels.

Table 8. Storage Capacities of Respondent Michigan Apple Packing Plants by Production Area, 1963

Storage Capacity[1]	Area[2]				
	Southwest	West Central	Northwest	Southeast	Minor
(1,000 bu.)	percent of firms				
0- 30	51	32	33	81	92
30- 60	20	39	17	11	8
60- 90	9	20	11	8	--
90-120	11	3	17	--	--
120-150	3	3	11	--	--
Over 150	6	3	11	--	--
Total	100	100	100	100	100

[1]Includes refrigerated and controlled atmosphere.

[2]See Figure 2.

Types of Containers Used in Packing Apples

There have been marked changes in container use for packed apples in Michigan during the last 10 years. In the 1953-54 packing season most apples were shipped to market in three types of master containers: bushel baskets, open returnable crates and bushel and half-bushel cartons.[14] Estimates of shipments by type of container placed 24 percent of the 1953-54 pack in bushel baskets, 39 percent in open returnable crates, 22 percent in cartons, and 13 percent in film bags.[15]

Today the once popular open returnable crates and bushel baskets are used very little by Michigan apple packers, Table 9. A combination of these two containers accounted for only 6 percent of the 1962-63 pack as contrasted to 63 percent 10 years ago.

Table 9. Percent of Volume of Apples Packed by Type of Container and Producing Areas, Michigan, 1962-1963

Packed for Fresh Market	Producing Areas[1]					State
	S.W.	W.C.	N.W.	S.E.	Minor Areas	
	- - - - - - - percent of volume - - - - - - - - - -					
Poly bags	63	70	69	47	52	65
Tray pack	5	12	12	1	4	9
Bushel basket	5	2	1	3	3	3
Jumble pack	16	11	7	8	8	11
Open returnable crates	1	*	2	24	12	3
Other	10	5	9	17	21	9
Total	100	100	100	100	100	100

[1]See Figure 2. *Less than 1 percent.

[14]B. C. French, "Estimates of Apple Shipments by Type of Container, Marketing Channel, and Producing District," The Quarterly Bulletin of The Michigan Agricultural Experiment Station, Vol. 38, No. 3 (February 1956), p. 386.

[15]Ibid.

Types of Containers Used in Packing Apples

There have been

in Michigan

The big change in the past 10 years has been to the use of three and four pound bags. The pack in bushel and half-bushel cartons, which is a combination of tray and jumble packs in Table 9, has remained fairly constant at about 20 percent. As shown, the relative importance of type of container varies from area to area in the state. For instance, open returnable crates are still of significant importance in the southeast and minor areas of the state, Table 9.

Table 10 shows the percent of Michigan apple packing firms using various types of containers. The figures in Column 1 of Table 10 indicate, for example, that in the southwest area 77 percent of the packers packed some apples in poly bags, 55 percent packed some apples in trays, and so on. The percentages do not add to 100 since almost all packers used more than one type of container.[16]

Table 10. Percentage Distribution of Apple Packers by Type of Container Used and Producing Area, Michigan, 1962-63

Type of Container	Producing Areas[1]					State
	South-west	West central	North-west	South-east	Minor Areas	
	percent of firms					
Poly bags	77	92	94	36	78	75
Tray pack	55	56	59	9	22	43
Bushel basket	42	12	6	9	22	20
Jumble pack	74	52	59	14	22	49
Open crate	10	20	12	32	22	18
Other	42	20	29	32	44	33

[1]See Figure 2.

[16]Comparable data for the 1953-54 packing season are presented by French, ibid., p. 388.

A recent article indicated that about 80 percent of the apples packed in Washington state were tray packed.[17] The primary reason for the acceptance of trays by Washington packers is the product damage problem resulting from cross-country shipments. Less than 20 percent of the Washington pack is prepackaged by apple packers into consumer-sized containers. This is in sharp contrast to the Michigan situation.

As previously noted, over 60 percent of the apples sold at retail are in consumer packages. The comparisons noted above indicate that Michigan apple packers have adjusted their use of containers to correspond with market demand. Their proximity to fresh apple markets has undoubtedly been a major factor in the shift to consumer type containers.

Apple packers are beginning to adopt another type of consumer container: the shrinkfilm, overwrapped, molded tray. This pack holds from 6 to 12 apples (or more depending on apple size and type of molded tray). The apples do not bruise as easily as do apples in poly bags. The molded tray permits apple placement to display color and the shrinkfilm gives the apples a glossy appearance.

Sales Outlets Utilized

Michigan apple packers were asked to list the quantities of fresh apples sold to final consumers, retail stores, wholesalers, brokers, and other outlets in 1962-63, Table 11.

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[17] W. H. Mapes, Jr., "Molded Apple Trays Solve Packaging Problems in Washington State," American Fruit Grower (March 1964), p. 57.

Table 11. Volume of Apples Sold by Sales Outlet and Producing Areas, Michigan, 1962-63

Sales Outlet	Producing Areas[2]					State
	South-west	West Central	North-west	South-east	Minor Areas	
	percent of volume sold					
Final consumers	1	2	*	21	37	4
Retail stores	12	21	26	15	34	19
Wholesale[1]	80	62	57	36	22	63
Broker	3	15	15	18	*	11
Other	4	*	2	10	2	3
Total	100	100	100	100	100	100

[1] Some packers listed deliveries to retail chain warehouses as wholesale outlets.

[2] See Figure 2.

* Less than 1 percent

Sales directly to final consumers, while accounting for only 4 percent of the state total, were an important outlet for southeastern and minor area packers. Sales through brokers were least important in the southwestern and minor areas, Table 11.

For the state as a whole, 63 percent of the fresh apple sales were reported as made to wholesale outlets. Nineteen percent of sales were reported made to retail outlets. However, since some packers listed deliveries to retail chain warehouses as "wholesale" the retail outlet percentage may be under-stated and the wholesale category over-stated. Despite this difficulty, changes over the past 10 years are evident.

In the 1953-54 packing season, sales of packed apples directly to

truckers accounted for 18 percent of the total.[18] During 1962-63, the sales to truckers were not large enough to be classified separately. They are included in the "other" category in Table 11.

Some Implications of Continued Change

The preceding survey results are descriptive of the current status of the Michigan fresh apple packing industry. In addition, they show the rapid changes which have occurred in the structure of the industry. The decrease in numbers, increases in average volume packed, higher capacity equipment, and larger storage units all provide evidence that opportunities have existed for cost savings through the use of larger packing plants. The extent to which there are cost savings in larger plants will be investigated in the following chapters of this thesis.

A continued reduction in the number of packers and accompanying changes in size, legal organization, handling methods, storage facilities, container use, and sales outlets have implications for the Michigan apple packing industry. A few of these implications will be discussed concerning their effect on producers, packers, and competitors in other producing regions.

Implications to Michigan Apple Producers

Producer's direct labor requirements will probably decrease with further reductions in on-farm packing, increases in the use of bulk boxes, and improved handling techniques. The movement to off-farm packinghouses

[18] French, op. cit., p. 389.

will relieve many producers of the packing job. Thus, producers can concentrate more time and effort to management of production and other activities by substituting capital inputs for direct labor.

With increased centralized buying by corporate and voluntary chain food stores, Michigan apple packers are now finding it necessary to pack larger and larger volumes of uniform quality apples. Hence packers are demanding more uniformity of size and quality from producers.

Many producers maintain small volume packing equipment on their farms. The necessity for established sales outlets will make it increasingly difficult to utilize these facilities on an intermittent basis. Entry into the packing business is limited by the difficulty of establishing and maintaining sales outlets. A producer-packer may find it necessary to become a stockholder in a corporate packing operation, a member of a packing cooperative, or contract with an established sales organization in order to insure himself of an outlet for his apples. The organizations just mentioned all have established sales outlets for their apples.

Implications to Michigan Apple Packers

Fresh apple packing will probably become a more specialized marketing function performed by off-farm firms using high capacity equipment, large storage facilities, and complex sales organizations. The capital requirements of large packing and storage operations will undoubtedly lead to more corporate and/or cooperative packing organizations.

The changing structure, i.e., fewer and larger firms, will provide

increased opportunity for packers to carry out coordinated programs designed to upgrade quality, improve advertising and promotion, and educate themselves on the latest techniques of handling, storing, and packing apples. Because of changes in buyers' tastes, packers need to be flexible enough to adjust quickly to changes in types of packages, especially consumer type packages. Packers will also have to be aware of new equipment and packing techniques.

As apple packing becomes more of an off-farm activity, large-scale packers will depend more on purchased apples and apples packed on consignment to fill their needs. Because of the large volumes handled, packers will need dependable, large volume, year-around market outlets for their apples. Packers will need to be increasingly aware of quality of pack in order to maintain these outlets.

Implications Concerning Inter-area Competition

Concentration of packing and selling operations seems to draw the producer "closer" to the market. Because of better communications, the producer must be more sensitive to changes, especially changes in consumer demand. Since sellers are better informed of alternative market opportunities in other areas, there is increased competition in consumer markets. This may be especially true of large consumer markets. Insofar as one producing area has a comparative advantage in a specific set of markets, the advent of large packing and selling organizations can be instrumental in the growth of the industry in that area.

This suggests the need for expanded knowledge of regional cost differences in production, packing, and transportation. If members of the industry in a particular area have this information, they will be better able to determine the possibilities for expansion or the need for contraction. This thesis will provide packing cost data which can be used in a future study of interregional competition in fresh apple production and packing.

CHAPTER IV

PLANT ORGANIZATION AND OPERATING STAGE ANALYSES

Plant Organization

A sequence of operations is involved in plants packing apples for the fresh market. This sequence is illustrated by the process flow diagram (Figure 6). The representative apple packing plant floor plan (Figure 7) illustrates a layout of equipment involved in the various operations. The sequence of operations begins when apples are moved from refrigerated storage by lift truck to the dumping station. The filled box is moved into position and the apples are either dumped or floated out of the box. The fruit then passes over a 2-1/4 inch eliminator which removes all undersized fruit. Then, after being inspected by the sorters, the apples pass through a washer and brusher which removes foreign material from the apples' surfaces. Sparkling clean, the apples are sized, placed in a container, and the container is closed and palletized. The pallet load of packed apples is then held in temporary storage until loaded out on a truck.

In the packing operation the apples can be placed in a variety of packages. As previously noted, the three and four pound poly bags placed 12 and 10 to a master container are currently the most popular package for Michigan. Depending on customer's requirements, the apples may

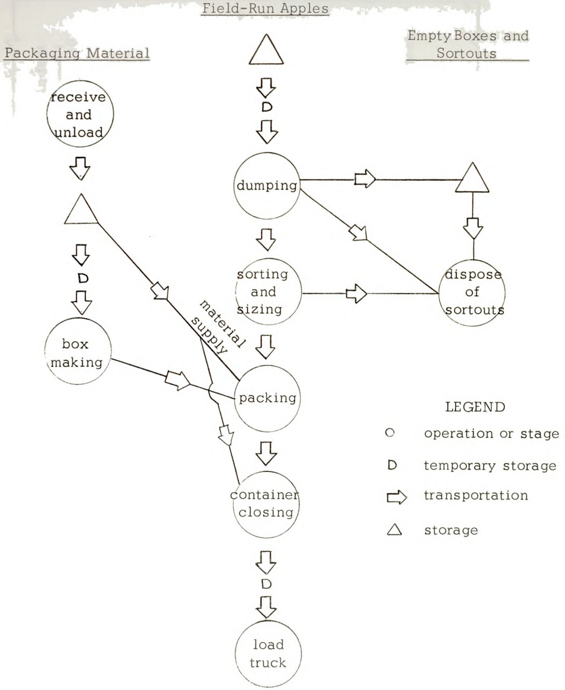

Figure 6. Process Flow Diagram for Michigan Apple Packing Plants, 1964

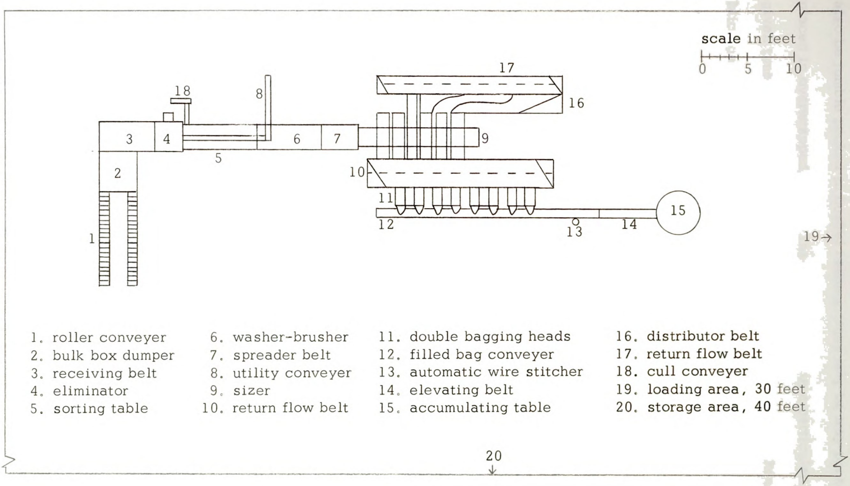

Figure 7. Floor Plan for a Representative Medium-Size Apple Packing Plant, Michigan, 1964

also be jumble packed in bushel cartons, they may be tray packed, or placed in overwrapped trays. The package used in a particular plant at a given time will depend largely on the current day's orders. Because most Michigan packers pack strictly on order, the apples remain in temporary storage only a short time before being loaded out on trucks.

Activities included in the previously mentioned sequences of operations are, for ease of analysis, grouped into production stages. These stages allow independent cost analysis of each segment of the total plant. Analysis by stages simplifies the analysis by reducing the total number of plant combinations which must be considered. Within many of the stages there are alternative methods or techniques which can be used to perform a given operation. This means that there can be a few or many ways to organize a plant. By choosing the least cost technique in each stage, a least cost organization can be constructed for each size plant and length of season. Assuming that the stages are independent (i.e., the technology utilized in one stage does not affect the choice of technology for another stage), a least cost plant organization is derived by simply adding least cost techniques for each stage. If the stages are dependent, they must be redefined into a single stage for cost comparison purposes. Since the number of alternative technologies for a joint stage is the product of the technologies of the individual stages, it is obvious that the number of calculations which must be made increases sharply. An additional limitation to the simple combination of least cost technologies for each stage is

the problem of smoothly matching the capacities of each stage. This problem is commonly referred to as the problem of harmonious combinations of equipment. Neither of these limitations affected the analysis of the synthetically constructed plants in this study. The plant stages proved to be independent and stage capacities were such that they smoothly matched to provide plant capacities of 100 through 500 cartons per hour output.

For analytical purposes of this study, the cost components of apple packing plants are defined as consisting of five operating stages and four indirect components which are associated with one or more of the operating stages. The operating stages include (1) dumping, (2) sorting and sizing, (3) packing, (4) container closing, and (5) in-plant handling of products and materials. Indirect cost components include (1) office and administrative expense, (2) packaging materials, (3) building costs, and (4) supervision and miscellaneous labor, equipment, and materials.

Assumptions

Because of variations in varieties packed, quality and size of fruit, hours of operation, and quantity measurement of apples, the following assumptions are necessary for the analysis.

1. The mixture of varieties packed includes approximately 50 percent Jonathan, 25 percent McIntosh, 15 percent Delicious, and 10 percent other varieties.

2. Five percent of the apples dumped are eliminated as less than 2-1/4 inches in diameter. Another 25 percent are sorted out as culls or utilities. Seventy percent of the volume dumped is packed.

3. Michigan apple packers typically operate for eight or ten hours a day. No overtime wages are paid.

4. The per bushel weight of apples is 48 pounds. Packed containers of apples will average approximately 40 pounds.

Analysis of Operating Stages and Indirect Costs

Stage 1: Dumping

As noted in the preceding chapter, apples are handled in both bushel crates and bulk boxes. Different methods of dumping are used for the two containers. Dumping bushel crates is primarily a hand operation while dumping bulk boxes, because of their weight, is a machine operation. The dumper's job consists of obtaining a filled container of apples, moving it into position at the dumping station, dumping the apples, and placing the empty container aside.

When hand dumping field crates, the dumper obtains a filled crate from an adjacent pallet, moves it to the receiving belt and dumps the apples using his arm to slow the flow of apples and reduce bruising. The dumper then places the empty crate aside on a pallet. Often the dumping station will include a mechanical aid. The aid generally consists of a spring-loaded crate holder into which the filled crate is placed. The crate is tipped with a lever and the rate of flow of the apples onto the receiving belt is controlled by the hinged cover of the dumping aid.

Because of the cost advantages which can be realized through the

use of bulk boxes, most Michigan apple packers now use this container.[1] Capacities of bulk boxes range from 15 to 23 bushels of apples. This means that a filled bulk box may weigh as much as 1,300 pounds. Two types of bulk box dumpers are commonly used in Michigan. They are the tilt-type hydraulic dumper and the water immersion dumper. With the tilt-type dumper the filled box is placed in a hydraulically controlled dumping frame. As the filled box swings up into dumping position, it comes in contact with a padded cover, one side of which is hinged to allow the operator to control the rate of flow of apples out of the box.

The water immersion dumper consists of a large water tank with a water circulating pump and a hydraulically controlled box submersion unit. Filled bulk boxes are transferred from roller conveyer onto a hydraulically operated platform for submersion into the water filled tank. Once the box is located on the platform, the operator depresses the control lever and the box is gently lowered into the water. The apples float to the top and are carried to a roller conveyer at the front of the tank by the constantly circulating water. When all of the apples are cleared from the bulk box, the hydraulic lift raises the box to the top of the tank, the empty box is allowed to drain, and is then moved to a take-away conveyer.

The actual rate of dumping with the hand dumping method varied in the plants studied from 107 to 210 bushels per hour. However, the rate

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[1] For a discussion of the cost savings in storage, transportation, and initial purchase price see: Gaston and Levin, op. cit., pp. 16-19, and S. W. McBirney and A. Van Doren, Pallet Bins for Harvesting and Handling Apples, Stations Circular 355 (Pullman: Washington Agricultural Experiment Station, April 1959).

of dumping is governed by other operations on the packing line. The dumper adjusts his pace so as to maintain the proper flow of fruit to other workers on the line. After attempting to take this pacing into account, a computed standard for the manual dumping job is 142 bushels per hour. With the dumping aid the standard is 152 bushels per hour.

Average rates of operation for plants using the tilt-type hydraulic bulk dumper ranged from 119 to 185 bushels per hour. As with the manual method the dumper paced himself so as to maintain an even flow of fruit on the line. Observations over short periods of time in addition to data from manufacturers, however, indicate that a worker with a tilt-type dumper can easily deliver 300 bushels per hour to the packing line. This is the figure used as the standard. For a higher capacity line, two of the dumpers can be installed.

Water immersion bulk dumpers were in use in the higher capacity plants. Average rates of operation for the plants observed ranged from 225 to 361 bushels per hour. The rate of dumping is paced to correspond with other operations on the packing line, but the capacity rate is also dependent on the size and design of the dumping unit. Bulk water dumpers come in various sizes so that one man may be able to dump anywhere from 300 to 800 bushels per hour when working at capacity. Advantages of this method of dumping include higher capacity operation and a lower rate of bruising to the apples.

Table 12 presents labor and equipment requirements and costs for

dumping apples at five different input rates. Assuming a 70 percent pack-out, these are the input rates necessary to obtain outputs of 100, 200, 300, 400, and 500 cartons per hour. Costs are computed for three dumping methods, manual, dry bulk, and water bulk. Note that costs for the manual dumping method were computed for only three input rates. Because of the rapid adoption of bulk boxes, it is doubtful that a sufficient volume of apples in bushel crates would be available to satisfy the requirements of larger capacity plants.

Total season costs for a particular dumping method and plant size are computed by multiplying the total variable costs per hour by the number of hours operated and then adding the annual fixed charge. Variable costs per hour include charges for labor, power, and variable repairs and maintenance of equipment. The annual fixed charge includes allowances for fixed repairs, insurance, interest on investment, property tax, and depreciation. Total season costs for a given volume and length of season vary by the method of dumping used. For a plant input capacity of 120 bushels per hour, manual dumping is the least cost method for seasons up to 1,600 hours. Dry bulk dumping is the least cost method for plants dumping 240 bushels per hour and operating up to 1,600 hours. It is also the least cost method for 360 bushels per hour plants operating up to 400 hours per season. For this size plant operating more than 400 hours per season water bulk dumping offers lowest total season costs. Water bulk dumping is also the least cost method for plants in the 480 and 600 bushels per hour capacities.

Table 12. Labor Requirements, Hourly Variable Costs, Equipment Replacement Costs, and Annual Fixed Charge for Dumping Apples with Respect to Method Used and Size of Plant, Michigan, 1963-64

		Variable Costs Per Hour			Equipment Replacement Cost and Annual Fixed Charge[3]						
Input Capacity	Workers Required	Labor[1]	Power and Repair[2]	Total	Dumper	Receiving Belt	Leaf Eliminator	2-1/4" Eliminator	Roller Conveyer	Total Replacement Cost	Annual Fixed Charge
(bu. per hr.)	(number)	- - -	- - -	- - -	- - -	- - -	dollars	- - -	- - -	- - -	- - -
					MANUAL DUMP						
120	1	1.38	.06	1.44		332.80		366.29		699.09	136.32
240	2	2.76	.07	2.83		402.58		474.03		876.61	170.94
360	3	4.14	.08	4.22		441.48		474.03		915.51	178.52
					DRY BULK DUMP						
120	1	1.38	.21	1.59	964.08	441.48		474.03	312.00	2191.59	427.36
240	1	1.38	.21	1.59	964.08	441.48		474.03	312.00	2191.59	427.36
360	2	2.76	.37	3.13	1928.16	546.52		605.07	624.00	3703.75	722.23
480	2	2.76	.37	3.13	1928.16	546.52		605.07	624.00	3703.75	722.23
600	2	2.76	.37	3.13	1928.16	546.52		605.07	624.00	3703.75	722.23
					WATER BULK DUMP						
120	1	1.38	.39	1.77	4160.00		280.80	366.29		4807.09	937.38
240	1	1.38	.40	1.78	4160.00		280.80	474.03		4914.83	958.39
360	1	1.38	.53	1.91	5200.00		452.40	474.03		6126.43	1194.65
480	1	1.38	.55	1.93	5200.00		452.40	605.07		6257.47	1220.21
600	1	1.38	.55	1.93	5200.00		452.40	605.07		6257.47	1220.21

[1]Hourly wage, \$1.25 plus 10 percent to cover social security and workmen's compensation.

[2]Electric power estimated at 3.5 cents per hour per motor horsepower. Variable repairs and maintenance calculated at 0.5 percent of replacement cost per 100 operating hours.

[3]See Appendix Table C for list of equipment replacement costs and annual fixed charges.

Labor is an important cost element in dumping. In the three methods of dumping considered, the least-cost method is generally the one with the lowest labor costs. This is the reason the least-cost method changes from manual to dry bulk to water bulk dumping as plant size increases.

Figure 8 presents stage planning costs for seasons of 400, 800, 1200, and 1600 hours. The lines illustrate the relation of total season costs to input capacity when plants are equipped with the least-cost dumping method. It is obtained by fitting a least squares regression line through the least-cost points at selected output rates for the alternative methods considered. Costs in relation to dumping rate as represented by this line are referred to as "planning costs" since they represent attainable levels of cost with respect to plant size.[2]

The relationship between total season costs, plant size, and length of season can be generalized by the following "planning equation":

$$TSC = 131.78\ (H) + 272.93\ (C) + 15.32\ (H)\ (C)$$

where

TSC = Total season cost of dumping in dollars.
H = Hundred hours of plant operation per season.
C = Capacity output of plant in hundred cartons.
HC = Total season pack in ten thousand cartons.

The above equation can be used to estimate total season costs of dumping apples for a given plant size and length of season. For example,

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[2]This method of fitting curves to stage cost data was used by Carleton C. Dennis, An Analysis of Costs of Processing Strawberries for Freezing, Mimeo Report No. 210 (Berkeley: California Agricultural Experiment Station, July 1958), p. 13.

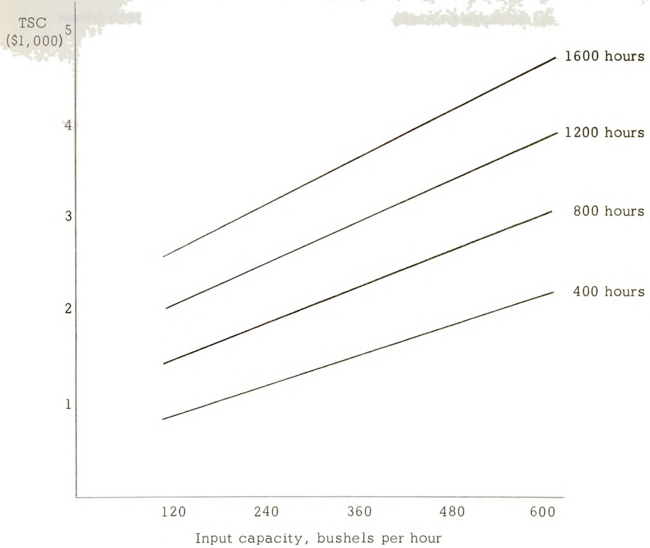

Figure 8. Total Season Costs for the Dumping Stage by Plant Capacity and Length of Season, Michigan, 1963-64

if a 300 carton per hour capacity plant were to operate 800 hours, the estimated cost of the dumping stage, using the planning equation is:

$$TSC = 131.78\ (8) + 272.93\ (3) + 15.32\ (8)\ (3) = \$2,240.71$$

The "planning equation" shows an average relationship between costs and rate of output for a given length season. Planning equations will be developed for all stages and cost components, and these will be combined to form planning cost equations for an entire plant. This procedure permits the derivation of average costs for different capacity plants.

Stage 2: Sorting and Sizing

Apples are deposited on the sorting table after leaving the dumping stage. Workers stationed along each side of the sorting table remove the cull and utility grade apples. The cull apples are placed in chutes at the side of the table and are conveyed to a bulk box beside the packing line. Most cull grade apples are processed for juice, cider, or vinegar. Utility grade apples are placed on a conveyer belt which runs over the center of the sorting table and then to a bulk box beside the packing line. The utility grade apples are sold to processors for processing into sauce, slices, and other products.

After being sorted, the apples enter the washer-brusher. Here the apples are cleaned by a combination of water jets and circular brushes and then dryed by absorber rolls. The cleaned and polished apples leave the washer-brusher, pass over a short spreader belt, and then go through the sizing process.

If a 300 carton per hour capacity plant were

mated cost of the

The above sequence of operations may be changed so that the apples are first washed and brushed and then sorted and sized. This change has no noticeable effect on output. Sorting prior to washing has the advantage of removing any decayed or partially decayed fruit. This fruit will break apart on the brushes of the washer-brusher and will reduce the cleaning ability of the machine for a short time.

To perform the operations in this stage, three major pieces of equipment are required. They include the sorting table, the washer-brusher, and the sizing equipment. Other necessary equipment items include the conveyer belts for cull and utility apples and automatic box filling equipment to handle the utility apples in larger volume operations.

Most apple packing plants in Michigan use some type of a roller sorting table. The type most commonly observed consists of a series of closely spaced wood or rubber rolls which rotate as they move forward. Apples rest in the valleys between the rolls and rotate as they move in front of the sorters. The positive turning of the fruit enables the sorters to inspect most apples without handling them.

The float roll sorting table, a table similar to the roller sorting table used in Michigan, was developed and tested in Washington State.[3] The float roll table was found to be more efficient than any of the other tables observed. Rates of sorting, however, were not as high as those observed

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[3] D. L. Hunter, F. Kafer, and C. H. Meyer, Apple Sorting Methods and Equipment, U. S. Department of Agriculture Marketing Research Report No. 230 (Washington: U. S. Government Printing Office, August 1958).

in Michigan when using the roller sorting table. Probable explanations for these differences include size of fruit, variety and type of pack, and differences between workers. Two sorting table modifications tested in the Washington study include the installation of sorting lanes and cull disposal chutes.[4] These modifications, as yet largely untried by Michigan apple packers, should increase the efficiency of the sorting operation.

The function of the washer-brusher is to clean all dirt and residues from the fruit. This piece of equipment is included because of buyers' demands for clean fruit and because of the increasing awareness and concern over insecticide residue problems. Cleaning is accomplished by a series of circular brushes and sponge rolls combined with jets of water under pressure.

Two types of dimension sizers are used by the majority of Michigan apple packers. They are the chain sizer and the variable-speed cup-type sizer. The chain-type sizer was generally found in the smaller packinghouses while larger volume operations tended to use the variable-speed cup-type sizer. Other types of dimension sizers are in use but only by a limited number of packers. No weight-type sizers were observed being used in Michigan plants.

Costs are computed using only the variable-speed cup-type sizer. Even though chain sizers are used by many of the smaller packers, their disadvantages preclude their use in this study. The major disadvantages

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[4] Ibid., p. 1.

include space requirements, bruising of apples, and accuracy of sizing.[5] The variable-speed cup sizer consists of sets of plastic cups made up of two parts. These cups separate as they move forward. When the diameter of the cup equals the diameter of the apple, the apple falls through the cup onto a takeaway belt. The takeaway belts deliver apples to the return flow belts.

No labor is required for the washing-brushing and sizing operations in this stage. The amount of labor required for sorting varies with the percent of culls and utility fruit. Since the percent of culls and utilities may vary from lot to lot of apples, it may be necessary to adjust the number of sorters one or more times during a working day. Because the sorting operation is an important determinant of the quality of the pack, supervision of the operation is an important and continuing job.

Sorting is a judgment job and it is thus difficult to measure labor utilization through ordinary time and production studies. Simply observing

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[5] Evans and Marsh found that mechanical demage averaged 6 percent with properly used chain sizers and 3.5 percent with the variable-speed cup sizer. Evans and Marsh, op. cit., pp. 22-23. Burt found that chain sizers were particularly damaging. Bruising with the chain sizer averaged 15.8 percent and with the variable-speed cup sizer only 1.4 percent. Burt also concluded that if no more than 1/8-inch variation from the standard diameter (giving a range of 1/4 inch) is acceptable, then chain sizing is not adequate since only 49 to 87 percent of the sized apples fell within this range. With the variable-speed cup sizer 60 to 89 percent were within 1/8 inch of the standard diameter. Stanley W. Burt, Packing Apples in the Northeast, U. S. Department of Agriculture Marketing Research Report No. 543 (Washington: U. S. Government Printing Office, October 1962), pp. 8-9, 25-26.

apples with the objective of finding and removing subgrade apples requires effort which cannot be easily measured. Because of this, labor requirements for the sorting operation are based on plant records and observations of total quantities of apples dumped and removed as cull and utility grades. An average of the amount of labor actually used forms the basis for the computed production standards. These figures include job performances which may be substandard but because of the nature of the job and the seemingly diverse factors associated with performance, no basis exists for discarding some observations of low output per man hour.

The predominant factor affecting the number of sorters required is the percent of cull and utility grade apples which must be removed. Table 13 illustrates the number of workers required for different capacity rates of operation and for removing various percentages of cull and utility grade apples. The cost advantage of packing high quality fruit is pointed out by data in this table. For instance, when dumping at a rate of 360 bushels per hour, labor costs increase 50 percent per hour when the percent of culls and utilities increases from 10 to 40 percent.

Labor requirements in Table 13 were computed using the labor standards in the footnote. Any time a fraction of a worker is required a worker is added. For example, in row one of Table 13, 2.04 workers are required to sort 114 bushels of apples per hour when there are 15 percent cull and utility grades present. This results in a labor requirement of 3 workers.

Table 13. Number of Sorters Required for Various Rates of Operation and Percentages of Cull and Utility Grade Apples, Michigan, 1963-64

Rate of Operation[1] (bushels per hour)	Percent of Cull and Utility Grade Apples						
	10	15	20	25	30	35	40
	number of workers[2]						
120	2	3	3	3	3	3	3
240	4	5	5	5	5	5	6
360	6	7	7	7	7	8	9
480	8	9	9	9	10	10	11
600	10	11	11	11	12	13	14

[1]It is assumed that 5 percent of the apples dumped are removed at the 2-1/4" eliminator.

[2]Labor standards: 10 percent culls and utilities, 57 bushels per hour; 15 percent, 56 bushels per hour; 20 percent, 55 bushels per hour; 25 percent, 53 bushels per hour; 30 percent, 50 bushels per hour; 35 percent, 46 bushels per hour; and 40 percent, 42 bushels per hour.

Table 14 shows the per hour costs of sorting apples for different percentage quantities of cull and utility grade apples and for various rates of operation. This information, combined with the annual fixed charge and per hour power and repair costs in Table 15 permits the derivation of estimated total season costs for the sorting and sizing stage.

Table 14. Per Hour Sorting Labor Costs for Various Rates of Operation and Different Percentage Quantities of Cull and Utility Grade Apples, Michigan, 1963-64[1]

Rate of Operation (bushels per hour)	Percent of Cull and Utility Grade Apples						
	10	15	20	25	30	35	40
	dollars per hour[2]						
120	2.76	4.14	4.14	4.14	4.14	4.14	4.14
240	5.52	6.90	6.90	6.90	6.90	6.90	8.28
360	8.28	9.66	9.66	9.66	9.66	11.04	12.42
480	11.04	12.42	12.42	12.42	13.80	13.80	15.18
600	13.80	15.18	15.18	15.18	16.56	17.94	19.32

[1]This table is based on labor requirements listed in Table 13.

[2]Labor costs figured at $1.25 per hour per worker plus 10 percent to cover social security and workmen's compensation.

Table 15. Hourly Variable Equipment Costs, Equipment Replacement Costs, and Annual Fixed Charge with Respect to Size of Plant for the Sorting and Sizing Stage, Michigan, 1963-64

	Variable Costs per Hour	Equipment Replacement Costs and Annual Fixed Charge[2]							
Output Capacity	Power and Repair[1]	Sorting Table	Cull and Utility Conveyers	Washer-Brusher	Spreader Belt	Sizing Unit	Automatic Box Filler	Total Replacement Cost	Annual Fixed Charge
(cartons per hr.)	- - - - - - - - -	- - - - - - - - -	- - - - - - - - -	- - - - - - - - -	dollars	- - - - - - - - -	- - - - - - - - -	- - - - - - - - -	- - - - - - - - -
100	.79	768	840	1855	291	8320		12074	2354.43
200	.85	1048	882	2057	333	8320		12640	2464.80
300	1.33	1265	1205	2256	364	13104	1448	19642	3830.19
400	1.42	1464	1219	2808	484	13104	1448	20527	4002.77
500	1.52	1800	1327	3874	582	13104	1448	22135	4316.33

[1] Electric power estimated at 3.5 cents per hour per motor horsepower. Variable repairs and maintenance calculated at 0.5 percent of replacement cost per 100 operating hours.

[2] See Appendix Table C for list of equipment replacement costs and annual fixed charges.

The lines in Figure 9 illustrate estimated total season planning costs for the sorting and sizing stage. The planning costs are for specified lengths of season when sorting out 25 percent of the apples as utilities and culls. Variation in the percent of cull and utility grade apples would result in total season cost lines which would be lower for less than 25 percent sortout and higher for more than 25 percent sortout. Each of the planning cost lines shows, for specified hours operated per season, estimated total season costs for sorting and sizing in relation to rate of output. Again the planning costs can be expressed in a "stage planning equation" as follows:

$$TSC = 1740.76 + 143.33 (H) + 549.73 (C) + 244.45 (H)(C) + 3.24 (H)(C)(P)$$

where

TSC = Total season cost of sorting and sizing in dollars.
H = Hundred hours of plant operation per season.
C = Capacity output of plant in hundred cartons.
P = Percent of apples sorted out as culls and utilities.
HC = Total season pack in ten thousand cartons.
HCP = A relative measure of total season sortout.

If a 300 carton per hour plant were to operate 800 hours and sortout 25 percent of the apples as culls and utilities, the estimated cost of the sorting and sizing stage would be

$$TSC = 1740.76 + 143.33(8) + 549.73(3) + 244.45(8)(3) + 3.24(8)(3)(25)$$
$$= \$12,347.39.$$

Stage 3: Packing

The packing stage is the focus of activities in apple packing operations. It is here that apples are placed in containers as specified by

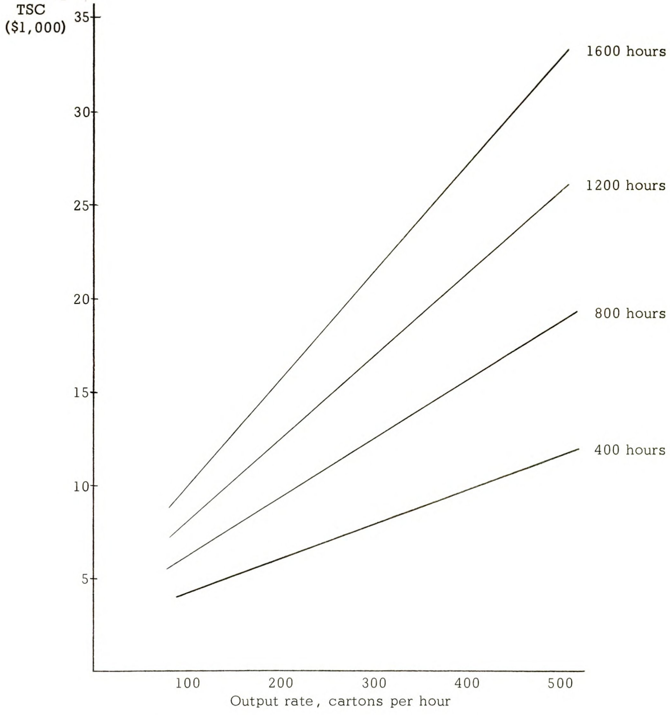

Figure 9. Total Season Planning Costs for the Sorting and Sizing Stage by Plant Capacity and Length of Season, 25 Percent Sortout, Michigan, 1963-64

buyers for shipment to markets. The majority of apples (over 65 percent of the 1962-63 Michigan pack and probably over 70 percent of the 1963-64 pack) are placed in consumer sized packages. These consumer packages, mainly three and four pound poly bags, are shipped in master containers which hold 36 to 40 pounds of bagged apples. Some apples are also placed in tray packs and in jumble-type packs. Other packs may be put up at the request of a buyer. These include gift packs, shrinkfilm overwrapped trays, bushel baskets, and small unit jumble packs.

Regardless of the package used, apples proceed through a fairly standard sequence of operations in the packing stage. The apples are delivered to the return flow belt from the sizer, they are removed from the belt and placed in packages, and the packages are closed. The apples may travel through several steps from the time they leave the return flow belt until they are placed in the final container, depending of course, on the type of pack.

The equipment necessary for this stage varies with the type of package being used. Almost all Michigan plants have equipment for bagging, for tray packing, and for jumble packing. This equipment includes return flow belts, baggers, filled bag conveyer, bag closing device, and accumulating table for bagging. When packing trays or jumble packs, needed equipment includes distributor belts, return flow belts, packing stands, and roller conveyer to transfer filled cartons to the closing station. There may be a trend to shrinkfilm overwrapped trays. This requires additional investment in wrapping stands, heat tunnel, roller conveyer, and accumulating table.

From the preceeding discussion it is evident that a degree of flexibility is necessary in this stage. A packer must be prepared to pack a variety of containers during the packing season and also have sufficient capacity to supply buyers' needs in any one type of container. Michigan packers may pack all of their output in poly bags for several consecutive days.

Labor efficiency for packing apples in different types of containers varies when compared with published data from other regions. Michigan apple packers, because of their specialization in bagging, have labor costs for bagging as low or lower than packers in other regions.[6] Labor costs for tray packing and jumble packing are, however, higher than for other regions. Other areas have tended to specialize in these types of packs.

The analytical procedure for the packing stage is to construct plants with sufficient capacity to bag all of their output in three and four pound poly bags. Additional equipment is added to this basic line so that 15 to 20 percent of the pack can be placed in tray packs and in jumble packs. Thus, total season costs can be computed for a plant bagging 65 percent of its output, tray packing 20 percent of its output, and jumble packing 15 percent of annual output.

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[6] For some comparative labor requirements see: Stanley W. Burt, Apple Handling and Packing in the Appalachian Area, U. S. Department of Agriculture Marketing Research Report No. 476 (Washington: U. S. Government Printing Office, June 1961); Burt, Packing Apples in the Northeast, op. cit.; Kinne, op. cit.; and L. A. Sax, "The Economies of Scale of Fruit Packing Warehouses in the Oroville Area" (unpublished M.A. thesis, Washington State University, 1960).

Bagging

In Michigan four pound bags are placed upright ten to a master container. This pack is called 10-4's by persons in the industry. Three pound bags are placed on their sides, six bags to a layer, and two layers to a master container. This pack is called 12-3's. Since most packers place from two to three ounces extra in each bag to allow for shrinkage, the net weight of the two containers is about 42 and 38 pounds respectively. There seems to be no preference for one container over the other by buyers. While taking in-plant observations half of the cartons bagged were 10-4's and half were 12-3's.

The type of equipment used, the equipment layout, and the sequence of operations are all important determinants of output when bagging apples. In the matter of equipment, plant observations and equipment prices revealed that for plants in the output ranges considered in this study, automatic baggers and automatic bag stitchers should be used. The use of these two pieces of equipment influences the layout and sequence of operations. The automatic baggers require more space than semi-automatic baggers and move the worker away from the return flow belt. With the automatic bag stitcher, the bagger fills the bag, places it on a filled bag conveyer, and it is closed by another worker. Without the automatic bag stitcher each bagger fills the bag, tapes it closed, and places it on a conveyer. Labor standards in the Appendix show that when using five workers, four workers bagging and one worker tieing have a higher output

per hour than five workers bagging and taping their own bags. The placement of the filled bag conveyer belt is important. To increase output the belt should be placed directly under the bagging heads rather than to the rear of the workers. This eliminates the time and effort necessary to turn around in order to dispose of a filled bag.

The equipment requirements for packing three and four pound bags are identical. The cost per carton for packing three pound bags is higher, however, because of higher labor requirements (Table 16). The extra worker is required to place the filled bags in master containers. For the larger output capacity plants (300, 400, and 500 cartons per hour) two bagging areas are necessary. This means that two each of the return flow belt, filled bag conveyer, automatic bag closer and the elevating belt and accumulator table are required. There will be some waiting to place filled bags on the conveyer when ten baggers are using one conveyer but the standard rate of bagging can be maintained.

The sequence of operations when packing in poly bags is as follows: apples moving down the return flow belt are diverted into the bagger by a diverter rod. A short belt automatically dumps apples into the bagging head until the required weight is reached. The bagger checks the weight and adds or subtracts apples as necessary. The bagger then places a poly bag over the bagger head, dumps the apples into the bag, and places it upright on the filled bag conveyer. The conveyer carries the bag toward an automatic wire stitcher where a worker guides the top of the bag into

Table 16. Labor Requirements, Hourly Variable Costs, Equipment Replacement Costs, and Annual Fixed Charge for Packing Apples with Respect to Size of Bag and Size of Plant, Michigan, 1963-64

		Variable Costs per Hour			Equipment Replacement Cost and Annual Fixed Charge[3]						
Output Capacity	Workers Required	Labor[1]	Power and Repair[2]	Total	Return-Flow Belt	Baggers	Angle Bag Conveyer	Automatic Bag Closer	Elevating Belt and Accumulator Table	Total Replacement Cost	Annual Fixed Charge
(cartons per hour)	(number)	- - -	- - -	- - -	- - -	- - -	- - - dollars	- - -	- - -	- - -	- - -
FOUR POUND BAGS											
100	6	8.28	.41	8.69	1333.28	2277.60	609.44	1432.00	618.80	6271.12	1393.69
200	11	15.18	.58	15.76	1433.12	4555.20	803.92	1432.00	618.80	8843.04	2066.03
300	17	23.46	.97	24.43	2516.80	6832.80	1418.56	2864.00	1237.60	14869.76	3412.07
400	22	30.36	1.16	31.52	2866.24	9110.40	1607.84	2864.00	1237.60	17686.08	4132.07
500	27	37.26	1.41	38.67	3592.16	11388.00	2184.00	2864.00	1237.60	21265.76	5000.92
THREE POUND BAGS											
100	7	9.66	.41	10.07	1333.28	2277.60	609.44	1432.00	618.80	6271.12	1393.69
200	12	16.56	.58	17.14	1433.12	4555.20	803.92	1432.00	618.80	8843.04	2066.03
300	18	24.84	.97	25.81	2516.80	6832.80	1418.56	2864.00	1237.60	14869.76	3412.07
400	23	31.74	1.16	32.90	2866.24	9110.40	1607.84	2864.00	1237.60	17686.08	4132.07
500	28	38.64	1.41	40.05	3592.16	11388.00	2184.00	2864.00	1237.60	21265.76	5000.92

[1] Hourly wage, $1.25 plus 10 percent to cover social security and workmen's compensation.

[2] Electric power estimated at 3.5 cents per hour per motor horsepower. Variable repairs and maintenance calculated at 0.5 percent of replacement cost per 100 operating hours.

[3] See Appendix Table C for list of equipment replacement costs and annual fixed charges.

the stitcher intake. The stitcher gathers and closes the neck of the bag and deposits it back on the conveyer. The closed bag then travels to an accumulating table from which it is placed in a master container.

Labor requirements, equipment replacement costs, annual fixed charges, and variable costs for packing in three and four pound poly bags are given in Table 16. Total season planning costs for four lengths of season are illustrated by the lines in Figure 10. These planning costs which show the relationship between total season costs and plant size are given by the following equations:

$$TSC_4 = 417.0 + 109.80\ (H) + 928.0\ (C) + 757.20\ (H)\ (C)$$

$$TSC_3 = 417.0 + 247.80\ (H) + 928.0\ (C) + 757.20\ (H)\ (C)$$

where

TSC_4 = Total season cost for packing four pound poly bags.
TSC_3 = Total season cost for packing three pound poly bags.
H = Hundred hours of plant operation per season.
C = Capacity output of plant in hundred cartons.
HC = Total season pack in ten thousand cartons.

If a 300 carton per hour plant were to operate 800 hours, the estimated cost for packing four pound poly bags would be

$$TSC_4 = 417.0 + 109.8\ (8) + 928.0\ (3) + 757.2\ (24) = \$22,252.20$$

and for packing three pound poly bags it would be

$$TSC_3 = 417.0 + 247.8\ (8) + 928.0\ (3) + 757.2\ (24) = \$23,356.20.$$

Tray and Jumble Packing

Tray and jumble packs have become a popular pack and now take the place formerly occupied by bushel baskets. The tray pack consists of a

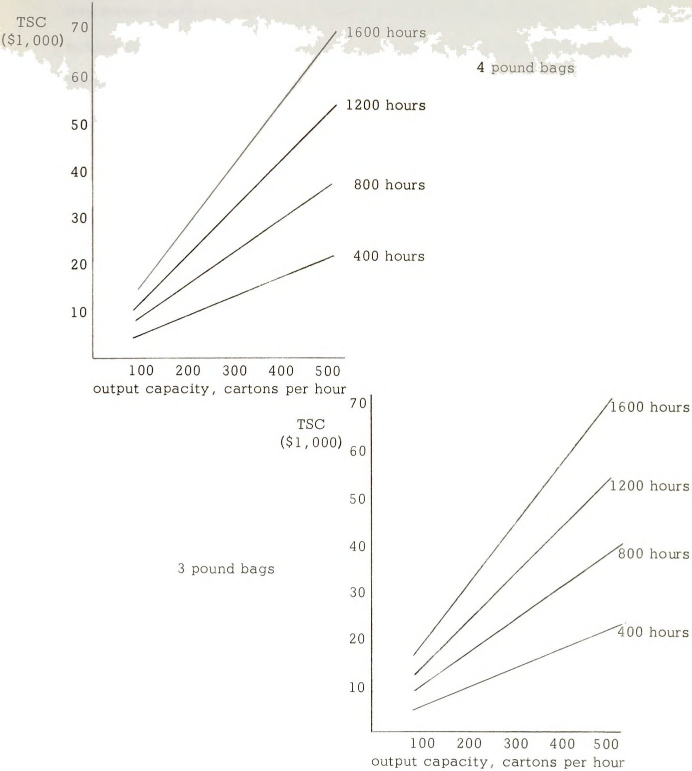

Figure 10. Total Season Planning Costs for Packing in Four and Three Pound Poly Bags by Plant Capacity and Length of Season, Michigan, 1963-64

tray master measuring 20 x 12 x 12 and four or five molded pulp trays. The number of trays necessary depends on the size of the apples being packed. Three and one-quarter inch apples and larger require four trays while apples smaller than 3-1/8 inches require five trays. The jumble pack is placed in a 17 x 13 x 11 carton.

When tray packing, the worker first positions an empty carton on the packing stand, places a tray in the carton, and then lifts apples from the return flow belt and places them on the tray. When a tray is filled another tray is positioned in the carton. When the carton is filled, it is placed aside on a conveyer which carries it to the carton closer. When jumble packing, the worker follows a packing procedure similar to tray packing except that no trays are placed in the carton.

Several pieces of equipment must be added to the basic bagging plant equipment. Necessary equipment includes distributor belts, a return flow belt or additional length on the return flow belt used for bagging, packing stands for each packer, and roller conveyer.

Labor requirements, equipment replacement costs, annual fixed charge and variable costs for tray and jumble packing are presented in Table 17. Total season costs for each of the packages can be estimated through application of the following planning equations:

$$TSC_t = 315.00 + 65.70\ (H) + 431.82\ (C) + 1141.36\ (H)\ (C)$$

$$TSC_j = 296.26 + 9.73\ (H) + 352.77\ (C) + 822.02\ (H)\ (C)$$

Table 17. Labor Requirements, Hourly Variable Costs, Equipment Replacement Costs, and Annual Fixed Charge for Tray and Jumble Packing Apples with Respect to Size of Plant, Michigan, 1963-64

		Variable Costs per Hour			Equipment Replacement Cost and Annual Fixed Charge[3]						
Output Capacity	Workers Required	Labor[1]	Power and Repair[2]	Total	Distributor Belt	Return-Flow Belt	Packing Stands	Conveyer	Conveyer Stands	Total Replacement Cost	Annual Fixed Charge
(cartons per hour)	(number)	- - -	- - -	- - -	- - -	- - -	dollars	- - -	- - -	- - -	- - -
TRAY PACK											
22	2	2.76	.13	2.89	726.96	1137.76	93.60	70.72	18.72	2047.76	394.73
44	4	5.52	.15	5.67	933.92	1333.28	187.20	70.72	18.72	2543.84	489.13
66	6	8.28	.20	8.48	1368.64	1606.80	280.80	106.08	24.96	3387.28	650.22
88	8	11.04	.22	11.26	1368.64	1796.08	374.40	106.08	24.96	3670.16	703.04
110	10	12.42	.23	12.65	1368.64	1985.36	468.00	141.44	31.20	3994.64	762.93
JUMBLE PACK											
17	1	1.38	.12	1.50	726.96	1137.76	46.80	35.36	12.48	1959.36	379.71
34	2	2.76	.13	2.89	726.96	1137.76	93.60	70.72	18.72	2047.76	394.73
51	3	4.14	.15	4.29	933.92	1333.28	140.40	70.72	18.72	2497.04	481.17
68	4	5.52	.15	5.67	933.92	1333.28	187.20	70.72	18.72	2543.84	489.13
85	5	6.90	.20	7.10	1368.64	1606.80	234.00	106.08	24.96	3340.48	642.27
102	6	8.28	.20	8.48	1368.64	1606.80	280.80	106.08	24.96	3387.28	650.22

[1] Hourly wage, $1.25 plus 10 percent to cover social security and workmen's compensation.

[2] Electric power estimated at 3.5 cents per hour per motor horsepower. Variable repairs and maintenance calculated at 0.5 percent of replacement cost per 100 operating hours.

[3] See Appendix Table C for list of equipment replacement costs and annual fixed charges.

where

TSC_t = Total season costs of packing tray packs.
TSC_j = Total season costs of packing jumble packs.
H = Hundred hours of plant operation per season.
C = Capacity output of package in hundred cartons.
HC = Total season pack in ten thousand cartons.

Other Containers

Michigan apple packers may pack in other containers in order to satisfy buyers needs. These containers include 1/3 and 1/2 bushel gift packs, jumble packs in returnable field crates, and bushel baskets. Many of the small packers with roadside retail outlets place apples in paper bags. A new package currently arousing interest in the packing industry is the shrinkfilm overwrapped tray. This package holds from 6 to 12 apples (or more depending on apple size and type of tray) and generally has a net weight of 2-1/2 pounds or more. Advantages of overwrapping include reduced bruising through immobilization of apples, color placement of apples, and a glossy appearance. This package has high labor requirements and is presently a low volume operation. Because of higher packaging costs buyers must be willing to pay a premium for the overwrapped tray.

The other containers used by Michigan apple packers individually account for a small percent of annual packed volume. Packers using these containers were observed infrequently while gathering in-plant observations. Since no labor standards were developed, no costs are calculated for packing in these containers. For those interested, some cost data

are available in other studies.[7]

Stage 4: Container Closing

Container closing is the final operation in putting out a finished package. Filled containers move to the closing station on roller conveyers. The worker or workers in this stage obtain a filled container, staple it shut, stamp it with data on variety, size, and grade, and then place the finished package aside on a pallet. The preceding operations may be performed by one or several workers depending on the output of the plant.

Very few equipment items are required for this stage. Needed items include two staplers per closing station and roller conveyer to aid in moving the filled cartons. The roller conveyer also serves as a surge area for filled cartons while the worker performs operations other than carton closing. The stapler used may be a hand operated or a compressed air model. The computed work standards for stapling are for the hand operated model.

The organization of workers and work assignments is an important aspect of this stage. The nature of the jobs to be performed are such that one man can perform one or all of the operations. Following are the crew organizations used in the five model plants: 100 cartons per hour

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[7] Labor costs for gift packs can be approximated by those for similar tray and jumble packs. For costs of packing bushel baskets see: French and Gillette, op. cit., p. 66. Costs of overwrapping can be found in James B. Fountain, Prepackaging Medium-Size Apples in Shrinkable Films at Shipping Point, U. S. Department of Agriculture Marketing Research Report No. 534 (Washington: U. S. Government Printing Office, April 1962), p. 22.

plant, one man closes, stamps, and palletizes the cartons; 200 cartons per hour, one man closes the cartons while another man stamps and palletizes them; 300 cartons per hour, two men close cartons and palletize them while another man stamps the cartons; 400 cartons per hour, two men close cartons and two men stamp and palletize cartons; 500 cartons per hour, two men close cartons, two men palletize cartons while another man stamps the cartons.

Crew requirements, variable costs, equipment replacement costs, and annual fixed charges for output rates of 100 to 500 cartons per hour are given in Table 18. Using calculated total season costs, a stage planning equation was derived. It follows:

$$TSC = 52.59 + 139.19\ (H)\ (C)$$

where

TSC = Total season costs of container closing.
H = Hundred hours of plant operation per season.
C = Capacity output of plant in hundred cartons.
HC = Total season pack in ten thousand cartons.

Total season costs of a 300 carton per hour plant operating 800 hours per season would be

$$TSC = 52.59 + 139.19\ (8)\ (3) = \$3393.15.$$

Stage 5: In-Plant Handling of Products and Materials

This stage is concerned with the handling and movement of apples and packing materials within the packing plant. Activities and operations in this stage include: receiving and storing packing materials, bringing unpacked apples out of storage and positioning at the dumper, removing

Table 18. Labor Requirements, Hourly Variable Costs, Equipment Replacement Costs, and Annual Fixed Charges for Closing Containers with Respect to Size of Plant, Michigan, 1963-64

		Variable Costs per Hour			Equipment Replacement Cost and Annual Fixed Charge[3]					
Output Capacity	Workers Required	Labor[1]	Power and Repair[2]	Total	Staplers	Roller Conveyer	Conveyer Stands	Stamps and Pads	Total Replacement Cost	Annual Fixed Charge
(cartons per hour)	(number)	- - - -	- - - -	- - - -	- - - -	- - - - dollars	- - - -	- - - -	- - - -	- - - -
100	1	1.38	.01	1.39	130.00	70.72	18.72	10.40	229.84	42.58
200	2	2.76	.01	2.77	130.00	70.72	18.72	10.40	229.84	42.58
300	3	4.14	.02	4.16	195.00	140.72	37.44	20.80	393.96	72.37
400	4	5.52	.02	5.54	260.00	140.72	37.44	20.80	458.96	85.05
500	5	6.90	.03	6.93	260.00	212.16	49.92	20.80	542.88	99.31

[1]Hourly wage, $1.25 plus 10 percent to cover social security and workmen's compensation.

[2]Variable repairs and maintenance calculated at 0.5 percent of replacement cost per 100 operating hours.

[3]See Appendix Table C for list of equipment replacement costs and annual fixed charges.

empty boxes to the storage areas, removing filled boxes of cull and utility apples, returning empty boxes into position at cull and utility conveyers, moving pallets of packed fruit to temporary storage, and loading out packed fruit.

Transportation is very important in this stage since all of the previously mentioned activities involve the movement of apples or materials. Fork lift trucks are used extensively in this stage. Charges for lift trucks are made on the basis of the time actually used. A total charge of $.48 per hour of lift truck operation includes $.23 for variable repairs and maintenance and $.25 for fuel and oil. Lift truck drivers must be present whenever the plant is operating even though they may not be driving a lift truck at all times. Therefore labor costs for this stage, as shown in Table 19, are computed for the total number of hours the plant is operated. Because the charge for lift trucks is made on the basis of time used, the majority of the analysis for this stage is concerned with lift truck time requirements for the different operations and activities.

For receiving and storing packing materials with a lift truck, a time requirement of .03 man-minutes per carton was used.[8] This allowance includes time for unloading the truck and stacking cartons, bags, and other materials in storage. A plant packing 100 cartons per hour and operating for 500 hours during the packing season would thus require 25 hours of lift truck time for receiving and storing packing materials.

[8] This time requirement as developed in an earlier study by French and Gillette, op. cit., p. 49, includes an allowance for delay.

Table 19. Labor Requirements, Hourly Variable Costs, Equipment Replacement Costs, and Annual Fixed Charges for Handling Products and Materials with Respect to Size of Plant, Michigan, 1963-64

		Variable Costs per Hour			Equipment Replacement Cost and Annual Fixed Charge[3]				
Output Capacity	Workers Required	Labor[1]	Power and Repair[2]	Total	Lift Truck	Pallets	Bulk Boxes	Total Replacement Cost	Annual Fixed Charge
(cartons per hour)	(number)	- - - -	- - - -	- - - -	- - - - dollars	- - - -	- - - -	- - - -	- - - -
100	1	1.76	.05	1.81	5993	400	675	7068	1201.56
200	2	3.52	.11	3.63	11986	800	1350	14136	2403.12
300	3	5.28	.16	5.44	17979	1200	2025	21204	3604.68
400	4	7.04	.22	7.26	23972	1600	2700	28272	4806.24
500	5	8.80	.27	9.07	29965	2000	3375	35340	6007.80

[1] Hourly wage, $1.60 plus 10 percent to cover social security and workmen's compensation.

[2] Variable repairs and maintenance calculated at 1.0 percent of replacement cost per 100 operating hours for pallets and bulk boxes. The table includes no charge for the fork lift trucks. Charges for the fork lift trucks are $.23 for variable repairs and maintenance and $.25 for fuel and oil per hour of lift truck operations.

[3] See Appendix Table C for list of equipment replacement costs and annual fixed charges.

Several simplifying assumptions are necessary in order to compute time requirements for bringing unpacked apples out of storage and positioning at the dumper. As the season pack increases storage capacity must increase and, consequently, travel distances will also increase. It is assumed that the packer has storage capacity for 90 percent of his annual pack and that storage capacity is added in units of 25,000 bushels. It is also assumed that for a 25,000 bushel storage unit the one-way travel distance from storage to dumper is 100 feet.[9] For each additional unit of storage one-way travel distance is increased 20 feet. A gross travel time of .0055D (where D = one-way distance in feet) plus .764 minutes per trip for turn-around time is required when bringing apples from storage to the dumper.[10] Assuming that 70 percent of the apples are packed and using 20 bushel bulk boxes, six trips per 100 cartons packed are required. Using travel distances, number of trips, and time requirements, total lift truck time requirements for bringing apples out of storage were computed by length of season and size of plant.

A time requirement of .0055D plus turn-around time of .764 minutes per trip was used for moving packed fruit to temporary storage and to trucks. The one-way travel distance is assumed to be 100 feet. With

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[9] Packinghouse and storage layout would be similar to that found in Robert E. Heffernan, Apple Storage and Packing Facilities for Southern Illinois, U. S. Department of Agriculture Marketing Research Report No. 610 (Washington: U. S. Government Printing Office, July 1963), p. 14.

[10] This time requirement as developed by French and Gillette, op. cit., p. 50, includes a delay allowance of 10 percent.

20 cartons of packed fruit per pallet, the lift truck time requirement is 6.57 minutes per 100 cartons.

The miscellaneous operations of moving empty boxes to storage, moving empty boxes to the cull and utility belts, and removing filled boxes of cull and utility apples requires 10.65 minutes for each 100 cartons packed.

The time requirements just outlined were used to compute lift truck costs which were then combined with data in Table 19. From the combined data, a stage planning equation was developed. It is:

$$TSC = 229.96 - 62.71\,(H) + 1038.28\,(C) + 251.01\,(H)\,(C)$$ [11]

where

TSC = Total season cost of in-plant handling of products and materials.
H = Hundred hours of plant operations per season.
C = Capacity output of plant in hundred cartons.
HC = Total season pack in ten thousand cartons.

Because of the large number of figures, the lift truck time requirements used in computing total season costs are omitted. The planning equation, with a correlation coefficient of .9983, provides reasonable estimates of total season costs by length of season and size of plant.

Since the lift trucks may be used for handling other fruits and for receiving apples into storage, the fixed cost allocation to this stage in Table 19 may be overstated. If the lift truck is used for these other activities, the effect is to lengthen the season and thus decrease per unit costs.

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[11] While the coefficient for hours is negative, an expansion in hours will not reduce total season costs. The variable for total season pack, (H)(C), more than offsets the effect of hours alone. Taking the derivative of total season costs with respect to hours: $\frac{\partial TSC}{\partial H} = -62.71 + 251.01(C)$ it is evident that for the range of plant sizes considered (100 to 500 cartons per hour), an increase in hours operated will increase total season costs.

Indirect Cost Component 1: Office and Administrative Expense

Office and administrative costs consist of the salaries of office employees - bookkeeper, secretaries, and manager - as well as office supplies. The costs of office help and management are considered jointly because of some overlap in duties. The manager may perform some of the bookkeeping or secretarial duties while the bookkeeper or secretaries may perform some of the management duties.

Accurate information on costs of management are difficult, if not impossible, to obtain. Most managers perform selling as well as management functions, but there is no way to determine precisely the amount of time spent performing each of the activities. In many cases where the owner performs the management function, no allowance is made for management. The manager-owner's returns include profits as well as returns to management. The clerical component is also difficult to estimate. The office workers are involved in selling and in many cases perform administrative work as well.

French, Sammet, and Bressler as well as Dennis have alluded to the above difficulties as well as several others.[12] They encountered difficulties in obtaining management costs because of the joint management of a farm supply store, present salaries being based on performance over several years time, and the highly imperfect market for managerial labor. French, Sammet, and Bressler found management costs to be a function of plant size while Dennis found costs to be a function of the total season pack.

[12] French, Sammet, and Bressler, op. cit., p. 650 and Dennis, op. cit., p. 50.

Information from cooperating apple packing plants suggests that costs for this stage are a function of total season pack. While the stage planning equation lacks a great deal of precision, it does offer what is felt to be a reasonable approximation of costs for the range of plant sizes and season lengths considered. The stage planning equation is:

$$TSC = 1041.51 + 301.88\ (H)\ (C)$$

where

TSC = Total season cost for office and administration.
H = Hundred hours of plant operation per season.
C = Capacity output of plant in hundred cartons.
HC = Total season pack in ten thousand cartons.

For example, the total season costs of this stage in a 300 carton per hour plant operating 800 hours per season would be:

$$TSC = 1041.51 + 301.88\ (8)\ (3) = \$8286.63.$$

Planning curves based on the above equation show total season costs for different plant capacities and lengths of season in Figure 11.

Indirect Cost Component 2: Packaging Materials

Packaging materials account for a significant portion of total apple packing costs. Included in this stage are charges for packaging materials, wire stitching, and staples as well as labor and equipment charges for box making and supplying materials to packers.

Table 20 presents packing material prices as quoted in Michigan during the 1963-64 packing season. Included are all material items necessary for packing three and four pound poly bags, tray packs, and jumble packs. The charge for poly bags includes an allowance for printed bags.

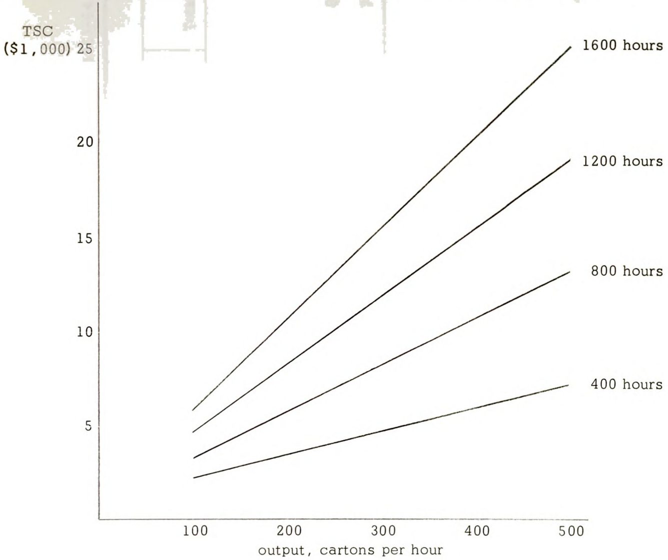

Figure 11. Total Season Planning Costs for the Office and Administration Stage by Plant Capacity and Length of Season, Michigan, 1963-64

Table 20. Packing Material Costs for Poly Bags, Tray Packs, and Jumble Packs, Michigan, 1963-64

Tray Pack	Material Item: Master Container	Wire for Stitching Master[1]	Bags[2]	Wire Closure for Bags	Trays	Staples for Closing Filled Cartons[3]	Total
	- - - - - - - - - dollars per 100 cartons - - - - - - - - -						
10-4's	31.40	.14	10.25	.11	-	.03	41.93
12-3's	32.30	.14	11.10	.14	-	.03	43.71
Tray Pack	29.15	.14	-	-	20.50	.03	49.82
Bushel Carton	18.58	.14	-	-	-	.03	18.75

[1]Worker places 8 stitches in the bottom of each carton.

[2]Includes charge for printed bags.

[3]Worker uses two staples to close top of carton.

This is not regarded as a selling expense since Michigan packers are required to identify their product with their name and address. Art work and printing plate charges for printed bags vary considerably but are charged at cost. A fair approximation is $125 as a one-time expense. This charge is allocated over a period of five years and is included as a fixed charge in Table 21.

It should be noted that the master containers priced in Table 20 are 200 pound test board with printing of two colors on four panels. The dimensions of the cartons are as follows: bag masters, 28 x 12-1/4 x 10-1/2; tray masters, 20 x 12 x 12; and jumble carton, 17 x 13 x 11. The prices in Table 20 would be increased for such extras as waterproofed adhesives, heavier corrugating mediums, overlap top or bottom, colored outside liner board, or additional art work.

The only equipment required for this stage is a wire stitcher and table for the box-making operation. Table 21 presents labor requirements, equipment replacement costs, annual fixed charges, and variable costs for the packaging material stage. The addition of material costs as developed in Table 20 permits the derivation of planning equations for each of the containers. They are:

$$TSC_4 = 182.20 + 64.25 (H) + 4295.38 (H) (C)$$

$$TSC_3 = 180.20 + 63.71 (H) + 4473.56 (H) (C)$$

$$TSC_t = 5062.00 (H) (C)$$

$$TSC_j = 1955.00 (H) (C)$$

Table 21. Labor Requirements, Hourly Variable Costs, Equipment Replacement Costs, and Annual Fixed Charges for the Packing Materials Stage with Respect to Size of Plant and Type of Package, Michigan, 1963-64

		Variable Costs per Hour				Equipment Replacement Cost			Annual Fixed Charge	
Output Capacity	Workers Required	Labor[1]	Power and Repair[2]	Material[3] Cost	Total	Wire Stitcher	Table	Total Replacement Cost[4]	Equipment	Material
(cartons per hour)	(number)	- - - -	- - - -	- - - -	- - - -	dollars	- - - -	- - - -	- - - -	- - - -
FOUR POUND BAG MASTER										
100	1	1.43	.04	41.93	43.40	640.64	20.00	660.64	112.31	25.00
200	2	2.81	.04	83.86	86.71	640.64	20.00	660.64	112.31	25.00
300	3	4.19	.04	125.79	130.02	640.64	20.00	660.64	112.31	25.00
400	3	4.24	.08	167.72	172.04	1281.28	40.00	1321.28	224.62	25.00
500	4	5.62	.08	209.65	215.35	1281.28	40.00	1321.28	224.62	25.00
THREE POUND BAG MASTER										
100	1	1.43	.04	43.71	45.18	640.64	20.00	660.64	112.31	25.00
200	2	2.81	.04	87.42	90.27	640.64	20.00	660.64	112.31	25.00
300	3	4.19	.04	131.13	135.36	640.64	20.00	660.64	112.31	25.00
400	3	4.24	.08	174.84	179.16	1281.28	40.00	1321.28	224.62	25.00
500	4	5.62	.08	218.55	224.25	1281.28	40.00	1321.28	224.62	25.00
TRAY PACK										
200	1	1.43	.04	99.64	101.11	640.64	20.00	660.64	112.31	
JUMBLE PACK										
200	1	1.43	.04	37.50	38.97	640.64	20.00	660.64	112.31	

[1]Hourly wage, carton maker $1.30, utility worker $1.25 plus 10 percent to cover social security and workmen's compensation.

[2]Electric power estimated at 3.5 cents per hour per motor horsepower. Variable repairs and maintenance calculated at 0.5 percent of replacement cost per 100 operating hours.

[3]See Table 20 for list of material costs.

[4]See Appendix Table C for list of equipment replacement costs and annual fixed charges.

where

TSC_4 = Total season cost of materials for packing four pound poly bags.
TSC_3 = Total season cost of materials for packing three pound poly bags.
TSC_t = Total season cost of materials for packing tray packs.
TSC_j = Total season cost of materials for packing jumble packs.
H = Hundred hours of plant operation per season.
C = Capacity output of plant in hundred cartons.
HC = Total season pack in ten thousand cartons.

Indirect Cost Component 3: Building Costs

Floor space requirements for well-organized plants of various capacities, based on observations in the sample plants and on published recommendations,[13] are given in Table 22. These total space requirements include allowances for packing, temporary storage of packed fruit, packing materials storage, rest rooms, and office.

Table 22. Building Space Requirements, Dimensions, Replacement Costs, and Annual Fixed Charges with Respect to Plant Output Capacity in Apple Packing Plants, Michigan, 1964

Output Capacity	Space Requirement	Dimensions	Building Replacement Cost	Annual Fixed Charge[1]
(cartons per hour)	square feet	feet	dollars	
100	4800	60 x 80	28891	2571.30
200	9600	80 x 120	48358	4303.86
300	14400	80 x 180	68220	6071.58
400	19200	80 x 240	88180	7848.02
500	24000	100 x 240	104443	9295.43

[1]The annual fixed charge includes depreciation 2.5 percent; repairs 1.8 percent; insurance 0.6 percent; taxes 1.0 percent; and interest 3.0 percent (approximately 5.5 percent on the undepreciated balance) for a total of 8.9 percent of the replacement cost.

[13]H. P. Gaston and J. H. Levin, Equipment and Layout for Fruit Packing Houses, Special Bulletin 417 (East Lansing: Michigan Agricultural Experiment Station, July 1957), p. 4.

Many factors can influence building costs. The building materials selected, the building site, and local conditions can cause large variations in costs. The amount of fill or the size of footings required can have a significant effect on costs as can the availability of building materials, contractors, and labor. Despite these difficulties, building costs for west central Michigan are estimated in Table 22. These costs are based on specifications and prices as reported by French and Gillette and Pflug and Brandt.[14] Prices and wages which were for the third and fourth quarter of 1957 were adjusted to August 1964 levels through use of the Engineering News - Record Building Cost Index.[15]

The walls of the packinghouse are constructed of Waylite block. The walls are 20 feet high and are not insulated. The costs in Table 22 include charges for excavating and backfilling, 12" x 24" footing with 2-5/8 inch reinforcing rods, poured concrete foundation walls, and a 4 inch reinforced concrete floor. The buildings have a wood bowstring truss roof with a fairly long span. Included in the computed costs are allowances for plumbing, electric system, doors, windows, and two coats of paint. Land costs and costs of outside surfacing are not included.

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[14]See French and Gillette, op. cit., pp. 53-54 and I. J. Pflug and M. W. Brandt, "Cost of Michigan Fruit Storage Buildings as Affected by Size and Type of Construction," The Quarterly Bulletin of the Michigan Agricultural Experiment Station, Vol. 41, No. 4 (February 1956), p. 778.

[15]"Building and Construction Cost Indexes," Engineering News - Record, March 19, 1964, pp. 79-88, and August 13, 1964, p. 65. Using base 1957 = 100, the index for August 1964 is 123.13.

The stage planning equation for the annual fixed building charge is:

$$TSC = 920.40 + 1699.20\,(C)$$

where

TSC = Total season cost of building.
C = Capacity output of plant in hundred cartons.

<u>Indirect Cost Component 4: Supervision and Miscellaneous Labor, Equipment, and Materials</u>

The workers included in this stage often perform several jobs and thus it is difficult to assign the costs to a particular stage. One worker is needed in each of the plants to handle cull and utility apples. Workers must also be available to load out trucks with packed apples and to perform miscellaneous jobs. While most of the larger plants have a full-time supervisor, in the smaller plants the manager generally performs the supervision function.

Following are the number of workers required for each of the plant sizes considered. For the 100 carton per hour plant, one man is needed to take care of cull and utility apples and to perform the miscellaneous jobs. This man, with the lift truck driver, can load out packed apples. In the 200 carton per hour plant, one man is needed to take care of cull and utility apples and another man is needed to load trucks and take care of miscellaneous jobs. In this plant, as in the 100 and 300 carton per hour plants, supervision is performed by management or by a lift truck driver at no additional salary. In the 300 carton per hour plant, one man is required to care for cull and utility apples and two men are needed to

load out packed apples and perform miscellaneous jobs. For the 400 and 500 carton per hour plants, a supervisor is required, one man is required to care for cull and utility apples, and two men are needed to load out packed fruit and take care of miscellaneous jobs.

Table 23 presents labor requirements, equipment replacement costs, annual fixed charges, and variable costs for this stage. The miscellaneous equipment required consists of radiant heaters, a scale, extra conveyer, and other equipment. The replacement cost of the other equipment is based on records of the sample firms. Because of the large variety involved, no attempt was made to list individual items.

Using the data presented in Table 23, a stage planning equation was derived. It is:

$$TSC = 608.90 + 64.40\,(H) + 159.50\,(C) + 138.20\,(H)\,(C)$$

where

TSC = Total season costs of supervision and miscellaneous labor, equipment, and materials.
H = Hundred hours of plant operation per season.
C = Capacity output of plant in hundred cartons.
HC = Total season pack in ten thousand cartons.

For example, with a 300 carton per hour plant operating 800 hours per season the estimated total season costs for this stage would be:

$$TSC = 608.90 + 64.40\,(8) + 159.50\,(3) + 138.20\,(8)\,(3) = \$4919.40.$$

Table 23. Labor Requirements, Hourly Variable Costs, Equipment Replacement Costs, and Annual Fixed Charges for Supervision and Miscellaneous Labor, Equipment, and Materials with Respect to Size of Plant, Michigan, 1963-64

		Variable Costs per Hour			Equipment Replacement Cost and Annual Fixed Charge[3]					
Output Capacity	Workers Required	Labor[1]	Fuel and Repair[2]	Total	Heaters	Scale	Conveyer and Stands	Other Equipment	Total Replacement Cost	Annual Fixed Charge
(cartons per hour)	(number)	- - - -	- - - -	- - - -	- - - -	- - - -	dollars	- - - -	- - - -	- - - -
100	1	1.38	.32	1.70	1835	210	303.68	1600	3948.68	671.28
200	2	2.76	.50	3.26	2936	210	303.68	2500	5949.68	1011.45
300	3	4.80	.57	5.37	3303	210	303.68	3100	6916.68	1175.84
400	4	6.18	.58	6.76	3303	210	303.68	3300	7116.68	1209.84
500	4	6.18	.68	6.86	4037	210	303.68	3500	8050.68	1368.62

[1] Hourly wage, $1.25 for utility workers, $1.85 for supervision, plus 10 percent to cover social security and workmen's compensation.

[2] Variable repairs and maintenance calculated at 0.5 percent of replacement cost per 100 operating hours. Also included is fuel allowance for radiant heaters at $.25 per gallon.

[3] See Appendix Table C for list of equipment replacement costs and annual fixed charges.

CHAPTER V

PLANT COSTS

Planning equations for the operating stages and indirect cost components reveal the relationships between total season costs and the variables of plant capacity, length of operating season, total season pack, and percent of cull and utility fruit. These equations provide the "building blocks" for constructing the estimated long-run cost or "planning" function for Michigan apple packing plants. This chapter is concerned with combining the stage cost functions to obtain the planning function and to interpret this function in terms of length of season and size of plant as they affect costs.

Simplifications and Specifications

Several simplifications and specifications are necessary in order to concentrate the analysis on the relevant variables. Many of these simplifications and specifications have been mentioned in preceding sections and are only summarized here.

1. The cost analysis is for five selected plant sizes ranging from 100 to 500 cartons per hour output.
2. The average net weight of a packed carton of apples is assumed to be 40 pounds.
3. All packed apples are loaded on trucks for shipment to market.

4. Wage rates utilized in the analysis are given in Appendix Table B.
5. Costs of assembly, receiving into storage, storage, and selling are omitted. Also omitted are costs of land for building sites as well as the cost of any outside paved area.
6. Five percent of the apples dumped are eliminated as less than 2-1/4 inches in diameter. Thus, a plant with a sortout of 25 percent culls and utilities would pack out 70 percent of the apples dumped.

Total Cost Calculations

The combination of stage planning costs to obtain total plant costs is primarily a case of addition. This combination is accomplished by adding the coefficients of the stage cost equations. In the case of the synthesized apple packing plants the addition is simple since the stages are independent, i.e., the technology in one stage does not affect the cost of a technology in another stage.[1]

The stage cost equations are summarized in Table 24. Cost categories are separated into common costs and costs based on the package used. This helps to simplify further computations since common costs are the same regardless of the package used. The total plant cost equation is obtained by adding the costs of the relevant package to total common costs.

[1]For a discussion of the difficulties encountered when stages are dependent see French, Sammet, and Bressler, op. cit., p. 661.

Table 24. Summary of Planning Cost Equations for Operating Stages and Indirect Cost Components for Apple Packing Plants, Michigan, 1963-64

Cost Category	Variables[1] a	H	C	HC	HCP
	Coefficients				
Common Costs					
Dumping		131.78	272.93	15.32	
Sorting and sizing	1740.76	143.33	549.73	244.45	3.24
Container closing	52.59			139.19	
Handling	229.96	-62.71	1038.28	251.01	
Office & administration	1041.51			301.88	
Building costs	920.40		1699.20		
Supervision & miscellaneous	608.90	64.40	159.50	138.20	
TOTAL	4594.12	276.80	3719.64	1090.05	3.24
Costs Based on Package					
Packing Costs					
4# bags	417.00	109.80	928.00	757.20	
3# bags	417.00	247.80	928.00	757.20	
Tray pack	315.00	65.70	431.82	1141.36	
Jumble pack	296.26	9.73	352.77	822.02	
Package Material Costs					
4# bags	182.20	64.25		4295.38	
3# bags	180.20	63.71		4473.56	
Tray pack				5062.00	
Jumble pack				1955.00	

[1]The cost equation variables are as described previously.

a = A constant cost that is incurred regardless of length of season or size of plant.

H = Hundred hours of plant operation per season.

C = Capacity output of plant in hundred cartons.

P = Percent of apples sorted out as culls and utilities.

HC = Total season pack in ten thousand cartons.

HCP = A relative measure of total season sortout.

An individual equation is read from Table 24 by combining the coefficients in the table with the proper variables in the sub-heading. For example, the cost equation for the sorting and sizing stage is read:

$$TSC = 1740.76 + 143.33 (H) + 549.73 (C) + 244.45 (H) (C) + 3.24 (H) (C) (P)$$

where TSC is the total season cost in dollars, (H) is hundreds of hours of plant operation per season, (C) is the capacity output in hundred of cartons, and (P) is the percent of apples sorted out as culls and utilities.

Reading Table 24 in the same manner, the equation giving total common costs is:

$$TSC == 4594.12 + 276.80 (H) + 3719.64 (C) + 1090.05 (H) (C) + 3.24 (H) (C) (P)$$

where the variables are the same as previously defined.

The equation for total plant costs when packing four pound poly bags is obtained by adding the coefficients for packing four pound bags and package material costs for four pound bags to total common costs. This procedure yields the cost equation for packing apples in four pound poly bags which is:

$$TSC_4 = 5193.32 + 450.85 (H) + 4647.64 (C) + 6142.63 (H) (C) + 3.24 (H) (C) (P) \qquad (1)$$

Likewise, the cost for packing three pound poly bags is:

$$TSC_3 = 5191.32 + 588.31 (H) + 4647.64 (C) + 6320.81 (H) (C) + 3.24 (H) (C) (P) \qquad (2)$$

Since the usual proportion of poly bags is one-half three pound and one-half four pound, a simple average of equations (1) and (2) yields the cost equation for a Michigan packing plant which bags all of its output. It is:

$$TSC = 5192.32 + 519.58 (H) + 4647.64 (C) + 6231.72 (H) (C) + 3.24 (H) (C) (P) \qquad (3)$$

By specifying the variables in equation (3), the total season costs of a plant operating at capacity and bagging all of its output can easily be computed. Take, for example, a 200 carton per hour plant which operates

for an 800 hour season and has an average sortout of 25 percent. Estimated total season costs for this plant are:

$$TSC = 5192.32 + 519.58(8) + 4647.64(2) + 6231.72(8)(2) + 3.24(8)(2)(25)$$
$$= \$119,647.76$$

A slightly different procedure is used for estimating costs in a packing plant operating under the same conditions, but packing 70 percent bags, 20 percent trays, and 10 percent jumble packs. First, the estimated total common costs are calculated. They are:

$$TSC = 4599.12 + 276.80(8) + 3719.64(2) + 1090.05(8)(2) + 3.24(8)(2)(25)$$
$$= \$32,984.60$$

Then the packing costs and the package material costs for the individual containers are calculated. For packing 70 percent of the output in poly bags, estimated total season costs are:

$$TSC = 598.20 + 242.78(8) + 928.00(1.4) + 5141.67(8)(1.4)$$
$$= \$61,426.34$$

For packing 20 percent in trays, estimated total season costs are:

$$TSC = 315.00 + 65.70(8) + 431.82(.4) + 6203.36(8)(.4)$$
$$= \$20,864.08$$

For packing 10 percent in jumble packs, estimated total season costs are:

$$TSC = 296.26 + 9.73(8) + 352.77(.2) + 2777.02(8)(.2)$$
$$= \$4,887.89$$

Total plant costs are then the sum of total common costs and the costs of packing the individual containers.

Common Costs	$ 32,984.60
Bagging Costs	61,426.34
Tray Pack Costs	20,864.08
Jumble Pack Costs	4,887.89
Total	$120,162.91

Total season costs for other size plants, lengths of season, and proportions of apples in bags, trays, and jumble packs can be derived in a similar manner.

Average costs are calculated by dividing total season costs by the number of cartons packed. For the cost example just calculated with the 200 carton per hour plant operating 800 hours, total season costs were $120,162.91 and total output was 160,000 cartons. Dividing total season cost by total output results in an average cost of $.751 per carton packed. Estimated average costs for other packs, lengths of season, and plant size are derived in the same manner. The following sections examine the effects of size of plant and length of season on average costs.

The Effect of Plant Size on Costs

The relationship between size of plant and average costs of production have long been summarized in a planning or long-run average cost curve. Given the total cost equations just developed, planning curves can be derived for apple packing plants. To derive a planning curve requires that several variables be specified. These include length of season, type of pack, and percent sortout. As an illustration, suppose that the

season length is 400 hours, that the pack is bagged (1/2 four pound and 1/2 three pound), and that 25 percent of the apples are removed as culls and utilities. These specifications and the technology specified in deriving the stage planning equations results in the planning curve shown in Figure 12. This figure shows that average costs decrease rapidly in the range of 100 to 300 cartons per hour and then gradually taper off up to 500 cartons per hour. Major economies of size, however, are realized by the time plant output capacity reaches 300 cartons per hour. The characteristic shape of the planning curve results from spreading the fixed costs of buildings, equipment, and management over more units of output and the substitution of various cost-reducing techniques in the larger plants. Planning curves for other lengths of season, type of pack, and percent sortouts will exhibit a shape similar to Figure 12, but will be above or below the curve illustrated.

The Effect of Type of Pack on Costs

Cost equations are derived for four types of packages -- 10-4's, 12-3's, tray packs, and jumble packs. Per unit costs of these packs vary with capacity of plant and hours of operation per season. Costs between different packages differ due to labor and machine requirements as well as container costs. In general, it costs less to pack in a jumble pack than in the other containers. Following in order of increasing per unit costs are 10-4's, 12-3's, and tray packs. Data are presented in a manner such that once length of season, size of plant, and percent of sortout are specified, the average costs of the various packs can be computed.

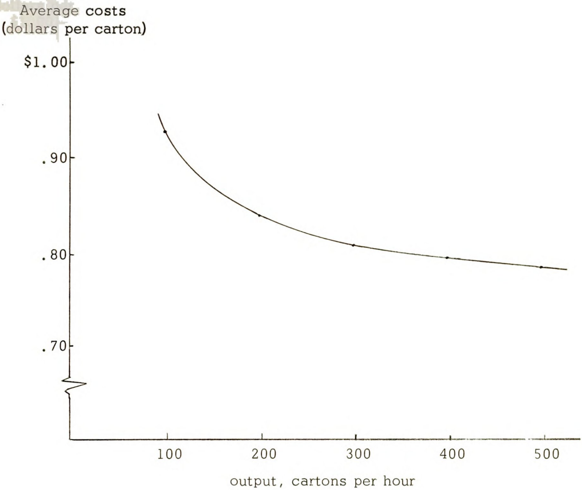

Figure 12. Average Planning Costs for Packing Apples -- Costs Based on Bagging in Poly Bags (1/2 Four Pound and 1/2 Three Pound), 400 Hour Operating Season, and 25 Percent Sortout, Michigan, 1963-64

<u>The Effect of Length of Season on Costs</u>

There are fixed and partially fixed costs which do not vary or do not vary proportionately with the number of hours operated. A longer packing season spreads these costs over a greater number of units which results in a lower per unit cost. Controlled atmosphere storage permits the storage of apples over long periods of time and some packers now pack over

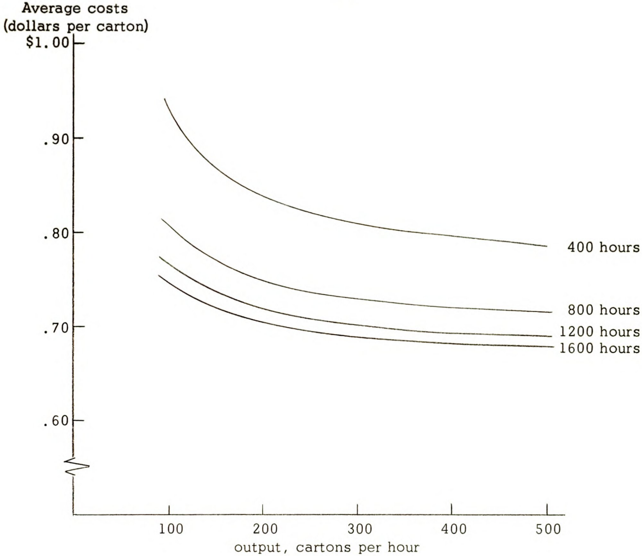

Figure 13. The Effect of Length of Season on Average Costs of Packing Apples — Costs Based on Bagging in Poly Bags (1/2 Four Pound and 1/2 Three Pound) and 25 Percent Sortout, Michigan, 1963-64

a 9 - 10 month period. Costs of controlled atmosphere storage are higher than costs of conventional refrigerated storage and there is also a seasonal increase in prices during the packing season. These factors are not considered in this analysis.

Figure 13 shows the effect of length of season on average costs for

plants bagging apples and having a sortout of 25 percent. While there is a significant decrease in per unit costs as length of season increases, the majority of the decrease is in the range between 400 and 800 hours. The decrease in average costs is less for each additional increment of 400 hours than for the preceding one.

The Effect of Underutilization of Plant Capacity on Costs

All of the cost relationships developed in previous sections are based upon plant operation at planned capacity. In established plants there are cost items such as labor and materials which vary with output and other cost items such as building, equipment, and management which are fixed. The fixed costs continue to be incurred regardless of the rate of plant operation. Thus, for rates of operation at less than capacity per unit costs of packing will increase. Table 25 lists the fixed and variable costs for a 300 carton per hour plant bagging four pound bags of apples at selected rates of operation. Similar tables can be computed for other plant sizes and types of pack. Using these tables, short-run average cost curves can be calculated for the five plant sizes considered.

Figure 14 illustrates the short-run average cost curves in relation to the previously derived planning curve. The cost curves are for plants bagging four pound bags of apples, operating 800 hours per season, and with a sortout rate of 25 percent. For all plant sizes, operation at less than capacity results in higher per unit costs than those shown by the planning curve. As rate of output moves toward capacity, short-run costs

move toward planning costs until the two become equal at plant capacity. No attempt was made to calculate costs in excess of the capacity rate of operation. No plants were observed operating in this range and thus no observations on labor requirements are available. Operating at more than capacity would, however, undoubtedly result in a sharp increase in average costs due to increased hand labor, crowding of workers, and overloading of equipment.

Table 25. Total Fixed and Variable Costs for Bagging Apples in a 300 Carton per Hour Capacity Plant, Sortout Rate of 25 Percent, Michigan, 1963-64

Stage or Cost Component	Fixed Cost	Rate of Output (cartons per hour)			
		100	150	200	250
		- - - - dollars per hour - - - -			
Dumping	1194.65	1.91	1.91	1.91	1.91
Sorting and sizing	3830.19	5.47	6.85	8.23	9.61
Packing four pound bags	3412.07	9.25	13.39	20.29	21.67
Container closing	72.37	1.40	2.78	2.78	4.16
Handling products & materials	3604.68	1.92	1.92	3.68	3.68
Office and administration	8286.63				
Packaging materials	137.31	43.40	65.10	86.71	107.68
Building costs	6071.58				
Supervision & miscellaneous	1175.84	1.95	3.33	3.33	5.37
TOTAL	27785.32	65.30	95.28	126.93	154.08
		- - - - - - dollars - - - - - -			
Fork lift charge		249.60	374.40	499.20	624.00

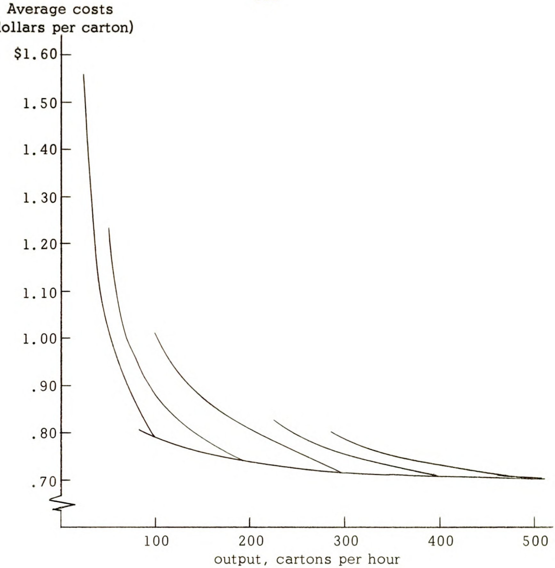

Figure 14. The Relation of Short-Run Average Costs to Long-Run Planning Costs in Apple Packing Plants — 800 Hour Season, Bagging in Four Pound Poly Bags, and 25 Percent Sortout, Michigan, 1963-64

Figure 14 demonstrates the costs of operating at less than planned capacity. For instance, a 300 carton per hour plant which is operating at an average rate of 100 cartons per hour incurs a 43 percent increase in per unit costs over costs when operating at capacity. Average costs are 24 percent higher than for a 100 carton per hour plant operating at capacity.

While it is sometimes desirable to have the capacity to pack extra large orders it must be remembered that this type of flexibility is costly.

Optimum Combination of Hours and Capacity

Preceding sections have discussed the effects of length of season and size of plant on per unit costs of packing apples. Figure 13 shows that per unit costs decrease with increases in plant size and with longer packing seasons. It is obvious that a given season output can be handled by many different combinations of hours and capacity and that the particular combination used will influence costs. While the length of the working day and the storage period place limitations on hours of operation there is still considerable latitude for combining hours and capacity. How then should they be combined? The particular combinations will vary with the type of pack, but the general relationships will be the same. Following are the computations for plants packing poly bags (1/2 four pound and 1/2 three pound) and removing 25 percent of the apples as utilities and culls. The long-run cost function given these conditions is:

$$TSC = 5192.32 + 519.58\ (H) + 4647.64\ (C) + 6312.72\ (H)\ (C) \qquad (4)$$

where the variables are as previously specified.

Season volume may be expressed as:

$$S = (H)\ (C)$$

Substituting S=(H) (C) the long-run cost function becomes

$$TSC = 5192.32 + 519.58\ (H) + 4647.64\ \frac{S}{H} + 6312.72\ (S) \qquad (5)$$

To minimize this function in terms of hours:

$$\frac{dTSC}{dH} = 519.58 - 4647.64 \frac{S}{H^2} = 0 \qquad (6)$$

Thus:

$$H^2 = 8.9449\ S$$

$$H = 2.99 \sqrt{S} \qquad (7)$$

Since $S = (H)\ (C)$

$$C = \sqrt{\frac{S}{2.99}} \qquad (8)$$

Thus if the total season volume is specified, the minimum cost combination of hours and capacity is given by equations (7) and (8). Substituting S = (H) (C) back in equation (7) it can be seen that hours and capacity should be expanded in the ratio of H = 8.94 (C). The optimum combination of hours and capacity for a packer planning to bag 250,000 cartons per season would be:

$$H = 2.99 \sqrt{250,000}$$

$$H = 2.99\ (500) = 1495$$

and

$$C = \frac{500}{2.99} = 167$$

Thus to bag 250,000 cartons per year the packer would operate a 167 carton per hour plant for 1495 hours.

It is obvious that the application of equations (7) and (8) is limited. Because of custom, sales, and wage rates, Michigan packers typically pack 8 - 10 hours per day. The storage life of apples is limited even though controlled atmosphere storage lengthens it. Suppose that because

of these factors the total packing season is limited to 3000 hours. Thus, for season packs up to 1,005,000 cartons, capacity and hours can be expanded in the ratio of H = 8.94 (C). Once the limit of 3000 hours is reached the size of total season pack can be expanded only through larger capacity plants. Even with a season pack of 1,005,000 cartons the optimum sized plant packs only 335 cartons per hour. This is well below the 500 carton per hour capacity plant included in the calculations.

Limitations to the Study

Since apple packing is just one link in the apple marketing chain, this study is only a step toward a complete study of apple marketing. Not included are cost relationships for assembly, storage, and selling of fresh apples. A combination of these costs with packing costs would probably lead to an average cost curve of slightly altered curvature. Since these cost relationships were not studied, their effect on average costs can only be hypothesized.

Within the range of plant sizes considered in this study, average costs for packing continue to decrease. However, the assembly cost relationship is one of increasing costs since a larger and larger supply area is necessary to increase season volume. Thus, the combination of assembly costs and packing costs would probably result in an average cost curve which reaches a minimum and turns up at very large season volumes. In an earlier study, French and Gillette estimated that with high density production, costs of assembly and packing would not begin to increase until

a volume of nearly one million bushels was reached — and even at this volume the increase was very slight.[2]

The storage of apples influences the cost of packing since it permits the lengthening of the packing season. No analysis of costs of storage and seasonal price movements is included. This study implicitly assumes that storage costs are covered through the seasonal increase in prices. If this is the case, the combination of storage costs and seasonal prices with packing costs would not affect the shape of the planning curve. If storage costs were not covered by seasonal price increases, there would be less advantage to longer packing seasons.

There is some evidence to suggest that there are economies to large scale selling. Given that Michigan packers pack on order, then a large selling agency can help to regularize firm operations. With the movement to large-scale retailing, a packer must have a large season pack in order to acquire and service the accounts of large buyers. The large selling agency permits individuals with a knowledge of the many factors affecting price to specialize in selling. If there are economies of large scale in selling, then the addition of selling costs and packing costs will yield a curve showing more pronounced economies of scale than are exhibited by packing alone.

There is no way to predict the development and adoption of new technology in apple packing. While companies and other agencies are working

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[2] French and Gillette, op. cit., p. 40.

on the development of completely automatic baggers, electronic sorters, hydro-handling equipment, and other innovations, the gestation period is highly uncertain. In general, an innovation will be adopted only if it is cost saving. Thus, the effect of an innovation on the planning curve will be to lower it. An innovation could also alter the slope of the curve if it is suitable for only large or only small packing plants.

The packing operations described in this study are flexible enough to adopt innovation. The building sizes will permit expansion of equipment and a short write-off period is used in depreciating the equipment. Management can be in a position to adopt cost-saving innovations with the same type of flexibility in buildings and equipment.

Potential Areas for Research

The limitations to the study as just outlined suggest areas for further research. The general areas of assembly, storage and seasonal price movements, and selling need to be further researched in order to make more complete recommendations for apple packing industry adjustments.

A study of costs of storage as related to the seasonal movement in apple prices is needed. Particularly useful would be a comparison of costs of conventional controlled atmosphere storage and costs of a new storage technology, Tectrol, which is an externally generated controlled atmosphere. A study of this type would aid storage operators in their decisions to store apples and would also aid operators in their decisions concerning the acquisition of additional storage.

The assembly cost relationship will be particularly useful for packers who are considering the acquisition of a large packing facility packing a large season volume. A study of assembly costs will need time and labor requirements for the assembly of apples in bulk boxes. Also needed is information on tree numbers and yields by area. The assembly cost relation derived from these data can be combined with the planning curve for packing to yield a better estimate of cost relationships by size of total season pack. These data can also be used as inputs for a linear programming study of the optimum adjustment of apple packing plant numbers and size in Michigan.

An estimate of costs of selling by size of selling agency and by type of channel , while difficult to obtain, would be of general interest to the industry. If this cost relationship demonstrated economies of large size, as hypothesized, there would be increased interest in concentrating the selling function in a few agencies. A question which needs research is whether a selling organization should pack through a number of medium sized plants located throughout the producing areas or through one large centralized plant. The selling cost relationships can also be combined with packing and assembly costs to yield a more meaningful cost relationship.

CHAPTER VI

SUMMARY AND CONCLUSIONS

Summary

Michigan, the third largest apple producer in the United States, currently packs about 10 percent of the total fresh pack. Apples are becoming more important to the Michigan farm economy and Michigan is gaining stature in the total apple industry. Comparison of changes in production for the five leading apple producing states for the periods 1946-54 and 1955-63 shows that Michigan's increase was the largest in both real and percentage terms. The annual value of the Michigan apple crop is now over $24 million.

This study originated with requests by members of the Michigan apple packing industry for information on cost-volume relationships in apple packing. Many small volume apple packers must decide if they are going to continue operating at their present scale, expand their operations, sell their apples field-run, or combine operations with other packers. This study provides information for Michigan apple packers to use in planning future plant operations.

The principal objective of this study was to determine the cost-volume relationships in synthetically constructed apple packing plants operating under conditions representative of those found in Michigan. Intermediate

objectives included the determination of industry structure, least cost packing methods, and labor requirements for the jobs in apple packing plants.

The economic-engineering method of cost analysis was used in this study. Labor utilization and equipment data for the analysis were obtained from observations taken in 14 Michigan apple packing plants. Additional data concerning the industry structure were obtained through a mail questionnaire followed up with personal interviews.

The number of apple packing plants in Michigan has declined 55 percent during the last seven years. Accompanying this change in plant numbers has been an increase in their average size. Despite this movement, there are still a large number of small plants.

During the last several years there has been a significant change in apple handling methods and equipment. Since 1958, bulk handling of apples from field to packing plant has increased from less than 40 percent to almost 70 percent of total volume. Packages used for the wholesale-retail trade have also changed during the last 7-10 years. The once popular bushel basket has been largely replaced by polyethylene bags. Now over 65 percent of the Michigan fresh apple pack is placed in three and four pound poly bags.

For convenience of analysis, labor and equipment requirements are given by plant stages for various rates of operation. Least cost methods of operation for the various stages were determined. Then planning equations

which indicate estimated total season costs in relation to size of plant and length of operating season were developed for each operating stage and non-stage cost component.

The cost components considered in this study include: (1) dumping, (2) sorting and sizing, (3) packing, (4) container closing, (5) in-plant handling of products and materials, (6) office and administrative expense, (7) packaging materials, (8) building costs, and (9) supervision and miscellaneous labor, equipment, and materials.

The costs for three methods of dumping apples were considered in the dumping stage. Manual dumping proved to be the most efficient method for plants dumping 120 bushels per hour and for all season lengths. Dry bulk dumping was most efficient for plants dumping 240 bushels per hour and for all season lengths. It was also the most efficient method for plants dumping 360 bushels per hour and operating up to 400 hours per season. For 360 bushel per hour plants operating over 400 hours, water bulk dumping was the most efficient. Water bulk dumping was also the most efficient method for plants dumping from 480 to 600 bushels per hour for all lengths of season.

The sorting and sizing operation was fairly well standardized among the plants studied in terms of equipment and work methods used. Costs of sorting and sizing are presented in relation to the percent of cull and utility grade apples which must be removed. Because of increased labor requirements, costs for this stage increase with increases in the percent of cull and utility grade apples.

Two methods are used when packing apples in poly bags. With the first method the worker bags the apples, ties the bag, and places it on a conveyer. With the second method the bagger fills the bag and deposits it upright on a conveyer. The conveyer carries filled bags to a worker who guides them into an automatic bag closer. For all plant sizes considered in this study the latter method is most efficient. The preferred equipment layout for this stage is to place the filled bag conveyer directly under the bagging heads.

The remaining cost components did not involve a choice of work methods or equipment used. The method and equipment employed in Michigan packing houses are fairly well standardized and are considered to be most efficient in terms of available alternatives.

Within each stage and cost component, costs were computed for plants with output capacities of 100, 200, 300, 400, and 500 cartons per hour. These stage and component cost estimates were then added together to derive estimated total season costs for each of the five plant sizes. Length of packing season and size of plant were analyzed in relation to average costs of packing apples.

Based on the total plant cost equations developed in this study, average packing costs decrease with increases in plant capacity. The majority of this decrease is realized by the time capacity reaches 300 cartons per hour output. Average costs, however, continue to decline within the range of plant sizes studied.

Increasing the length of the packing season also results in a significant decrease in average costs of packing. A sharp decrease in average costs occurs when increasing length of season from 400 to 800 hours. Average costs of packing continue to decrease as length of packing season increases.

Using the total season cost equation for packing apples in bags (equation (4)), the optimum combination of hours of operation and plant capacity was derived. This analysis shows that total season volume should be expanded in the ratio of H = 8.94 (C). For example, a packer planning to pack 250,000 cartons per year would have a plant capacity of 167 cartons per hour and operate 1495 hours per season. Similar ratios can be derived for other types of packs. The application of this hours-capacity ratio is limited only by the total possible season length.

Short-run cost curves were derived for the five plant sizes considered. These curves demonstrate that average costs increase significantly when operating apple packing plants at less than planned capacity. Maintaining excess capacity in order to be flexible enough to pack unusually large orders or seasonal production is costly.

Conclusions

The Michigan apple packing industry is a dynamic industry. Many changes have occurred during the last decade and more will occur during the next decade. Michigan apple packers are quick to adopt cost-saving technology and packages which better satisfy buyers' needs.

Several opportunities exist for the reduction of average costs in Michigan apple packing plants. In some plants, costs can be reduced through better training and supervision of workers. There are further opportunities to reduce average costs through improved work methods and equipment layout. Significant reductions in average costs of packing can be achieved through fuller utilization of existing packing facilities.

There are good economic reasons for a further reduction of apple packing plant numbers in Michigan. Only with increases in the total season pack will packers be able to realize the potential cost savings available through increased plant capacity and length of packing season. Almost 80 percent of the Michigan apple packers packed less than 60,000 bushels of apples in 1962-63. Assuming a 70 percent packout rate, this upper limit would be reduced to approximately 50,000 cartons per year. Suppose that five packers who presently pack 100 cartons per hour for a 500 hour season were to combine. The optimum operation would be to pack 167 cartons per hour for a 1495 hour season. This combination would result in an annual total cost saving of $41,467 ($220,007 - $178,540) or $8,293.40 per packer. Even if they were to pack 200 cartons per hour for a 1250 hour season the total cost saving would be $41,207 ($220,007 - $178,800) or $8,241.40 per packer. Possible cost savings are even greater for smaller volume packers. The net saving to the individual packer will be the total saving in packing costs minus any increase in assembly costs.

The possible cost savings just illustrated do not mean that members

of the Michigan apple packing industry should rush into an unrestricted program of concentration and consolidation of packing facilities. The abandonment of existing facilities with no alternative use and little salvage value might entail losses greater than the possible savings. In addition, many packers place a high value on individual control. Some small packers, because of an established and profitable local market, will not be able to improve their income position through consolidation. Higher packing costs are more than offset by a premium price.

Packers who construct or acquire packing facilities should maintain a degree of flexibility. They must be in a position to adopt cost-saving innovations and to satisfy buyer demands for improved packages and improved product quality. Care must be exercised in constructing plants to avoid the high costs associated with underutilization of capacity.

Possible advantages of plant consolidation, in addition to cost savings, include the opportunity for packers to carry out coordinated programs designed to upgrade quality, improve advertising and promotion, and educate themselves on the latest techniques of handling, storage, and packing apples.

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APPENDIX

Table A. Labor Production Standards for Jobs Performed in Michigan Apple Packing Plants, 1963-64

Job Classification and Description	Production Standard
	units per hour
1. Manual Dumping Get full crate from pallet, move to the receiving belt, and dump. Group and place empty crates aside on a pallet.	142 bushels
2. Manual Dumping (mechanical aid) Same as number 1 except a mechanical aid is used to assist the dumper in turning and dumping the crate.	152 bushels
3. Mechanical Dumping Bulk Boxes The worker rolls a full box into the hydraulically controlled frame. The box is tipped and the flow of apples is controlled by means of a hinged gate on the dumper lid. The empty box is lowered and moved aside on roller conveyer.	300 bushels
4. Mechanical Dumping Bulk Boxes (water immersion) A full box is positioned over the dumping tank. The box is hydraulically lowered into the water. After the apples have floated ahead of the empty box, it is raised, drained, and moved aside.	600 bushels
5. Packing Trays Place an empty carton on the packing stand. Using both hands, remove apples from a 2-way belt and place on tray. Trays are positioned in the carton as needed. The filled carton is placed aside on a roller conveyer.	11 cartons
6. Jumble Pack An empty carton is positioned on the packing stand. Using both hands, the worker moves apples from the 2-way belt to the carton. Filled cartons are placed aside on a roller conveyer	17 cartons
Same as above, but a scoop is used in one hand.	25 cartons

Table A--Continued

Job Classification and Description	Production Standard
	units per hour
7. Filling 3 Pound Poly Bags The worker obtains a bag from the bag holder, checks and adjusts the weight of the apples, places the bag over the dumping head, and dumps the apples into the bag. The filled bag is then placed upright below the bagging head on an L-shaped conveyer.	308 bags (25 cartons)
8. Filling 3 Pound Poly Bags (operator ties) Same as number 7 except the worker tapes the bag before placing it on the conveyer.	207 bags (17 cartons)
9. Filling 4 Pound Poly Bags Same as number 7.	250 bags (25 cartons)
10. Filling 4 Pound Poly Bags (operator ties) Same as number 8.	180 bags (18 cartons)
11. Bag Closing (automatic) Gather the top of each bag and feed it into the automatic closer as the bag moves by on the conveyer.	3100 bags
12. Boxing 4 Pound Poly Bags The worker gets a master container and fills it with 10 bags of apples from a circular table. The filled master container is pushed aside on roller conveyer to the box closer.	107 cartons
13. Boxing 3 Pound Poly Bags Same as number 12 except that a partition must be added to the master container so that it will hold 12 bags.	84 cartons
14. Carton Closing Filled cartons move to the worker on roller conveyer. The end and side flaps are closed and stapled. The closed box is pushed aside on the conveyer.	254 cartons

Table A--Continued

Job Classification and Description	Production Standard
	units per hour
15. Stamping Cartons The worker gets a rubber stamp, inks it, and stamps each end of the carton.	612 cartons
16. Stacking Cartons The worker lifts filled cartons from the roller conveyer and stacks them on an adjacent pallet.	390 cartons
17. Carton Making The worker gets, forms, and moves the carton to a wire stitching machine, stitches the bottom, and stacks the carton aside.	228 cartons 310 cartons with 2 workers
18. Placing Dividers and Moving Cartons Aside The worker gets a stapled carton, gets and places dividers, and either stacks the carton in a holding area or places it in a chute leading to the packing area.	666 cartons

Source: Work standards developed from time and motion studies in 14 Michigan apple packing plants, 1963-64.

Table B. Wage Rates Used in Computing Apple Packing Costs, 1964 Wage Levels[1]

Job	Hourly Wage
Dumping	$1.25
Sorting	1.25
Bagging	1.25
Boxing and closing bags	1.25
Carton maker	1.30
Utility handler	1.25
Fork lift operator	1.60
Direct supervision	1.85
Clerical work	1.50

Source: Current wage rates in 14 Michigan apple packing plants, 1963-64.

[1]Social Security and Workmen's Compensation payments are omitted. When included these plant wage rates must be increased by approximately 10 percent.

Table C. Dimensions, Installed Cost, Expected Life, and Annual Fixed Charge for Equipment Items Used in Michigan Apple Packing Plants, 1963-64

Item	Dimensions	Installed Cost[1]	Expected Life	Annual Fixed Charge[2]
		dollars	years	dollars
Receiving belt	24" x 5'	332.80	8	64.90
	30" x 5'	402.58	8	78.50
	36" x 6'	441.48	8	86.09
	48" x 7'	546.52	8	106.57
2-1/4" Eliminator	24" x 3'	366.29	8	71.43
	36" x 3'	474.03	8	92.44
	48" x 3'	605.07	8	117.99
Tilt-type bulk box dumper	67" x 84"	964.08	8	188.00
Hydro bulk box dumper				
(300 bu. per hour)		4160.00	8	811.20
(800 bu. per hour)		5200.00	8	1014.00
Leaf eliminator				
(300 bu. per hour)		280.80		54.76
(800 bu. per hour)		452.40	8	88.22
Sorting table	24" x 6'	768.00	8	149.76
	30" x 8'	1048.00	8	204.36
	36" x 10'	1265.00	8	246.68
	48" x 10'	1464.00	8	285.48
	48" x 14'	1800.00	8	351.00
Washer-brusher	24" x 7'	1855.00	8	361.73
	30" x 7'	2057.00	8	401.12
	36" x 7'	2256.00	8	439.92
	48" x 10'	2808.00	8	547.56
	48" x 14'	3874.00	8	755.43
Spreader belt	24" x 4'	291.00	8	56.75
	30" x 4'	333.00	8	64.94
	36" x 4'	364.00	8	70.98
	48" x 4'	484.00	8	94.38
	48" x 6'	582.00	8	113.49
Sizing unit	24" x 13'	8320.00	8	1622.40
	48" x 13'	13104.00	8	2555.28
Automatic box filler		1448.00	8	282.36

Table C--Continued

Item	Dimensions	Installed Cost[1]	Expected Life	Annual Fixed Charge[2]
		dollars	years	dollars
Distributor belt	24" x 10'	726.96	8	141.76
	24" x 15'	933.92	8	182.11
	36" x 20'	1368.64	8	266.88
	36" x 25'	1638.00	8	319.41
	36" x 35'	2125.00	8	414.38
Return flow belt	24" x 15'	1137.76	8	221.86
	24" x 20'	1333.28	8	259.99
	36" x 16'	1258.40	8	245.39
	36" x 20'	1433.12	8	279.46
	36" x 25'	1606.80	8	313.33
	36" x 30'	1796.08	8	350.24
	36" x 35'	1985.36	8	387.15
Automatic bagger		1138.80	5	307.48
Automatic bag closer		1432.00	8	279.24
Packing stands		46.80	10	7.96
Stapler		65.00	8	12.68
Stamps and pad		10.40	8	1.77
Wire stitcher		640.64	10	108.91
Table		20.00	10	3.40
Fork lift truck	2000#	5993.00	10	1018.81
Pallets		2.50	10	.43
Bulk boxes	20 bu.	9.00	10	1.53
Space heaters		367.00	10	62.39
Table scale		303.68	10	51.63
Cull and utility conveyer	6" x 4'	195.52	8	38.13
for each additional foot	6" x 1'	8.32	8	1.62
Filled bag conveyer	15'	609.44	8	118.84
	20'	709.28	8	138.31
	25'	803.92	8	156.76
	30'	1092.00	8	212.94

Table C--Continued

Item	Dimensions	Installed Cost[1]	Expected Life	Annual Fixed Charge[2]
		dollars	years	dollars
Elevating belt and accumulator table		618.80	8	120.67
Skate conveyer	12" x 10'	35.36	8	6.90
Roller conveyer	12" x 10'	104.00	8	20.28
Conveyer stands		6.24	10	1.06

Source: Equipment manufacture price quotations and prices paid by apple packers, Michigan, 1963-64.

[1]Includes f.o.b. price, transportation, installation, and sales tax.

[2]Estimated on the basis of installed cost. Includes fixed repair, 2.0 percent; insurance, 1.0 percent; interest on investment, 3.0 percent; property tax, 1.0 percent; and depreciation calculated according to expected life (5 years, 20 percent; 8 years, 12.5 percent; and 10 years, 10 percent).