PACKING ROUND WHITE POTATOES: COMPARATIVE COST ANALYSIS OF ASSORTED AND CLOSELY SIZED PACKS

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A THESIS

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

MASTER OF SCIENCE

Department of Agricultural Economics

1986

ABSTRACT

PACKING ROUND WHITE POTATOES: COMPARATIVE COST ANALYSIS OF ASSORTED AND CLOSELY SIZED PACKS

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Michigan round white potato packers face a declining share of the fresh tablestock market and an overall low quality image. This study examines the Michigan packing industry organization and analyzes costs of packing round white potatoes in four representative synthetic packing plants. Cost differentials are determined as follows: 1) packing assorted sizes versus closely sized potatoes; 2) packing in small versus large plants and 3) packing under various capacities of plant utilization. Results show the Michigan packing industry is characterized mainly by many small independent packers packing only assorted sized packs over a relatively short packing season and exhibiting high costs. Results also indicate that increasing plant size from small to large and plant utilization from Michigan's relatively low average to full utilization while packing closely sized packs may improve pack quality and reduce costs by up to thirty percent.

To Susan Bacharach Meyer

ACKNOWLEDGEMENTS

I would like to thank the people who aided me in completing this thesis. Dr. Thomas Pierson, my major professor, provided guidance and encouragement. Dr. Richard Chase provided information on potatoes as well as careful editing of many drafts. Dr. Jack McEowen gave many useful comments and suggestions.

The Michigan Potato Industry Commission secured funding for this research which was distributed through the Michigan Agricultural Experiment Station. The executive director of the Commission, provided information and potato industry contacts.

I would especially like to thank the many potato packing plant owners and managers who took time to show me their operations and answer questions. John Johnson of the Lockwood Corporation also took much of his time to help with the design and equipment specifications for the synthetic packing plants in this study.

Last, but not least, I would like to thank my friends whose support was invaluable: George Galasso, Sharon Bylenga, Evelyne Chota, Tom Hebert, Shayle and Janet Shagam, Robin Allison, Garth Allison, Michael Morris, Kris Allen, David Trechter, Gerry Gavin and Leslie Kratz.

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CHAPTER I

RESEARCH SETTING

This chapter provides general background on the market situation for Michigan round white potatoes as well as a brief overview of the nature of the study, which begins the chapter. Changes in the fresh fruit and vegetable marketing system which affect round white potato markets are addressed next, followed by the difficulties these changes present to round white potato producers. The specific research problem, economic justification for the study, its objectives and hypotheses and a guide to the remaining content of the thesis complete the chapter.

1.1 A Brief Overview

The current grading, sizing and packaging practices for tablestock[1] potatoes in Michigan are considered by many in the industry to be an economic deterrent to profitable marketing. Grading, sizing and packaging are important determinants of the quality and image of tablestock potatoes. This study determines the economic costs of sizing

[1]"Tablestock" refers to potatoes packaged and sold for fresh consumption as opposed to potatoes sold for processing or seed.

and packing potatoes in order to evaluate changes of current packing practices to improve Michigan fresh pack quality.

The study addresses cost differentials between: 1) packing potatoes in small plants versus large plants; 2) the current practice of packing 10 lb. consumer bags of U.S. No. 1 round white potatoes with assorted sizes of potatoes (hereafter referred to as assorted packs) versus separately packaging closely sized, i.e. small, medium and large, potatoes (hereafter referred to as closely sized packs) and 3) a 2 month versus a 10 month packing season length. Results of this study may have implications for the organization of the Michigan tablestock industry as well as the marketing practices for round white potatoes.

1.2 Types of Potatoes

There are four major types of potatoes grown in the United States; round and long white, red and russet potatoes. Each type has different requirements for production, marketing and utilization. Round white potatoes are grown throughout the United States, but primary production regions are in the central and eastern states. Long white potatoes are grown in the southwestern states. Red potatoes are grown primarily in the north central region. Russet potatoes are the most popular type and are grown most extensively in the northwestern states, but are important in all of the northern states.

Most round and long white potatoes for tablestock use have a moist fine texture and are well suited for boiling, frying, salads and small canned potatoes. Many of the newer varieties are higher in dry matter and consequently are widely used for potato chips. Red potatoes have a texture similar to white potatoes but are considered a specialty item and are usually served boiled. Russet potatoes, on the other hand, have a dry mealy texture well suited for baking and french frying. Most frozen and dehydrated processed potato products are made from the Russet Burbank potato because of its higher level of dry matter.

1.3 Consumer Demand Changes

Consumer demands for quantity, quality and variety of fresh produce are changing. Throughout the 1970's and early 1980's increasing consumer awareness of health and nutrition led to increased per capita consumption of fresh fruits and vegetables.[2] Consumer expectations of better quality coupled with technological advancements in storage, handling, packaging and transportation of fresh produce have led to higher quality standards for produce and longer seasons of availability. Consumer willingness to try new items and varieties has led to a dramatic increase in the number of

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[2]Hamm, L. G., Changing Times in the Processed Fruit and Vegetable Industry, Economic Research Service, U.S. Department of Agriculture.

produce items available in retail stores.[3] Fresh produce markets are responding to changing consumer demands for quantity, quality and variety.

Overall trends in changing consumer demand for fresh produce have implications for, but don't clearly indicate, what has happened over the past twenty years to Michigan's round white potato market. Consumer demand has strengthened toward baking type potatoes.[4] Some factors which have influenced this shift are consumer taste changes, technological advancements and marketing efforts by the russet industry.

Interactions of the three aforementioned factors over the past two decades have influenced the position of the round white tablestock potato. Market share of round white tablestock potatoes has declined. Technological advancements in potato processing equipment and consumer acceptance of new processed products led to nearly a tripling of the annual per capita consumption of frozen potatoes between 1961 and 1981.[5] The development of markets for frozen and other processed potato products

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[3]McLaughlin, E. W. and Pierson, T. R., Produce Merchandising: Opportunities for Innovative and Strategic Marketing, presentation to the United Fresh Fruit and Vegetable Association, 1985 Annual Convention, Las Vegas.

[4]How, R. B., New York State Agricultural 2000 Project: Economic Opportunities for Vegetables, Potatoes and Dry Beans, Cornell University, pg. 4, 1984.

[5]Hamm, L. G., Changing Times in the Processed Fruit and Vegetable Industry, Economic Research Service, U.S. Department of Agriculture.

prompted the expansion of production of russets in the Northwest.

Marketing efforts by northwestern potato growers are to be credited for expansion of the russet potato market not only for processing but in the tablestock market as well. They include count packaging[6] providing a greater volume of "strippers" which compete directly with round white potatoes in retail food stores. In addition, marketing orders to control grades and sizes of potatoes marketed from the northwestern states of Idaho, Oregon and northern California have been in effect since the early 1940's.[7]

Long distances between northwestern potato growing regions and population centers in the south and east created an economic incentive for cooperation among growers and centralized packing operations developed. Transportation costs to southern and eastern markets were prohibitive for an individual grower, but economies of size in transportation could be realized by shipping many growers' crops together. To withstand long shipping distances in good condi-

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[6]"Count packs" are 50 lb. boxes containing potatoes which have been closely sized to within 4-6 oz. For example, a "70 count pack" would contain approximately 70 potatoes weighing between 9 oz. and 15 oz. "Strippers" are russet potatoes about 1 7/8 to 2 1/4 inches in diameter, or less than 6 oz.. Considered too small for count packs, they are usually bagged in 5-20 lb. bags.

[7]Armbruster, W. J., Henderson, D.R. and Knutson, R. D., Federal Marketing Programs in Agriculture: Issues and Options, The Interstate Printers and Publishers, Inc., Danville, Illinois, pp. 128-129, 1983.

tion, strict quality standards were imposed on the fresh tablestock potatoes through the marketing boards.

Promotional campaigns introduced the "Idaho potato" to consumers and reinforced its quality image. Marketing efforts of the northwestern russet industry promoted a uniformly sized, quality potato which is available throughout the U.S..

In contrast, round white potato growers in Michigan and other central and eastern states faced a different marketing environment. Close to population centers with relatively low transportation costs, many individual growers pack and ship their own potatoes. Quality standards of tablestock potatoes vary among growers due to varying cultural conditions and practices, and the many different varieties grown.

Neither state nor federal inspections of tablestock potatoes are mandatory, although the U.S.D.A. has established grades with specific tolerances for potatoes. Packers use the U.S.D.A. grades and standards as minimums in states where marketing order standards, which are typically higher, do not exist.

The Michigan tablestock potato industry is characterized by many independently operated packing plants and marketers. As a result, a wide variety of quality levels are evident in Michigan´s tablestock potatoes contributing to a perceived lower quality image.

Changing consumer demands coupled with increasingly strong competition from russet potato packers have created an increasingly challenging marketplace for round white potato packers. To be successful, round white potato marketers must be aware of changes in consumer demands and the produce marketing system.

1.4 Fresh Fruit and Vegetable Marketing System Changes

McLaughlin and Pierson[8] examined trends in the fresh fruit and vegetable distribution system which may have important implications for round white potato packers. Food retailers are responding to the marketing demands of distinguishable consumer segments, particularly in the produce department. An attractive produce department carrying quality items will "draw" consumers into the store where they are likely to purchase other grocery items as well. A 1981 survey of six major metropolitan areas by Chain Store Age Supermarkets showed that consumers ranked "quality produce" as the most important factor in a grocery store.

Retailers have increasingly aligned themselves with customers needs versus suppliers needs. The implication for the round white potato industry is to provide the quality

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[8]McLaughlin, E. W. and Pierson, T. R., The Fresh Fruit and Vegetable Marketing System: A Research Summary, Agricultural Economics Staff Paper #83-44, Michigan State University, August 1983.

image of round white potatoes that the retailer desires for the entire produce department.

The changing organization of the grocery industry has led to fewer and larger retail food firms, changing the nature of the buyer/seller relationship. Retailers, in general, are passing more functions and responsibilities back to growers and shippers in the form of increased packaging, handling, information and transportation services. As more marketing functions are expected of them, packers must carefully weigh the costs against the expected benefits.

Michigan potato growers, packers and shippers, along with most agricultural producers, have traditionally had a commodity orientation[9] in marketing their produce. The focus has been on producing a product which meets the same quality standards as the competitors product, but at a lower cost through more efficient operations. Higher volume of sales are emphasized to increase profits and price is the major competitive tool. A marketing orientation focuses on: 1) awareness of retailers' and consumers' demands and directions of change and 2) designing products and services to meet those demands.

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[9]Pierson, T. R. and Allen, J. W., Marketing Challenges Confronting the Beef Industry: A Synopsis of Key Issues in Beef Marketing and Needed Responses by Beef Industry Organizations, Michigan State University, Agricultural Economics Staff Paper #84-47, August 1984.

1.5 Issues Confronting Michigan's Round White Industry

Two issues have arisen for Michigan's round white potato industry: 1) declining market share of round white potatoes versus russets and 2) pressures to assume changing marketing activities brought about by the changing produce marketing system. The contrast in retail prices received for 10 lb. bags of russet potatoes as opposed to round white potatoes (often more than twice as much) has discouraged producers, packers and shippers from assuming additional marketing efforts for the lower priced round white potatoes.

Examining the success of the russet potato and other "new" fruits and vegetables may shed light on some actions the round white potato industry might consider. Major trends in produce which round white potato marketers need to examine are: 1) size uniformity; 2) bulk displays and clear packaging with high product visibility; 3) national brand names; 4) variety recognition; 5) strict quality standards and 6) year round availability. Current practices of the round white potato industry with respect to the above trends are:

1) Packs with potatoes ranging in size from 2" to larger than 4" in diameter in the same bag.

2) Bulk displays are not seen as practical due to the problem of "greening" when exposed to light.[10] nor are round white potatoes highly visible in the bag (which is usually made of paper with a mesh viewing vent on the back)

3) Brand names are numerous. A particular retail store may switch brands frequently which doesn't enable consumers to identify with a particular brand.

4) A packer may pack several varieties of round white potatoes under the same brand name over the course of a season. There is a proliferation of varieties of round white potatoes (more than 20 varieties are regularly grown in Michigan[11]) each with different cooking qualities. Consumers are unable to identify varieties from the bag labeling.

5) The most common quality standard for tablestock potatoes is the U.S. No. 1 grade. A packer's incentive is to pack to the bottom of this grade to receive the highest price for a given weight of potatoes.[12] This short run incentive leads to an overall low quality image for Michigan round white potatoes.

6) Many round white potato growers are in the market for only 3-7 months of the year. At other times of the year retailers and consumers must purchase potatoes from other sources. Each year packers or shippers must reestablish their market, thus competitors have annual opportunities to enter the market.

As seen from the list above there are many opportunities for round white potato packers to adopt new practices in the produce industry.

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[10]Photosynthesis takes place in potato skin cells exposed to light. In addition to discoloring the skin, the taste qualities of the flesh are altered resulting in a bitter flavor.

[11]Harrison, K. M., Sparks, S. D. and Fabre, M. M., The Michigan Potato Industry: A Market Analysis, Agricultural Economics Report 294, 1976.

[12]Kross, J. I., At What Grade Does It Pay to Sell Potatoes?, Journal of Farm Economics, Vol. 34, No. 3, pp. 387-391, 1952.

1.5.1 Pressures to Respond to Market Changes

As changes in the produce marketing system pressure growers, packers and shippers to adopt different marketing tactics and strategies each firm manager should examine the costs and benefits of altering marketing activities. Costs of each marketing activity can be estimated by determining the costs of labor and capital required at each activity stage.

Benefits tend to be substantially more difficult to measure. Observations of the benefits received by other marketers in the prospective activity would be useful, however, most firms do not usually share their cost and revenue information. They may also not have benefits recorded separately for each activity. Another consideration is that the environment in which an existing marketer operates may be quite different from a prospective marketer's environment.

Market price information may be gathered for a particular product, if it is available, but prices of agricultural products tend to fluctuate widely. Price data must be collected over several years and the supply and demand factors examined to meaningfully interpret the price information. Average market prices may not, however, give an accurate indication of how a particular firm may fare in a given market environment.

The question arises whether the existing industry organization can adequately respond to changing market pres-

sures or if an alternative organization might be more appropriate. Analysis of the costs and benefits for existing and alternative industry organizations to meet these marketing challenges would help answer this question.

1.6 Research Problem

The Michigan Potato Industry Commission has recognized that produce marketing system changes provide both opportunities and challenges for changing packaging at the grower/packer level. Many of Michigan's round white potato growers/packers would like to know the profitability of sizing round white tablestock potatoes into small, medium and large categories. This research determines costs per unit of packing 10 lb. consumer bags of assorted sizes versus small, medium and large sized round white potatoes in two sizes of packing plants, acknowledging that more research will be needed on the benefit side before any statements can be made about the potential profitability of close sizing.

1.7 Economic Justification

Michigan currently ranks tenth in the United States in production and in 1984 produced more than 12 million hundredweight of potatoes valued at approximately $79.6 million.[13] About 50% of potatoes grown in Michigan are

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[13]Michigan Department of Agriculture, Michigan Agricultural Statistics, 1984.

round white varieties and the other half are russet varieties. Although firm figures are not available, in 1985 an estimated 51% of the state's potatoes were used for processing or chips with the remaining 49% used for fresh market and certified seed.[14]

McLaughlin and Pierson's 1983 study of the fresh fruit and vegetable marketing system observed a lack of adequate cost information by many produce marketers. Potato packers are no exception. In an evolving market system, firm and industrywide decisionmakers need cost information to plan and implement changes. Information on the costs of packing and sizing potatoes may act as a catalyst for change. Potato industry participants have expressed an interest in close sizing of round white tablestock potatoes, therefore the cost information provided by this study may be a useful tool for implementing change.

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[14]Estimated by R. H. Kaschyk, Executive Director, The Potato Industry Commission, Lansing, Michigan.

1.8 Objectives of the Study

The general objective is to provide cost information on potato packing plants and sizing operations to decision-makers in the potato industry as they face present marketing challenges. Specific objectives are to:

A. Determine costs per 10 lb. consumer bag[15] of round white potatoes of:

   1. assorted sizes packed in a small packing plant
   2. assorted sizes packed in a large packing plant
   3. small, medium and large sizes packed in a small packing plant
   4. small, medium and large sizes packed in a large packing plant

B. Objectively demonstrate via fixed and variable cost analysis possible cost savings to the Michigan potato industry associated with greater utilization of plant and equipment

Incidental to meeting the above main objectives the following subordinate objectives will be met:

1. Provide a general description of the potato packing industry in Michigan
2. Discuss grading and sizing out of storage versus pre-storage sizing of potatoes
3. Describe current grading and sizing practices for round white potatoes in Michigan and other states
4. Describe the activity stages and equipment to pack potatoes
5. Determine total annual costs of operating representative small and large packing plants

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[15]For the purposes of this study all potatoes packed in 10 lb. bags are assumed to meet the U.S. No. 1 grade standards.

6. Provide a capacity utilization chart for different lengths of packing season

7. Determine costs of major resources used in packing potatoes

8. Determine resource costs per packing activity stage

9. Discuss costs associated with a number of marketing implications of closely sizing potatoes

1.9 Hypotheses

Hypotheses concerning the Michigan potato packing industry are:

1. It will be more costly to pack potatoes in closely sized small, medium and large packs than in assorted packs.

2. Larger packing plants will have lower unit packing costs than small plants when operated at the same percentage utilization of capacity.

3. A longer packing season as well as greater utilization of capacity will lead to reduced costs per unit of output for any size packing plant.

1.10 Organization of the Thesis

The remainder of this study proceeds as follows: Chapter II describes a conceptual approach to cost analysis and develops the hypotheses. Chapter III details the research methods and procedures used to gather information and perform cost analysis. Chapter IV presents findings of the study. Chapter V presents results of the cost analysis. Chapter VI presents conclusions, marketing challenges

of closely sized potatoes, limitations of research methods and suggestions for future research.

CHAPTER II

CONCEPTUAL APPROACH FOR COST ANALYSIS

This chapter addresses the conceptual approach taken for cost analysis, describes the cost analysis performed and develops the hypotheses to be tested.

2.1 Previous Cost Studies

This section provides examples of the basic approaches taken in previous cost studies, briefly discusses strengths and weaknesses of each and discusses the approach of this study.

Two basic approaches taken in previous cost studies of potato packing operations are case studies and synthetic plant analyses. The case study approach determines costs for existing packing plants while the synthetic plant approach determines costs for synthetic plants. Synthetic plants are usually "representative" of existing plants since they are designed using the types of equipment, plant layouts and labor found in existing packing plants, but they are "synthetic" because the characteristics of the plants which are designed and analyzed do not exactly match those of existing packing plants.

Two of the more notable previous studies include: "Economies of Size for Maine Potato Packing Plants"[1] by E. F. Johnston and "Operating Costs at Four Potato Packing Plants"[2] by M. D. Volz and J. P. Anthony, Jr.. Johnston employed a synthetic plant approach. Volz and Anthony employed a case study approach. A brief description of these studies and their important points for this study follow.

Johnston's study tested the economies of size theory for packing fresh tablestock potatoes in Maine. He states:

> "Quality maintenance and control measures are generally promoted by a volume of business that will enable diversity and specialization, and various efficiencies are obtained as volume of activity is increased."[3]

Ten potato packing lines were developed using the most economical combination of equipment to handle, grade, and package round white potatoes. Input rates ranged from 80 to 800 cwt per hour. A computer program was used to

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[1]Johnston, E. F., Economies of Size for Maine Potato Packing Plants, Life Sciences and Agricultural Experiment Station, University of Maine at Orono, Bulletin 746, December 1977.

[2]Volz, M. D. and Anthony, Jr., J. P., Operating Costs at Four Potato Packing Plants, United States Department of Agricultural, Agricultural Research Service, Marketing Report No. 1072, November 1977.

[3]Johnston, E. F., Economies of Size for Maine Potato Packing Plants, Life Sciences and Agricultural Experiment Station, University of Maine at Orono, Bulletin 746, page 5, December 1977.

select appropriate equipment and labor combinations from maximum practical handling capacity specifications.

Representative unit costs were found when packing a representative mix of container sizes. The results find the economies of size theory to hold; as plant size increases unit costs decrease, except between supply rates of 400 and 453 cwt/hr. Between these sizes a larger building, more equipment and personnel, including a secretary and an unassigned worker, led to a major upward shift in costs. Unit costs again declined as the supply rates were further increased to the maximum of 800 cwt/hr.

Changes in variables such as wage rate, operating time as a proportion of overall time, size of container, quality of input to the packing line and length of packing season were examined. Unit costs increased as wage rates increased, as operating time as a proportion of overall time decreased and as the size of the container packed decreased. Unit costs decreased as length of the packing season increased and as the quality of the input to the packing line is raised.

The above synthetic, efficient packing plants run at full capacity upheld the economies of size theory, but Volz and Anthony's case studies of four existing potato packing plants, two in Florida and two in California, did not find a strict correlation between volume packed and production per man hour.

> The man-hour production rate at the four firms studied during 1974 ranged from 709.5 to 1,131.4 pounds of potatoes. The highest volume occurred at one of the smaller volume potato firms: however the lowest production was at the firm with the least volume.
>
> In this study the production rate was not necessarily dependent on volume but on other factors, such as (1) scheduling of field and plant crews, (2) unloading area capacity to avoid delays in feeding the production line, (3) plant layout, (4) crew skill, (5) automatic bag closing and filling, (6) mechanized handling, (7) palletization, and (8) grade-out variation of potatoes."[4]

Unit costs were likewise found to be not directly correlated to size of firm.

2.1.1 Case Study Versus Synthetic Plant Approach

The above examples illustrate some of the strengths and weaknesses of the case study and the synthetic plant approaches. A strength of the case study approach is its realism. Costs determined reflect actual packing plant costs as closely as possible. A weakness of the case study approach is that it is difficult to make direct comparisons among the costs of different plants, due to unique characteristics of each existing plant. To borrow from an old saying, comparing case study costs is like comparing apples and oranges.

The synthetic plant approach allows direct comparisons between plants because it controls the factors that influ-

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[4]Volz, M. D. and Anthony, Jr., J. P., Operating Costs at Four Potato Packing Plants, United States Department of Agricultural, Agricultural Research Service, Marketing Report No. 1072, page 1, November 1977.

ence costs. Factors can then be varied one at a time, while holding all other factors constant, to determine their influence on costs. A criticism of the synthetic plant approach is that it lacks realism. In fact, it is not possible to change one factor without influencing other factors.

2.1.2 Cost Analysis Approach of This Study

A representative synthetic plant approach is taken in this study for two main reasons: 1) it allows specific identification of cost differentials due to plant size and complexity of sizing operations and 2) synthetic plant sizes and types of packs were determined from observation of existing Michigan packing plants, but close sizing operations which are an important part of this study's cost analysis do not presently exist in Michigan for round white potatoes, thus a synthetic plant approach is necessary.

The focus of the cost analysis is on packing 10 lb. bags of potatoes which presently comprise 60 to 80 percent of the packs of round white potatoes in Michigan. It is recognized that a viable packing plant will pack several packs of which the 10 lb. bag is only one. However, packers are generally able to calculate costs of other packs relative to the cost for 10 lb. bags.

Technology, types of equipment, buildings and materials found in existing Michigan packing plants were used in the synthetic plants. Equipment to closely size potatoes, which

is already being used by russet packers in Michigan, is adapted for use in the synthetic plants for round white potatoes. In addition to observation of existing packing plants, Paul H. Orr's study, "Potato Packinghouses - Guidelines for Plant Layout" provided useful information concerning the specifics to be considered in potato packing plant layouts. A brief description of the study follows.

Orr's study examined commercial potato packing facilities in the Red River Valley of Minnesota and North Dakota to determine the factors to be considered when planning potato packinghouse layouts.

> "Layouts for three synthesized potato-packing operations were developed to illustrate the operating procedures, work methods, and equipment common to the potato-packing industry...The operations in preparing potatoes for market [and]...equipment required to perform these operations also is noted in general. The specific equipment required for the sample layouts is described in detail and estimates of its initial costs are given. Crew requirements for operation of the example packing lines are also estimated."[5]

Costs for labor, taxes, insurance, utilities, repairs and transport in existing Michigan plants provided guidelines for the representative cost figures used in this analysis. Thus, although the plants analyzed are synthetic plants, they are representative of existing Michigan packing plants.

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[5]Orr, P. H., Potato Packinghouses--Guidelines for Plant Layout, United States Department of Agriculture, Agricultural Research Service, Marketing Research Report No. 975, page 1, April 1973.

Transport costs are not typically considered as a cost of packing potatoes. The current practice is for growers to pay the cost of transporting potatoes to packers. Thus packers may not consider transport as a cost of packing, unless the grower and packer is one and the same. However, the cost of transporting potatoes from storage to the packing line ranges from insignificant to a highly significant annual cost. Transport cost is insignificant when nearly all of the potatoes are taken from a storage building adjoining the packing plant. Transport cost is significant when a large percentage of the potatoes to be packed must be transported from storage to a distant packing plant.

In general, transport costs have become more significant as the potato packing industry has become more centralized. This point was emphasized by G. A. Zepp in "Costs of Producing Potatoes"[6], which is briefly described below.

Glenn A. Zepp's study estimated costs for producing, storing and packing potatoes in major U.S. production regions. The three fresh production areas studied included Idaho and Central Wisconsin, packing mostly russet potatoes, and Maine, packing round white potatoes. Estimated packing and selling costs were assumed to be the same in Idaho and

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[6]Zepp, G. A., Costs of Producing Potatoes: 1980 and 1981 with Projections for 1982, United States Department of Agriculture, Economic Research Service, Agricultural Economics Report Number 491, October 1982.

Central Wisconsin as they were both handling a similar product within similar centralized packing industries.

> "Ownership and fuel costs for the Maine estimates were lower per cwt because packing in Maine is typically done in the storage shed...Hence, the Maine packing cost estimate does not include maintenance and ownership of the packinghouse nor transportation from storage to the packingshed as does the Idaho/Wisconsin estimate."[7]

Estimated packing and selling costs for fresh potatoes in Maine ($1.934/cwt) were lower than those in Idaho and Central Wisconsin ($2.104/cwt). However, when total costs of production, storage and packing were considered, f.o.b. the packinghouse, Wisconsin's total cost was the lowest while eastern Idaho's was the highest.

Considering the entire potato marketing sequence from production to consumer, Maine had a cost advantage over other producing areas for supplying fresh potatoes to northeastern U.S. markets. Zepp's study illustrates the point that a cost advantage in one stage of marketing may not be sufficient to allow a total cost advantage for a region. Product value also differs between varieties produced and production regions. Evaluation of profitability should thus consider product value as well as costs of all stages of marketing.

It is beyond the scope of this study to consider transport costs in depth, but estimates were made for each

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[7]Zepp, G. A., Costs of Producing Potatoes: 1980 and 1981 with Projections for 1982, United States Department of Agriculture, Economic Research Service, Agricultural Economics Report Number 491, page 13, October 1982.

plant size of the average percentage of potatoes transported from off-site storages and the average distance they are transported. Sensitivity analysis of effects of increasing transport distances on total costs is also performed.

It is hoped that some widely applicable generalizations about the cost effects of plant size and complexity of sizing operations can be drawn from developing synthetic plants that would not be possible with a case study approach. Results of this study may have implications useful to decisionmakers in all sizes and types of potato packing plants for evaluating their current practices and projecting their future actions as well as the future of the round white potato packing industry.

2.2 Four Packing Plants for Cost Analysis

Costs of packing potatoes in four representative synthetic packing plants are analyzed: 1) small plants packing assorted packs; 2) small plants packing closely sized packs; 3) large plants packing assorted packs and 4) large plants packing closely sized packs (Table 1). These plants will henceforth be interchangeably referred to as Plants #1-#4, respectively. The main distinctions are sizes of plants and complexity of sizing operations. The distinction between the two plant sizes is based on the output of 10 lb. bags the plant can pack when running at full capacity

TABLE 1. Four Packing Plants for Cost Analysis

PLANT SIZE	PRIMARY PACKS	
	10 lb. Bags of Assorted Sizes	10 lb. Bags of Small, Medium and Large Sizes
Small	Plant #1 (Small Assorted)	Plant #2 (Small Close)
Large	Plant #3 (Large Assorted)	Plant #4 (Large Close)

for an 8 hour day. Output is based on full capacity versus average output to focus on the size of the packing operation and to remove differences in output per day attributable to length of packing season, days packing per week and other factors which are not solely attributable to the size of the operation.

Small plants have a single 24"-36" packing line and pack 1 - 2 1/2 semiloads (4000 10 lb. bags per semiload) per 8 hour day when running at full capacity. Large plants have a single 48" packing line and pack 3-5 semiloads per 8 hour day when running at full capacity.

The complexity of sizing operations is divided into two packing categories; assorted packs and closely sized packs. The distinction between the two is based on the complexity of the equipment in the packing line which sizes the

potatoes and directs them towards the bagging equipment. Plants packing assorted packs are assumed to separate potatoes into two size categories in accordance with U.S.D.A. standards for U.S. No. 1 grade potatoes: 1) less than 1 7/8" inches in diameter and 2) greater than 1 7/8" inches in diameter. One piece of equipment, a screen sizer, is required for this sizing operation.

Plants packing closely sized packs are assumed to separate potatoes into four size categories in accordance with U.S.D.A. standards for Small, Medium and Large sizes of potatoes[8]: 1) less than 1 3/4 " in diameter; 2) between 1 3/4" and 2 1/2" in diameter; 3) between 2 1/4" and 3 1/4 " in diameter and 4) between 3" and 4 1/2" in diameter. Four pieces of equipment; a screen sizer, a roll sizer and two evenflow holding tubs with conveyor belts, are required for these sizing operations.

2.3 Cost Analysis

Costs are analyzed for plants running at three levels of plant utilization: 1) full capacity; 2) varying utilization and 3) average Michigan utilization.

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[8]See Table 6, U.S. Standards: Size Designation, in Chapter IV for more detail.

2.3.1 Cost Analysis at Full Capacity

The first analysis is from the perspective of packing plants running at full capacity[9]. There are two aspects to the analysis of costs at full capacity; a) small and large packing plants with typical equipment and b) small and large packing plants with the same types of equipment. The first aspect involved small and large packing plants with typical equipment found in Michigan packing plants. Large plants tend to have specialized equipment such as hot air dryers and soak tanks which are not commonly found in small packing plants.

Specialized equipment, in effect, changes the quality of the output. Although additional equipment adds to the cost of packing, the final product may be of higher quality, i.e. cleaner, less prone to rot, etc. Comparing costs of small packing plants without specialized equipment to large packing plants with specialized equipment involves a comparison of the packing costs, in essence, of two different products.

To remove this bias from the second aspect of the full capacity cost analysis, specialized equipment was removed from the large packing plants. Large packing lines are then composed of the same types of equipment as the small packing

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[9]Full capacity is assumed to be running the packing line 8 hrs. per day, 5 days per week for 8 months at the average output levels per hour of Michigan packing plants in each size group.

lines, but of a larger size to handle the additional volume packed.

Two cost comparisons are made for Plants #1-#4 running at full capacity: 1) between small and large plants and 2) between plants packing assorted packs versus closely sized packs.

2.3.2 Cost Analysis at Varying Utilization

The second analysis is of cost changes as the capacity of plant utilization varies in Plants #1-#4 with typical equipment. All estimates and formulas for the cost calculations were entered into Lotus 123, a computer spreadsheet. While all fixed costs remained constant, the length of the packing season was varied in one month increments from 2 to 10 months, resulting in increasing variable costs. Effects on total costs per year, costs per 10 lb. bag and the percentage fixed costs of total costs were recorded.

Three comparisons of costs at varying utilization are made: 1) within each plant size as the packing season length changed; 2) between plant sizes and 3) between plants packing assorted packs versus closely sized packs.

2.3.3 Cost Analysis at Average Michigan Utilization

The third analysis is of costs in Plants #1-#4 with typical equipment using average Michigan output per hour, number of hours in the packing season and length of packing season for small and large plants currently operating.

Averages were taken from estimates given by the six small and seven large packing plant owners/managers interviewed.

Three comparisons of costs for average Michigan utilization are made: 1) between small and large packing plants; 2) between plants packing assorted packs and closely sized packs and 3) between full capacity and average Michigan utilization.

2.4 Cost Categories

Cost categories for analysis are variable costs, fixed costs and total costs. Variable costs vary as the level of output (10 lb. bags of potatoes) varies; labor, materials, utilities, forklift fuel, transport, part of equipment repairs and operating capital. Fixed costs do not vary as output levels vary; land, buildings, equipment, property taxes, insurance, building repairs, part of equipment repairs and supervisor/manager wages. Total costs are the sum of variable and fixed costs.

2.5 Time Frame

A one year time period was chosen for cost analysis in this study, during which total costs are composed of both fixed and variable costs.

2.6 Tabulation of Results

Although it is useful to separate costs into fixed and variable costs for economic analysis, businesses view their

costs in accounting categories. Results were tabulated by accounting categories as well as by activity stages on a cost collection matrix (Table 2) in addition to being evaluated as fixed and variable costs.

Annual accounting costs (on the vertical axis) are separated into occupancy, materials, equipment, labor and operating capital categories. Annual activity stage costs (on the horizontal axis) are divided into eight categories; transport, receive, presize, clean, grade, size, package and load. An additional column for shared costs contains costs which are shared among all activity stages.

2.7 Hypotheses

Three hypotheses about the Michigan potato packing industry are tested. The first two hypotheses address, respectively, the cost differences due to the complexity of sizing operations and plant size. The third hypothesis examines the cost effects of varying the level of output within a given plant. The following sections address important concepts associated with each of these hypotheses.

Table 2. Cost Collection Matrix for Small Plant Packing Assorted Sizes Per Pack

Accounting Category	Activity Stage	Transport	Receive	Precize	Clean		Grade	Size	Package		Load		Shared Costs	Total per Resource
	Stage Component	Truck	Hopper											
	Subotage	Storage	Unload		Wash	Dry			Bang Bags	Check Weight	Sew Bag	Stack Bags	Move Pallets	
Occupancy Costs	land												$462.00	Land $462.00
	building												$6,500.81	Building $6,500.81
	annual building charges: property taxes												$1,324.40	Taxes $1,324.40
	insurance												$729.03	Insurance $729.03
	repairs												$1,120.00	Bldg Repairs $1,120.00
	utilities												$5,400.00	Utilities $5,400.00
Transport Material Costs	bags								$99,600.00					
	string										$2,217.96			
	pallet wrap											$5,470.00		Materials $107,295.96
	transport	$259.99												Transport $259.99
Equipment Costs	self unloading hopper		$743.93											
	draper chain elevator		$353.37											
	screen sizer w/ rubber belt conveyor for B's			$669.54										
	washer and sponge dryer				$967.11									
	metal roller grading table w/ conveyor for culls conveyor for U.S. no. 2's						$1,220.06							
	two chute 50 lb. manual bagger								$55.79					
	scale									$150.07				
	sewing-conveyor unit										$1,522.02			
	ten head rotary bagger								$4,776.03					
	sewing-conveyor unit										$2,055.48			
	forklift												$2,231.79	Equipment $14,746.77
	equipment operating charges: repairs												$2,973.42	Equip Repairs $2,973.42
	forklift fuel												$1,245.00	Forklift Fuel $1,245.00
Labor Costs	shared and direct labor						$12,664.08			$25,328.15		$12,664.08		
	supervisor/manager labor												$13,683.42	Labor $64,339.73
	operating capital costs												$600.00	Oper Capital $600.00
	Subotage Costs	Transport $259.99	Receive $1,097.30	Precize $669.54	Clean $967.11		Grade $13,884.12	Size $0.00	Package $135,707.18		Load $21,618.87		Shared Costs $32,801.00	Total per Yr $207,005.11

2.7.1 Hypothesis #1

> It will be more costly to pack potatoes in closely sized small, medium and large packs than in assorted packs.

Higher costs of packing closely sized packs versus assorted packs are due in part to: 1) more equipment and larger buildings associated with higher capital investment, insurance, property taxes, utilities and repair costs and 2) additional labor hours for changeover between sizes.

An important point is that the output of plants packing assorted packs is a different product than the output of plants packing small, medium and large closely sized packs. The value of the output may also be different. If buyers and consumers perceive the difference in the products and are allowed to express their preference through purchases at different price levels or quantities, it may be determined if close sizing is perceived as a positive or negative attribute. If consumers find close sizing a positive attribute, increased revenue from higher prices and/or additional purchases may accrue to packers to cover the additional costs of close sizing.

The same concept may be applied to quality differences between plants packing similar types of packs. The quality of packs may be highly variable depending upon the quality of potatoes that are loaded onto the packing line as well as quality influencing practices, such as grading, roughness of handling, storage and transport. Quality differences

perceived by buyers and consumers may affect the quantities purchased and the prices received by packers.

Hypothesis #1 addresses the costs associated with additional packing operations necessary for close sizing. The analysis comparing costs between plants which pack closely sized packs and assorted packs tests this hypothesis. An equally important consideration is the quality effect of additional packing operations which is more difficult to measure, but should be considered in conjunction with cost effects.

2.7.2 Hypothesis #2

> Larger packing plants will have lower unit packing costs than small plants when operated at the same percentage utilization of capacity.

Large plants produce more output and have higher total costs than small plants, however, as output levels increase from small plants to large plants, costs increase at a slower rate per unit of output. This results in lower unit packing costs in large plants than in small plants, known as "increasing returns to size". Examples of input costs which do not increase proportionally as output levels increase are buildings, equipment and labor. To illustrate, assume output doubles between small and large plants. For costs per unit to remain the same, known as "constant returns to size", total quantities of all inputs would have to double. This assumes input prices do not change.

In fact, as output doubles the sizes and costs of buildings and equipment do not double. They will be larger, but not necessarily twice as large. A machine which produces twice as much output as a smaller piece of equipment of the same type will usually cost less than twice as much. Part of the cost for a piece of equipment is the cost of developing the technology and designing the equipment. That cost will be nearly the same for a small or large piece of equipment of the same design. The additional cost for the larger piece of equipment may be due to the additional materials and assembly costs.

The analysis at full capacity with the same types of equipment in small and large plants tests the above hypothesis. Small and large plants with typical equipment which make the synthetic plants more representative are also analyzed. The large plants typically have more pieces of equipment which perform additional functions, as well as more costly specialized equipment, than smaller plants. This leads to higher equipment costs per unit of output in large plants with typical equipment than in large plants with the same types of equipment as small plants. However, total cost per unit of output may still be lower in large plants than in small plants because other costs, such as labor, land and buildings costs, increase less than proportionally as output rises.

An example of a cost which rises less than proportionately is the cost of supervisory labor. A single supervisor

is employed in both small and large plants, yet in the large plant a greater output is produced. This leads to lower supervisory costs per unit of output in the larger plants.

A small plant could employ the specialized equipment and additional functions of the larger packing plant. However, specialized equipment in small plants is likely to be relatively more expensive per unit of output than the same type of equipment in a larger plant, i.e. the productivity of equipment, output per dollar of capital investment, may be less for the smaller plant equipment. Even with the specialized equipment only in the large plants the packing costs per 10 lb. bag of potatoes may still be greater in the small plant.

It is hypothesized that for both the plants with the same types of equipment in small and large plants and the plants with typical equipment in small and large plants, the costs per unit of output will be lower for large plants than for small plants when they operate at the same percentage utilization of capacity.

A broader marketing approach beyond unit output cost minimization to evaluate the most efficient size of plant to pack potatoes should be taken. Factors such as the quality differences in the potatoes packed as perceived by buyers and consumers and reflected back to packers through effective demand for their product, availability of potatoes to be packed, transportation costs, existing and potential markets for sales, i.e. additional benefits as well as

costs associated with larger plant size should also be examined.

2.7.3 Hypothesis #3

> A longer packing season as well as greater utilization of capacity will lead to reduced costs per unit of output for any size packing plant.

Hypotheses #1 and #2 should hold for packing plants of different sizes and different number of activity stages during any given time period. The discussions of these hypotheses assumed the plants were fully utilizing their equipment and labor. In the short run, if a plant varies its output level or has not yet reached a minimum cost level of output, it is likely to be operating at above minimum cost. This is due to an inability to vary the fixed quantity of equipment and building size. In times of slack demand the plant may underutilize equipment and labor. Equipment and building costs are fixed and some labor costs, such as the supervisor/manager wages may be considered fixed. The supervisor/manager will still be employed even if the packing plant is not running at full capacity. Hourly workers may be underutilized if they are paid for an entire day, but work at a slower pace than when the plant is running at full capacity. Costs per 10 lb. bag will be higher than at full capacity as total costs are being spread over fewer units of output.

At the other extreme, in response to increased demand for tablestock potatoes, additional workers may be added and

equipment may be pushed beyond its most productive operating level. Costs per 10 lb. bag of potatoes again increase as declining marginal productivity of labor[10] causes marginal cost[11] to exceed the average total cost[12].

There is a range of increasing capacity of utilization before declining marginal productivity occurs when increasing the quantity of potatoes packed per year through: 1) more fully utilizing the equipment through increasing the speed of operation and/or the number of workers within a certain limit and 2) increasing the number of hours of operation per day and/or the length of the packing season leads to declining costs per unit of output. These actions will increase variable costs for labor, materials, utilities and repairs as output levels increase. Fixed costs will remain the same but be distributed over more units of output. If variable costs per unit of output remain constant and fixed costs per unit decline, total cost per 10 lb. bag packed will decline. Analysis of packing plants running at varying utilization tests hypothesis #3.

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[10]Marginal productivity of labor is the additional quantity of output that can be obtained by employing one more unit of labor when all other inputs are held constant. Diminishing marginal productivity of labor reflects the concept that as additional labor is added to fixed equipment beyond some point the equipment becomes "overutilized" and a decline in productivity will set in.

[11]Short-run marginal cost is the cost of producing one more unit of output.

[12]Short-run average total costs are the total costs per unit of output.

CHAPTER III

RESEARCH METHODS

This chapter describes the approach taken to gather information and data for this study as well as the techniques used to determine costs.

3.1 Literature Search

Information and data were collected from a literature search as well as personal and telephone interviews. The literature search was conducted through the Michigan State University library resources, including AGRICOLA[1], and letters requesting literature from extension potato specialists located in 15 states throughout the United States. Other sources included the Michigan State Agricultural Experiment Station collection of literature on potatoes and publications of the Michigan Potato Industry Commission. More than 50 sources were consulted (List of References and General References).

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[1]AGRICOLA is the cataloging and indexing database of the National Agricultural Library. The file includes comprehensive coverage of worldwide journal and monographic literature on agriculture and related subjects.

Literature was collected in eight areas:

1. Computer simulations of potato packinghouse operations and synthesized plant layouts.
2. Cost analysis of packing fruits and vegetables.
3. Agricultural cost analysis and economies of size studies.
4. Fresh fruit and vegetable marketing.
5. Previous marketing studies on potatoes including grading and sizing studies.
6. General information on historical development of the potato industry, cultivation, storage and transportation.
7. Income and property tax laws as they apply to agricultural businesses.
8. Economic theories of cost analysis and the firm.

The literature search provided information on potato packing plant layouts and operations, cost analysis, fruit and vegetable marketing, potato cultivation and marketing, tax laws for agricultural businesses and economic cost theory. It did not, however, reveal any studies on the costs in Michigan for packing round white potatoes. Neither did any study detail the costs of potato sizing operations. To meet these research objectives, primary data collection was required. The following section details the methods employed to collect this data.

3.2 Interviews

Personal and telephone interviews were conducted to obtain information on several topics: 1) the organization of the Michigan potato packing industry; 2) current Michigan

packing plant sizes, layouts, costs and outputs; 3) materials, building and equipment replacement costs; 4) interest rates, taxes and depreciation schedules for cost analysis and 5) current packing, presizing and sizing practices in other potato producing states.

People contacted for the above information include: 1) the Michigan Potato Industry Commission executive director, Michigan State University Agricultural Experiment Station and Crop and Soil Science potato specialists, Michigan county extension agricultural agents; 2) potato packing plant managers; 3) materials manufacturers and sales representatives, building contractors, equipment manufacturers, sales representatives and agricultural engineers; 4) Michigan State University farm management specialists; 5) potato commission directors and 6) university potato researchers throughout the United States and State Department of Agriculture personnel. The specific types of information obtained in these interviews is described in the following section.

3.2.1 Description of the Potato Packing Industry

Personal and telephone interviews were conducted with the executive director of the Michigan Potato Industry Commission, 13 county extension agents throughout Michigan and Michigan State University potato specialists to get an overview of the Michigan potato industry.

3.2.2 Current Plant Sizes, Layouts, Costs and Output

The executive director of the Michigan Potato Industry Commission suggested some of the better packing plant operators who might be willing to participate in a cost study. Other packer names were received from the chairman of the Michigan Fresh Tablestock Committee and county agents. Thirteen packing plant managers were interviewed; six from small packing plants and seven from large packing plants throughout Michigan and Central Wisconsin (Table 3). Phone interviews were conducted to determine size of the operations, types of potatoes packed and willingness to participate in a cost study.

Personal interviews and packing plant tours were then conducted with packing plant managers/owners. Information specific to each operation was collected in eight areas: 1) output; 2) labor and management; 3) materials; 4) land; 5) building; 6) equipment; 7) transport costs and 8) operating capital (Appendix A). Data was also gathered from observation of the packing line on equipment size, type and layout and labor use (Appendix B).

3.3 Materials, Building and Equipment Costs

Materials, buildings and equipment costs were determined at replacement cost from manufacturers to provide comparisons among costs of the four "synthetic" packing plants. The types of materials and equipment used and

TABLE 3. Potato Packing Plants Visited

LOCATION	COUNTY	SIZE	TYPE PACKED
Erie, MI	Monroe	small	round white
Dundee, MI	Monroe	large	round white
Manchester, MI	Washtenaw	large	round white
Mt. Clemens, MI	Macomb	small	round white
Rockford, MI	Kent	small	round white
Edmore, MI	Montcalm	large	round white/ russet
Munger, MI	Bay	small	round white
Essexville, MI	Bay	small	round white
AuGres, MI	Arenac	small	round white
Elmira, MI	Atrim	large	round white
Iron Mnt., MI	Dickinson	large	russet
Crystal Falls, MI	Iron	large	russet
Custer, WI	Portage	large	russet

manufacturer's names were obtained from packing plant managers and observation of existing equipment.

3.3.1 Materials

Information requested from materials manufacturers and sales representatives included; item type, unit size, cost per unit and quantity required to pack one 10 lb. potato bag or quantity required per pallet in the case of pallet wrap. The cost per 10 lb. bag was calculated from this information.

3.3.2 Building

A building contractor who had recently built an addition on a potato packing plant was contacted for the cost per square foot to build a metal packing building, years of useful life of the building and an estimate of repair costs over the useful life.

3.3.3 Equipment

Potato packing equipment is either custom made or standard equipment. Custom equipment is built by a local machine shop, the plant owner or an equipment manufacturer. Equipment in most packing plants is a combination of custom and standard equipment. Each packing plant is customized to the owner's specifications for input rate and feeding method, sizes and quantities of packs to be sold and layout to best utilize existing storage and loading facilities.

Packing plants generally buy the majority of their equipment from one of three national equipment manufacturers. This ensures that the line will operate with appropriate flow rates from one piece of equipment to another.

The author sketched general specifications for Plants #1-#4. Tables listing the equipment with blank spaces for the requested specifications were sent to a national equipment manufacturer. In addition to providing equipment prices, the equipment manufacturer's design engineers specified the exact equipment in Plants #1-#4, within the author's guidelines for Michigan, so the "synthetic" packing plants would in fact be functional as well as representative of current industry design specifications.

Equipment specifications requested from the national manufacturer as well as manufacturers of standard equipment, such as bagging machines, scales and sewing machines, were: 1) dimensions; 2) horsepower; 3) maximum practical capacity (cwt/hrs); 4) rate of operation (ft/min); 5) new price; 6) years of useful life and 7) salvage value. Repair and rebuilding costs were also discussed. Not all of the above specifications were applicable or known by the person being interviewed. Secondary data from equipment studies[2] by

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[2]Johnston, E. F., Economies of Size for Maine Potato Packing Plants, Life Sciences and Agricultural Experiment Station, University of Maine at Orono, Bulletin 746, pp. 32-35, December 1977.

agricultural engineers as to maximum practical capacity, horsepower requirements, etc. were used where applicable.

Equipment prices received from manufacturers were F.O.B. list prices. The cost to deliver and setup a packing line can add an additional 10-15% to the cost of equipment according to one national manufacturer. However, most equipment is sold at a discount off list price, often as much as 10-20% according to another equipment salesperson. Since the discount tends to cancel the delivery and installation charge, the F.O.B. list prices received from manufacturers are used in this study to calculate costs.

3.4 Interest Rates, Taxes, Depreciation Schedules

A Michigan State University farm management specialist was consulted to verify the procedures for cost analysis, interest rates, tax brackets, land values, property taxes, useful life and salvage value.

3.5 Packing and Sizing Practices in Other States

Potato commission directors, university potato researchers and State Department of Agriculture personnel were interviewed to determine the current packing, pre-sizing into storage and sizing practices in other states, particularly for round white potatoes.

3.6 Techniques for Cost Calculations

Three major categories of cost information were collected from the sources described in the following sections: 1) packing plant output capacity; 2) fixed costs and 3) variable costs.

3.6.1 Output Capacity

Output capacities of various width packing lines were determined from observing equipment size, manufacturers' specifications and plant managers' experience. The packing line is assumed to be operating at full capacity under current management and labor.

3.6.2 Fixed Costs

Fixed costs of land, buildings, building repairs, equipment, property taxes, insurance and supervisor/manager wages were determined on an annual ownership basis. A discounted cash flow technique is applied to building and equipment costs to account for the cost of capital, depreciation, tax benefits of a stream of depreciation and salvage value.

Average land value was calculated from the owners' estimates of value per acre then cross-checked with Michigan State University farm management specialists. Building and equipment replacement values, useful life and salvage values were obtained from the sources described in section 3.3. Interest rates (to calculate the opportunity cost of

capital), depreciation schedules, average property tax millage rates and representative tax rates for corporations and partnerships were obtained from Michigan State University farm management specialists. Interest rates for borrowing, tax rates and supervisor/management wages were obtained from plant owners. Building and equipment insurance rates were obtained from insurance companies and plant owners.

3.6.3 Variable Costs

Variable costs of labor (i.e. wage and non-wage employee costs such as social security, workers compensation and unemployment taxes), materials, forklift fuel, equipment repairs and semi-variable costs of utilities, operating capital and transport distances from storage to the packing line were obtained from plant owners. Standard transportation costs per mile by truck were obtained from plant owners and verified with transportation rate publications[3].

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[3]Wilson, W., Griffin, G. and Casavant, K., Costs and Characteristics of Operating Interstate Motor Carriers of Grain in North Dakota, Upper Great Lakes Transportation Institute and Department of Agricultural Economics, North Dakota Agricultural Experiment Station, Norht Dakota State University, Upper Great Lakes Transportation Institute Report No. 46, Agricultural Economics Report No. 161, September 1982.

Payne, W. F., Baumel, C. P. and Moser, D. E., Estimating Truck Transport Costs for Grain and Fertilizer, University of Missouri-Columbia, College of Agriculture, Agricultural Experiment Station, Research Bulletin 1027, June 1978.

3.7 Presentation of Preliminary Results

After all interviews were completed and all cost information was collected, the ranges of costs were recorded and representative cost figures were chosen for each synthetic plant. Output, fixed, variable and total costs per year and per 10 lb. bag were calculated. Preliminary cost results were then presented to a group meeting of several of the plant owners/managers interviewed. Assumptions and estimates for each cost category and each plant size were discussed. Suggested changes were incorporated into the final cost analyses.

3.8 Methods to Calculate Output and Costs

Costs are analyzed from three perspectives, packing plants running at: 1) full capacity; 2) varying utilization and 3) average Michigan plant utilization as described in Chapter II, Section 2.3. The methods to calculate costs for each of the three perspectives are the same, however, assumptions and estimates for each perspective are different. Assumptions and estimates for the analyses of packing plants running at varying and average Michigan utilization are explained in section 3.13.

The next section describes methods to calculate costs per year and per 10 lb. bag and assumptions for Plants #1-#4 packing at full capacity with typical equipment.

When assumptions or estimates differ between plants packing assorted packs and those packing closely sized

packs, estimates or assumptions are stated explicitly, if they are the same, they are stated only in terms of plant size. Differences between plants packing assorted packs and those packing closely sized packs include: 1) increased equipment costs; resulting in increased insurance, utilities and equipment repair costs and 2) increased labor hours to changeover between sizes.

3.9 Output of 10 lb. Bags per Season

Assumptions, estimates and examples for calculating output of 10 lb. bags per season by small and large plants follow. Output is assumed to be the same for plants packing closely sized packs as it is for plants packing assorted packs to allow comparability of costs.

Small plants with 24"-36" wide packing lines pack 4-9 pallets[4] per hour and 1 - 2 1/2 semiloads per day when running at full capacity. Most small plants packed 5-6 pallets per hour. Representative estimates of 5 pallets per hour and 1.875 semiloads per day are used to calculate output.

Large plants with 48" wide packing lines pack 6-12.5 pallets per hour and 3-5 semiloads per day at full capacity. Estimates of 9.5 pallets per hour and 3.56 semiloads per day are used to analyze output.

To allow direct comparisons of costs between small and large plants at full capacity, they are assumed to run the

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[4]One pallet is assumed to hold 200 10 lb. bags.

same number of hours per year; 7.5 machine hours per day, 5 days per week, 4.3 weeks per month for 8 months per year allowing for 6 vacation days over the 8 months.

Procedure:

Output of 10 lb. bags per year equals:

Number of 10 lb. bags packed in an hour x number of hours packing per day x ([number of days packing per week x number of weeks packing per month x number of months packing per year] - number of vacation days)

Calculations:

small plant (5 pallets of 200 bags each per hour) x 7.5 hours per day x ([5 days per week x 4.3 weeks per month x 8 months per year] - 6 days vacation) = 1,245,000 10 lb. bags per year

large plant (9.5 pallets of 200 bags each per hour) x 7.5 hours per day x ([5 days per week x 4.3 weeks per month x 8 months per year] - 6 days vacation) = 2,365,500 10 lb. bags per year

average MI small plant (3.75 pallets of 200 bags each per hour) x 8 hours per day x ([3 days per week x 4.3 weeks per month x 6 months per year] - 0 days vacation) = 464,400 10 lb. bags per year

average MI large plant (6 pallets of 200 bags each per hour) x 7.5 hours per day x ([5 days per week x 4.3 weeks per month x 8 months per year] - 6 days vacation) = 1,494,000 10 lb. bags per year

3.10 Method to Calculate Percent Output Value

Total costs per year are calculated for each cost category. Since packing plants produce several joint products; U.S. No. 1, Unclassified and B size potatoes, only a part of total costs is assigned to each product. For simplification, all U.S. No. 1 potatoes are assumed to be

packed in 10 lb. bags. Packers interviewed suggested approximately 80% of round white potatoes are U.S. No. 1 grade, 9% Unclassified, 7% B size and 4% are culls. Percentages vary depending on variety, cultivation practices and environmental influences.

Total costs could be assigned to various outputs based solely on the weight of each grade packed. If only costs were to be considered, this might be the most reasonable assumption. From a broader marketing perspective, different grades and sizes have different values in the market. U.S. No. 1 potatoes sell for more than Unclassified potatoes or B size potatoes. Absolute price differences between grades vary, but prices tend to move together.

Assigning costs on the basis of weight puts a relatively high cost on the low priced packs. On the other hand, to assign no cost to the low priced packs would be misleading. Assigning costs relative to the percent of total output value of each pack results in an assignment of costs in between the aforementioned extremes. The following technique was used to assign a percent of output value for each pack:

1. Determine percent of potatoes onto line which are U.S. No. 1, Unclassified, B size and culls from interviews.

2. Multiply the price per pound for U.S. No. 1's, Unclassified and B size times the pounds of each in a 100 lb. sample.

3. Sum to arrive at amount received for the entire 100 lbs.

4. Divide the amount received for each grade by the total for 100 lbs. to arrive at the percent of output value for each grade.

Calculations:

1. Of 100 lbs. of potatoes from storage approximately:

Weight	Category		Price per lb.		Value
80 lbs.	are U.S. No. 1	x	$0.075 per lb.	=	$6.00
9 lbs.	are Unclassified	x	$0.04 per lb.	=	$0.36
7 lbs.	are B size	x	$0.02 per lb.	=	$0.14
4 lbs.	are culls	x	$0.00 per lb.	=	$0.00
			Value for 100 lbs.	=	$6.50

Percent Value for Each Category

U.S. No. 1	$6.00/$6.50 = 0.92 x 100	= **92.0%**
Unclassified	$0.36/$6.50 = 0.055 x 100	= 5.5%
B size	$0.14/$6.50 = 0.022 x 100	= 2.2%
	Total Value = 99.7%[5]	

Output of 10 lb. bags per season and percent of output value of 10 lb. bags are used in the rest of the calculations to convert annual costs to costs per 10 lb. bag. Annual costs are first categorized as a shared or direct input into the packing of 10 lb. bags. Annual costs of those inputs which are shared; such as the grading table and workers' wages at the grading table, (since they grade all potatoes, not just U.S. No. 1's) are multiplied by the percent of output value for 10 lb. bags, 92%. Annual costs of direct inputs such as the rotary bagger machine,

[5]Does not total to 100% due to rounding.

which in our simplified plant packs only 10 lb. bags, and the wages of the workers that run it (other packs such as 50 lb. bags are done with a separate bagging machine) are used at 100% of annual cost. Annual costs for 10 lb. bags are then divided by the number of 10 lb. bags packed in a season to arrive at the cost per 10 lb. bag.

3.11 Fixed Costs Calculations

Fixed costs include land, building, equipment, insurance, property taxes, building repairs, 50% of equipment repairs and supervisor/manager wages. The annual cost of each is determined, multiplied by the percent output value in 10 lb. bags and divided by the number of 10 lb. bags packed per year to arrive at the cost per 10 lb. bag per year.

3.11.1 Land

Land is a nondepreciable capital asset. The annual ownership cost of land is the opportunity cost of capital which could be invested in an alternative conservative investment. Investment in a T-bill, presently yielding 11%, was chosen as the alternative conservative investment. Interviews revealed land for potato packing plants is valued between $1,000-$6,600 per acre, however, $2,100 was the average value per acre used in this study. Michigan plants are located on 1/3 acre - 5 acres of land. For this study, small plants are assumed to be located on 2 acres

and large plants are assumed to be located on 3 acres. The method for calculating opportunity costs of land is as follows:

Annual ownership cost of land equals:

(Cost per Acre x Number of Acres x Interest Rate)

small plant $2,100 x 2 x 0.11 = $462.00 per year

large plant $2,100 x 3 x 0.11 = $693.00 per year

Land cost per 10 lb. bag equals:

(Cost per Year x Percent Output Value)/ Number of 10 lb. Bags Packed per Year

small plant $462.00 x 0.92/1,245,000 = $0.0003414 per 10 lb. bag

large plant $693.00 x 0.92/2,365,500 = $0.0002695 per 10 lb. bag

3.11.2 Buildings

Buildings are depreciable capital assets valued at replacement cost for this study. New price for a metal structure on a cement foundation is approximately $8.00 per square foot. Building sizes of small plants visited ranged from 4,500-9,150 square feet. Estimates used for this study are 7,000 square feet with a replacement cost of $56,000 (7,000 square feet x $8.00 per square foot) for Plant #1, which includes temporary storage space, and 8,000 square feet and $64,000 for Plant #2, allowing additional room for evenflow bulk boxes to hold small and large potatoes and temporary storage of a more diverse inventory.

Building sizes of large plants visited ranged from 9,000-13,000 square feet. Estimates used are 10,500 square feet and $84,000 for Plant #3 and 11,850 square feet and $94,800 for Plant #4.

The method to calculate annual costs and costs per 10 lb. bag for buildings is the same as the method used for equipment. An example is given in the next section. Buildings are assumed to have a 30 year useful life with a salvage value of 10% of new cost.

3.11.3 Equipment

Equipment is a depreciable capital asset. Tax laws such as investment tax credits and depreciation schedules effect the annual ownership cost of equipment. For tax purposes, under current laws, potato packing equipment can be totally depreciated in 5 years. The depreciation rate is accelerated in the early years of ownership, however, in actual practice, most equipment is neither worn out nor obsolete in 5 years. In fact, the same equipment, with regular maintenance and rebuilding, may be used for more than 10 years. Some exceptions might be the semi-automatic bagging machines and close sizing machines where technological developments may make standard equipment obsolete in the future.

For this study, where annual ownership cost is desired over the varying lifespans of equipment and buildings, a discounted cash flow technique was used which accounted for

the cost of capital, depreciation and tax benefits of a stream of depreciation and salvage value. Useful life of the equipment is assumed to be 10 years. Straight line depreciation with a salvage value of 10% of the new cost is used. A tax bracket of 25% is assumed. A 12% interest rate is used, which was representative of the rate at which the packers interviewed were borrowing capital. An example of the discounted cash flow technique used to find the annual ownership cost and the cost per 10 lb. bag for a 10 head semi-automatic rotary bagger used in the small plants follows:

Calculations:

1) Determine the present value of bagger. This equals the replacement price of $32,100.

2) Determine the present value of tax shield created by stream of depreciation. This equals:

   (Total Depreciation Over the Life of the Input/Input Life Span) x The Marginal Tax Rate x The Present Value of $1.00 Received Annually at the End of Each Year over the Input Life

   Total depreciation over life of the input = new price - salvage value = $32,100 - $3,210 = $28,890

   Salvage value = new price x 10% = $3210

   ($28,890/10 yrs.) x 0.25 x 5.6502 = $4080.86

3) Determine the present value of the salvage value. This equals:

   Salvage Value Received at End of the Input's Life x The Present Value of $1.00 Received in the Salvage Year

   $3210 x 0.322 = $1033.62

4) Determine the annual payment on a regular annual annuity. This equals:

   The Algebraic Sum of the Above Present Value Factors [1)-2)-3)]/The Present Value of $1.00 Received Annually at the End of Each Year for the Input Life

   ($32,100 - $4080.86 - $1033.62)/5.6502 = $4776.03

5) Determine the ownership cost per 10 lb. bag. This equals:

   (Annual Ownership Cost x Percent of Output Value[6] in 10 lb. Bags)/ Number of 10 lb. Bags Packed per Year

   ($4776.03 x 1.0)/1,245,000 = $0.0038362 per 10 lb. bag

3.11.4 Property Taxes

Property taxes are based on the assessed value of land and buildings. According to farm management specialists interviewed, Michigan's assessed value cannot exceed 50% of the market value of the land and buildings. For this study, assessed values were assumed to be 50% of market value of land and 50% of replacement cost of buildings. An annual millage rate of $44.00 per $1000 of assessed value is representative of rural property in Michigan[7]. The method to calculate annual property taxes and costs per 10 lb. bag follows:

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[6]The bagger is used solely for 10 lb. bags in this study, therefore 100% of its annual cost is assigned to the cost per 10 lb. bag. If the piece of equipment were shared with other packs, such as the grading table, the annual cost would be multiplied by 0.92, the percent output of 10 lb. bags, instead of 1.0 as in the above example.

[7]Citizens Research Council of Michigan, Outline of The Michigan Tax System, Council Comments, 625 Shelby Street, Detroit, MI, Number 954, Thirteenth Edition, page 12, May 1985.

Procedure:

1) Determine property tax per year. This equals:

   (Millage Rate per Year x Assessed Property Value)

2) Determine property tax per 10 lb. bag. This equals:

   (Property Tax per Year x Percent of Output Value in 10 lb. Bags)/Number of 10 lb. Bags Packed per Year

Calculations:

Assessed property value = 50% of market value

small plant packing:

assorted sizes $44/$1000 x ([$4,200 + $56,000] x 0.50) = $1,324.40 property taxes per year

($1,324.40 x 0.92)/1,245,000 = $0.0009787 property taxes per 10 lb. bag

closely sized $44/$1000 x ([$4,200 + $64,000] x 0.50) = $1,500.40 property taxes per year

($1,500.40 x 0.92)/1,245,000 = $0.0011087 property taxes per 10 lb. bag

large plant packing:

assorted sizes $44/$1000 x ([$6,300 + $84,000] x 0.50) = $1,986.60 property taxes per year

($1,986.60 x 0.92)/2,365,500 = $0.0007726 property taxes per 10 lb. bag

closely sized $44/$1000 x ([$6,300 + $94,800] x 0.50) = $2,224.20 property taxes per year

($2,224.20 x 0.92)/2,365,500 = $0.0008651 property taxes per 10 lb. bag

3.11.5 Insurance

Buildings and equipment are insured together. The annual insurance cost is a rate for the particular type of property times the property value. A rate of $0.47 per $100 replacement value of equipment and buildings was found to be representative in Michigan. The method to calculate insurance costs per year and costs per 10 lb. bag follows.

Procedure:

1) Determine insurance cost per year. This equals:

   (Rate per Year x Value of Assets)

2) Determine insurance cost per 10 lb. bag. This equals:

   Insurance Cost per Year x Percent of Output Value in 10 lb. Bags)/Number of 10 lb. Bags Packed per Year

Calculations:

small plant packing:

assorted sizes ($0.47/$100) x $155,114 = $729.04 per year

$729.04 x 0.92/1,245,000 = $0.0005387 per 10 lb. bag

closely sized ($0.47/$100) x $198,264 = $931.84 per year

$931.84 x 0.92/1,245,000 = $0.0006886 per 10 lb. bag

large plant packing:

assorted sizes ($0.47/$100) x $282,600 = $1,328.22 per year

$1,328.22 x 0.92/2,365.500 = $0.0005166 per 10 lb. bag

closely sized ($0.47/$100) x $336,350 = $1,580.85 per year

$1,580.85 x 0.92/2,365.500 = $0.0006148 per 10 lb. bag

3.11.6 Building Repairs

Building repairs are assumed to be a percentage of replacement cost per year. Repair costs per year increase with building age, however, an average estimate is repairs are approximately 2% of the replacement cost per year. Building repair estimates for plants visited ranged from $100-$3,500 per year. The method to calculate annual repair costs and costs per 10 lb. bag follows:

Procedure:

1) Determine repair cost per year. This equals:

   New Price of Building x 2% per Year

2) Determine repair cost per 10 lb. bag. This equals:

   (Repair Cost per Year x Percent Output Value in 10 lb. Bags)/Number of 10 lb. Bags Packed per Year

Calculations:

small plant packing:

assorted sizes $56,000 x 0.02 = $1,120 per year

($1,120 per year x 0.92)/1,245,000 = $0.0008276 per 10 lb. bag

closely sized $64,000 x 0.02 = $1,280 per year

($1,280 per year x 0.92)/1,245,000 = $0.0009459 per 10 lb. bag

large plant packing:

assorted sizes $84,000 x 0.02 = $1,680 per year

($1,680 per year x 0.92)/2,365,500 = $0.0006534 per 10 lb. bag

closely sized $94,800 x 0.02 = $1,896 per year

($1,896 per year x 0.92)/2,365,500 = $0.0007374 per 10 lb. bag

3.11.7 Equipment Repairs

Equipment repair costs depend on the age of equipment, hours of use and its complexity. Equipment may have certain worn parts replaced before the new packing season begins to avoid possible breakdowns during the season. This repair does not depend directly upon the number of hours the machine is used during the season. To account for these repairs, fifty percent of the annual repairs are assumed to be fixed costs. The other fifty percent of equipment repairs are assumed to be dependent on the hours of use per season.

Basing repair costs on a percentage of new price allows the complexity of the machine to be considered, since more complex machines are usually more expensive. For this study, 1.5% of the new price per year approximated fixed repair costs. The method to calculate fixed equipment repair costs per year follows:

Procedure:

1) Determine repair cost per year. This equals:

   New Price of Equipment x 1.5% per Year

2) Determine repair cost per 10 lb. bag. This equals:

   (Repair Cost per Year x Percent Output Value[8] in 10 lb. Bags)/Number of 10 lb. Bags Packed per Year

Calculations:

small plant packing:

assorted sizes $99,114 x 0.015 = $1,486.71 per year

($1,486.71 per year x 0.92)/1,245,000 = $0.0010986 per 10 lb. bag

closely sized $134,264 x 0.015 = $2013.96 per year

($2013.96 per year x 0.92)/1,245,000 = $0.0014882 per 10 lb. bag

large plant packing:

assorted sizes $198,600 x 0.015 = $2,979 per year

($2,979 per year x 0.92)/2,365,500 = $0.0011586 per 10 lb. bag

closely sized $241,550 x 0.015 = $3,623.25 per year

($3,623.25 per year x 0.92)/2,365,500 = $0.0014092 per 10 lb. bag

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[8]One hundred percent of the annual repair costs for equipment used only for packing 10 lb. bags should be included in repair costs. However, the difference is likely to be small on a per unit basis compared to the complexity of making the calculation for each piece of equipment. Ninety two percent of all equipment repairs will be assigned to the cost per 10 lb. bag.

3.11.8 Supervisor/Manager Labor

Potato packing plants are usually managed or supervised by an owner or employee working year round. During the packing season this person will work more hours than other workers managing the plant, making repairs and preparing for the next day's work. Supervisor/manager wages are assumed to be a fixed cost, not dependent on the hours of operation of the packing line.

The supervisor/manager is assumed to work 10 hours per day, 5 days per week for 8 months, with 6 vacation days. Small and large plants have only one supervisor/manager. Supervisor/manager wages ranged from $5.00 to $10.00 per hour in small plants with an average of $6.65 per hour. Their wages ranged from $4.00 to $10.00 per hour in large plants with an average of $7.75 per hour.

Non-wage expenses such as social security, unemployment insurance and worker's compensation ranged from 10.05% to 30.05% of the hourly wage, averaging approximately 20.05%. Since the supervisor/manager oversees all packs produced, only 92% of the total supervisor/manager cost per year was assigned to the costs for 10 lb. bags. The method to calculate supervisor/manager costs per year as well as per 10 lb. bag follows:

Procedure:

1) Determine supervisor/manager costs per year. This equals:

   (Number of Managers for Plant x Number of Hours Worked per Year x Wage Rate) + (Supervisor/Manager Cost per Year x Percentage Non-wage Cost)

2) Determine supervisor/manager costs per 10 lb. bag. This equals:

   (Supervisor/Manager Cost per Year x Percent Output Value in 10 lb. Bags)/Number of 10 lb. Bags Packed per Year

small plant 1 person x 1714 hours per year x $6.65 per hour = $11,398.10 wage cost per year

$11,398.10 per year x 0.2005 = $2285.32 non-wage cost per year

$11,398.10 per year + $2285.32 non-wage cost per year = $13,683.42 total supervisor/manager cost per year

$13,683.42 per year x 0.92/1,245,000 = $0.0101114 per 10 lb. bag

large plant 1 person x 1714 hours per year x $7.75 per hour = $13,283.50 per year
$13,283.50 per year x 0.2005 = $2663.34 non-wage cost per year

$13,283.50 per year + $2663.34 non-wage cost per year = $15,946.84 total supervisor/manager cost per year

$15,946.84 per year x 0.92/2,365,500 = $0.0062021 per 10 lb. bag

3.11 Variable Costs

Variable costs are costs which vary as output levels vary; utilities, forklift fuel, 50% of equipment repairs,

transport, materials, labor and operating capital. Utilities and operating capital are actually semi-variable costs since they do not vary proportionally as output levels change. However, for this study, utilities are treated as variable costs, a given cost per month multiplied times the months of operation. Operating capital, on the other hand, is treated as a once a season start up cost. Variable costs are calculated on an annual basis as well as per 10 lb. bag.

3.11.1 Utilities

Utilities include gas, oil and electricity for heat, lights and equipment. Utilities costs are likely to vary greatly month to month due to heating costs. Costs obtained from packers were monthly averages while the plant was running at full capacity. Utility cost estimates for small plants ranged from $95-$1000 per month. This study uses an estimate of $675.00 per month for Plant #1. Additional equipment in small and large plants packing closely sized packs requires more electrical engine horsepower, therefore an additional $100.00 per month is allowed for Plant #2. Large plant estimates ranged from $273-$2,277 per month. This study uses an estimate of $1,200 per month for Plant #3 and an additional $200.00 per month for Plant #4. The method to calculate utility costs per year as well as costs per 10 lb. bag follows:

Procedure:

1) Determine utility cost per year. This equals:

   Monthly Cost of Utilities x Months Packing

2) Determine utility cost per 10 lb. bag. This equals:

   Utility Cost per Year x Percent of Output Value in 10 lb. bags/Number of 10 lb. Bags Packed per Month

Calculations:

small plant packing:

assorted sizes $675 per month x 8 months = $5,400 per year

$5,400 per year x 0.92/1,245,000 = $0.0039904 per 10 lb. bag

closely sized $775 per month x 8 months = $6,200 per year

$6,200 per year x 0.92/1,245,000 = $0.0045815 per 10 lb. bag

large plant packing:

assorted sizes $1,200 x 8 months = $9,600 per year

$9,600 per year x 0.92/2,365,500 = $0.0037337 per 10 lb. bag

closely sized $1,400 x 8 months = $11,200 per year

$11,200 per year x 0.92/2,365,500 = $0.0043560 per 10 lb. bag

3.12.2 Forklift Fuel

The cost of forklift fuel, propane, was considered separately. A forklift runs approximately 8 hours on a tank of propane and costs about $8.00 per tank, thus the cost for fuel is approximately $1.00 per hour per forklift. Typical large plants have two forklifts, making the fuel cost $2.00

per hour. The method to calculate costs per year as well as costs per 10 lb. bag for forklift fuel follows:

Procedures:

1) Determine forklift fuel cost per year. This equals:

   Fuel Cost per Hour x Hours of Operation per Year

2) Determine forklift fuel cost per 10 lb. bag. This equals:

   Fuel Cost per Year x Percent Output Value in 10 lb. Bags/ Number of 10 lb. Bags Packed per Year

Calculations:

small plant — $1 per hour x 1245 hours per year = $1,245 per year

$1,245 per year x 0.92/1,245,000 = $0.0009200 per 10 lb. bag

large plant — $2 per hour x 1245 hours per year = $2,490 per year

$2,490 per year x 0.92/2,365,500 = $0.0009684 per 10 lb. bag

3.12.3 Equipment Repairs

As discussed above, 50% of equipment repairs are considered fixed costs. The remaining 50% are considered variable costs, dependent on the hours of operation of the equipment. When the plant is running at 100% capacity of utilization, 1245 machine hours (7.5 machine hours per day, 5 days a week for 8 months, allowing 6 vacation days), total equipment repair cost per year is estimated at 3% of the new price of the equipment. Each hour the equipment is run less (more) the variable repair cost decreases (increases).

Variable equipment repair cost is calculated as a percentage of 100% utilization, 1245 hours, to account for this. The method to calculate variable equipment repair costs per year when the plant operates for 6 months (at 75% of full capacity) follows:

Procedure:

1) Determine variable repair cost per year. This equals:

   New Price of Equipment x 1.5% per Year x (Number of Hours Equipment is Run/1245 Hours)

2) Determine variable repair cost per 10 lb. bag. This equals:

   (Repair Cost per Year x Percent Output Value[9] in 10 lb. Bags)/Number of 10 lb. Bags Packed per Year

Calculations:

small plant packing:

assorted sizes	$99,114 x 0.015 x 937.5/1245 = $1,119.51 per year
	($1,119.51 per year x 0.92)/1,245,000 = $0.0008273 per 10 lb. bag
closely sized	$134,264 x 0.015 x 937.5/1245 = $1,516.36 per year
	($1,516.53 per year x 0.92)/1,245,000 = $0.0011207 per 10 lb. bag

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[9]One hundred percent of the annual repair costs for equipment used only for packing 10 lb. bags should be included in repair costs. However, the difference is likely to be small on a per unit basis compared to the complexity of making the calculation for each piece of equipment. Ninety two percent of all equipment repairs will be assigned to the cost per 10 lb. bag.

large plant packing:

assorted sizes $198,600 x 0.015 x 937.5/1245 = $2,243.22 per year

($2,243.22 per year x 0.92)/2,365,500 = $0.0008724 per 10 lb. bag

closely sized $241,550 x 0.015 x 937.5/1245 = $2,728.35 per year

($2,728.35 per year x 0.92)/2,365,500 = $0.0010611 per 10 lb. bag

3.12.4 Transport

An average of approximately 13.5% of potatoes packed in small plants are transported to the plant from offsite storages. The range was from 0% to 40% for individual plants. Distance transported ranged from 1/4 mile - 3 miles and 1.375 miles was used for this study.

An average of approximately 17.5% of the potatoes packed in large plants are transported to the plant from offsite storages. The range was from 0% to 70% for individual plants. Distance transported ranged from 1/4 mile - 30 miles, however, 3 miles was used for this study. Estimates of transport cost per hundredweight per mile ranged from $0.002-$0.17 and $0.009 per hundredweight per mile was used for this study after consulting transportation cost studies. The method to calculate transport costs per year as well as transport costs per 10 lb. bag follows:

Procedure:

1) Determine cwt transported per year. This equals:

   Cwt U.S. No. 1's Packed Out per Year [80% of Cwt onto Line] x 1.25) x Percent of Total Potatoes Transported from Offsite Storage

2) Determine transport cost per year. This equals:

   Cwt Transported per Year x Miles Transported x Transport Rate per Cwt per Mile

3) Determine transport cost per 10 lb. bag. This equals:

   Transport Cost per Year x Percent of Output Value in 10 lb. Bags)/Number of 10 lb. Bags Packed per Year

Calculations:

small plant

(124,500 x 1.25) x 13.5% transported = 21,009.38 cwt per year

21,009.38 x 1.375 miles x $0.009 per mile = $259.99 per year

($259.99 x 0.92)/1,245,500 = $0.0001921 per 10 lb. bag

large plant

(245,500 x 1.25) x 17.5% transported = 53,703.13 cwt per year

53,703.13 x 3 miles x $0.009 per mile = $1,347.12 per year

($1,347.12 x 0.92)/2,365,500 = $0.0005434 per 10 lb. bag

Sensitivity analysis of the effect of increased transport distances on total costs per 10 lb. bag for large plants with typical equipment was performed. Only distance transported was changed while other estimates remained

unchanged. Distances used were 3, 6, 10, 20, 30 and 50 miles.

3.12.5 Materials

Materials to pack 10 lb. bags of potatoes include paper bags with a mesh viewing vent on the back, string to sew the bag closed and plastic mesh to wrap around the stacks of bagged potatoes on pallets. No allowance is made for the fact that larger plants may purchase in sufficient quantities to receive a lower per unit price than smaller plants may receive. Both large and small plants are assumed to purchase truckload bundles of 100,000 bags at a price of approximately $80/1000 bags. 12/5 cotton string is sold on 20 lb. spools for approximately $2.40 per pound. Pallet mesh is sold in 6000′ x 20" rolls for $75.00 per roll. The method to calculate materials costs per 10 lb. bag as well as per year follows:

Procedures:

1) Determine materials cost per 10 lb. bag. This equals:

   Price per Sales Unit/Number of 10 lb. Bags a Sales Unit Will Pack

2) Determine materials cost per year. This equals:

   Materials Cost per 10 lb. Bag x Number of Bags Packed per Year

Calculations:

1) Cost per 10 lb. bag:

Bags $80.00/1000 10 lb. bags = $0.08 per 10 lb. bag

String 12/5 cotton $2.40 per lb./1347.2 bags sewn per lb. = $0.0017815 per bag

Mesh Pallet Wrap

pallets per roll 6000 ft. per roll/70 ft. per pallet (wrapped 4 times with 20" wide mesh) = 85 pallets per roll

cost per pallet $75.00 per roll/85 pallets = $0.88 per pallet

cost per 10 lb. bag $0.88 per pallet/200 10 lb. bags per pallet = $0.0044 per 10 lb. bag

Total cost for materials per 10 lb. bag equals:

$0.08 + $0.00171815 + $0.0044 = $0.08618815

2) Cost per year

small plant $0.08618815 x 1,245,000 = $107,304.25

large plant $0.08618815 x 2,365,500 = $203,878.07

3.12.6 Labor

Small plants in Michigan are operated with 7-9 workers, including one supervisor/manager. Both Plants #1 and #2 are assumed to be operated by 9 workers, including one supervisor/manager. Large plants are operated with 10-22 workers and in this study are assumed to be operated by 17 workers, including one supervisor/manager. Workers are divided into direct and shared labor. This distinction is made to assign 100% of the labor costs of those working directly on 10 lb. bags to the cost per 10 lb. bag. Only 92% of shared

labor costs are assigned to the cost per 10 lb. bag, based on the percent of output value for 10 lb. bags calculated above.

Direct labor includes those workers on the packing line whose task deals only with 10 lb. bags; those at the rotary bagger, bag hanger, the weight checker and the person who removes the bag from the bagger and feeds it into the sewing machine. Workers who stack 10 lb. bags onto pallets and run the forklift moving only pallets of 10 lb. bags are also included. Small plants are assumed to have 5 direct worker and large plants, 6 direct workers.

Shared labor includes workers on the packing line whose task involves more than one pack of potatoes; those moving hoppers to feed the line, graders, workers packing Unclassified potatoes and forklift drivers moving pallet boxes of B size potatoes. Small plants are assumed to have 3 shared workers and large plants, 10 shared workers. The supervisor/manager is also shared labor. His/her wage is considered a fixed cost and was discussed above.

Labor wages in small plants ranged from $3.35-$7.25 per hour and the average wage was $3.85 per hour. Labor wages in large plants ranged from $3.35-$7.00 per hour and the average wage was $4.07 per hour. Workers in small and large plants packing assorted sizes per pack are assumed to work 8 hour days. Workers in small and large plants packing closely sized packs are assumed to work 8.25 hours per day to allow additional time to switch between sizes. Non-wage

expenses such as social security, unemployment insurance and worker's compensation are approximately 20.05% of the hourly wage with a range from 10.05% to 30.05%. The method to calculate direct wage costs per year as well as per 10 lb. bag is identical for Plants #1-#4 using the appropriate figures for each. An example for Plant #1 follows.

Procedure:

1) Determine direct labor costs per year. This equals:

   (Number of Direct Workers x Number of Hours Worked per Year x Wage Rate) + (Direct Labor Cost per Year x Percentage Non-wage Cost)

2) Determine direct labor costs per 10 lb. bag. This equals:

   (Direct Labor Cost per Year x Percent Output Value in 10 lb. Bags)/Number of 10 lb. Bags Packed per Year

small plant packing:

assorted sizes

5 people x 1370 hours per year x $3.85 per hour = $26,372.50 wage cost per year

$26,372.50 per year x 0.2005 = $5,287.69 non-wage cost per year

$26,372.50 per year + $5,287.69 non-wage cost per year = $31,660.19 total supervi sor/manager cost per year

$31,660.19 per year x 1.0/1,245,000 = $0.0254299 per 10 lb. bag

Shared labor costs per year as well as per 10 lb. bag for Plants #1-#4 is calculated using the same method as above substituting appropriate figures for number of workers, hours worked and wage rates, however, in calcula-

ting shared labor cost per 10 lb. bag, labor cost per year was multiplied by the percent of output value in 10 lb. bags, 0.92, instead of by 1.0 as above for direct labor costs.

3.12.7 Operating Capital

Operating capital is the amount of money borrowed, usually at the beginning of the packing season to purchase materials, pay wages and other start up expenses until income is received. Operating capital costs per year are the costs of interest payments made over the loan period. As output increases the amount borrowed is likely to increase to cover the purchase of more materials or more than one loan may be taken out, however, the amount borrowed is unlikely to increase directly in proportion to the increased output level, which makes it a semi-variable cost. For simplicity in this study, operating capital is assumed to be a one-time cost incurred at the beginning of the packing season.

Small plants borrowed between $20,000-$35,000 at interest rates ranging from 11%-13% and the loan repayment period ranged from 1-6 months. Small plants in this study are assumed to borrow $20,000 at 12% interest with a 3 month repayment period.

Large plants borrowed between $20,000-$35,000 at interest rates ranging from 11%-14% and the loan repayment period ranged from 3-7 months. Large plants in this study

are assumed to borrow $30,000 at 12% interest with a 3 month repayment period. The method for calculating operating capital costs per year as well as costs per 10 lb. bag follows:

Procedure:

1) Determine interest paid on loan. This equals:

   Amount of the Loan x (Length of Repayment Period/Number of Months per Year) x Interest Rate per Year

2) Determine operating capital per 10 lb. bag. This equals:

   (Interest Paid on Loan x Percent Output Value in 10 lb. Bags)/Number of 10 lb. Bags Packed per Year

Calculations:

small plant

$20,000 x ([3 months/12 months per yr.] x 12% per year) = $600 per year

($600 x 0.92/1,245,000 Bags per Year = $0.0004434 per 10 lb. Bag

large plant

$30,000 x ([3 months/12 months per yr.] x 12% per year) = $900 per year

($900 x 0.92)/2,365,500 Bags per Year = $0.0003500 per 10 lb. Bag

3.13 Estimates and Assumptions for Additional Cost Analysis

Previous estimates, assumptions and examples for cost calculations were for plants running at full capacity of plant utilization. Methods to calculate costs for varying and average Michigan utilization are the same except

for some changes in the assumptions and estimates upon which the calculations are based. Changes in estimates and assumptions which are made are described in detail below.

3.13.1 Full Capacity with the Same Types of Equipment

Seven pieces of equipment are eliminated from the large plants and a simpler piece of equipment is substituted for a complex piece of equipment resulting the same types of equipment in both large and small plants. Equipment eliminated from the large plants includes; Item #2, metal roller conveyor (Figure 5, Chapter IV), Item #4, soak tank, Item #5, draper chain elevator, Item #8, hot air dryer, Item #12, roll sizer, Item #15, rubber belt conveyor, Item #16, accumulation table and Item #17, one forklift. A two chute manual bagger is substituted for Item #10, two head semi-automatic 50 lb. bagger.

Eliminating equipment lowers the new price for equipment for Plant #3 from $198,600 to $111,875, for Plant #4 from $241,550 to $154,825. The new price of equipment for small plants remains unchanged. All other assumptions and estimates are the same as those for the large and small plants with typical equipment.

3.13.2 Varying Utilization

In the analysis, the packing season length increases by one month increments from 2 to 10 months. Changing the number of months of the packing season changes machine

hours, labor hours and output of 10 lb. bags per year and all variable costs, while fixed costs, by definition, remain the same.

3.13.3 Average Michigan Utilization

Several changes are made to incorporate Michigan averages for small and large plants. Figures are averages of the estimates of small and large plant owners/managers interviewed. Changes for the small plants include: The number of pallets per hour for the small plants decrease from 5 pallets (1000 10 lb. bags) to 3.75 pallets (750 10 lb. bags) per hour. Machine hours of operation increase from 7.5 to 8 hours per day. The average for small plants in Michigan over the entire packing season is approximately 1.6 versus 1.875 semiloads per day assumed for full capacity small plants.

Worker hours per day increase from 8 to 9 hours per day in plants packing assorted packs and from 8.25 to 9.33 hours per day in plants packing closely sized packs. Supervisor/manager hours per day remain at 10 hours per day. Days packing per week decrease from 5 days to 3 days per week reducing utility costs from $675 to $576 per month for the small plants packing assorted packs and from $775 to $640 per month for small plants packing closely sized packs because of reduced equipment operation. Months packing per year decrease from 8 months per year to 6 months per year. The number of vacation days decrease from 6 to 0 days,

since the plant is operating an average of only 3 days per week.

The resulting changes for small plants are the output of 10 lb. bags per year decreases from 1,245,000 to 464,400 bags. Machine hours and worker hours per year decrease respectively, from 1245 to 619.2 hours and 1370 to 696.6 hours in plants packing assorted packs and from 1413 to 722.14 hours in plants packing closely sized packs. Forklift fuel costs decrease to $619.20 from $1245 per year. Supervisor/manager hours per year decrease from 1714 to 774 hours per year.

Changes for large plants include: The number of pallets per hour for the large plants decrease from 9.5 pallets (1900 10 lb. bags) to 6 pallets (1200 lb. bags) per hour. The machine hours of operation per day remain at 7.5 hours per day. The average for large plants in Michigan over the entire packing season is approximately 2.25 versus 3.56 semiloads per day for full capacity large plants. Forklift fuel costs decrease to $1245 from $2,490 per year. Worker hours per day remain at 8 hours per day in plants packing assorted packs and 8.25 hours per day in plants packing closely sized packs. Supervisor/manager hours per day remain at 10 hours per day. The days packing remain at 5 days per week and months packing at 8 per year. The number of vacation days remain at 6 days.

The resulting changes for large plants are the output of 10 lb. bags per year decreases from 2,365,500 to

1,494,400 bags. Machine hours and worker hours per year remain, respectively, 1245 and 1370 hours in plants packing assorted packs and 1413 hours in plants packing closely sized packs. Supervisor/manager hours per year stay at 1714 hours.

CHAPTER IV

RESEARCH FINDINGS

This chapter provides a general description of the Michigan potato packing industry, describes grades, sizes and packs of round white potatoes in Michigan and other states as well as activity stages and equipment used to pack round white potatoes in Michigan and discusses grading and sizing out of storage versus pre-storage sizing.

4.1 The Michigan Potato Industry

The decentralized and fragmented nature of the Michigan potato packing industry is due in part to; potato farm size, varieties of potatoes produced in different regions of the state as well as locations of potato processing facilities. This discussion, therefore, focuses on both the potato production and packing industries in Michigan.

4.1.1 Michigan Potato Production Industry

Michigan grows primarily round white and russet potatoes, although some specialty potatoes such as golden flesh potatoes are also grown. Michigan potatoes have three primary uses: 1) processing: frozen, chipping and canning; 2) seed and 3) fresh tablestock.

This study is concerned primarily with fall tablestock varieties of round white potatoes, but there are other potatoes which are important in the Michigan fresh tablestock market. In the summer months "new" potatoes enter the tablestock markets. They are round white varieties which are harvested, washed, packed and shipped directly to market.

Summer potatoes account for 16% of the total production in Michigan or about 2.3 million hundredweight[1]. They are produced in one of Michigan's two leading potato producing counties, Bay County, on the east central side of the lower peninsula (Figure 1, Region 4). They compete with fall varieties in the fresh market only during the late summer months when their harvests overlap.

The Russet Burbank potato is another competitor of fall varieties of round white potatoes in the fresh tablestock market. This is a fall variety with good storage characteristics. Fall varieties, including both russet and round white varieties, account for about 84% of the total production in Michigan. Approximately 4.9 million hundredweight of fall variety round white potatoes are grown in

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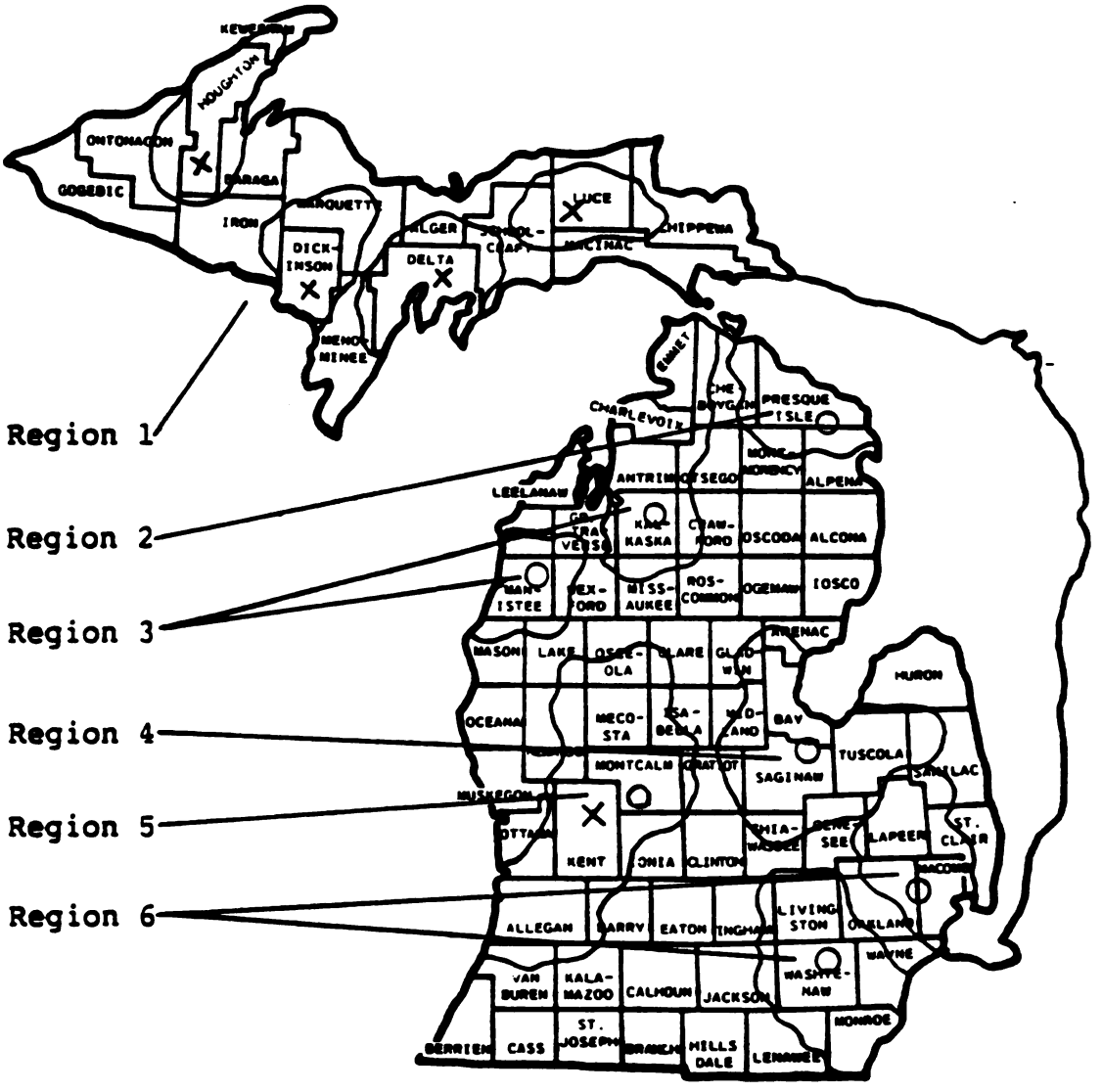
[1]Michigan Department of Agriculture, Michigan Agricultural Statistics, 1984.



X = Russet Production

○ = Round White Production

Figure 1. Michigan Potato Production and Packing Regions.

Michigan as compared to approximately 7.2 million hundredweight of Russet Burbanks[2].

However, more than 90% of Michigan Russet Burbanks are used for processing and seed[3]. This leaves less than 10%, or approximately 0.72 million hundredweight, of Michigan russet potatoes to be sold as tablestock. Approximately 60%, or 2.94 million hundredweight, of fall varieties of round white potatoes are sold as tablestock with the remaining 40% sold for processing and seed[4]. Michigan round white tablestock potatoes outnumber Michigan russet tablestock potatoes fourfold, but out-of-state russets also compete in the tablestock market.

Most Russet Burbanks sold in the fresh tablestock market are closely sized into strippers and count packs (Table 4). Count packs are usually sold to restaurants and

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[2]An estimated 14.4 million hundredweight of potatoes are grown in Michigan according to Michigan Agricultural Statistics, 1984. Approximately 50% of these are Russet Burbanks according to the Executive Director of the Michigan Potato Industry Commission. The remaining 50% is divided between approximately 16% summer and 34% fall varieties of round white potatoes. The above figures were arrived at by multiplying the indicated percentages times the estimated Michigan production.

[3]Estimate by the Executive Director of the Michigan Potato Industry Commission.

[4]Dr. Richard Chase, Professor of Crop and Soil Science at Michigan State University, estimates 6-8% of the fall varieties of round white potatoes are used for seed. Approximately 35% of the remaining potatoes are used for chips and approximately 65% are for tablestock uses. Multiplying these percentages times the estimated 4.9 million hundredweight of fall varieties of round white potatoes grown in Michigan results in approximately 2.94 million hundredweight or 60% of fall round white potatoes for tablestock use.

Table 4. U.S. Standards: Size Designation for Count Packs

Size Designation	Minimum Weight	Maximum Weight
	Oz.	Oz.
Under 50	15	--
50	12	19
60	10	16
70	9	15
80	8	13
90	7	12
100	6	10
110	5	9
120	4	8
130	4	8
140	4	8
Over 140	4	8

Minimum or minimum and maximum sizes may be specified in terms of diameter or weight or in accordance with Table 5 or Table 4. If used in connection with U.S. Extra No. 1, must not conflict with basic size for that grade.

The size designations shown in Table 4 may be packed in any size container provided weight ranges are within the limits specified. Example: 25-50 count (size) potatoes per carton would have to meet the weight range for 50 count.

Count packs in 50 lb. cartons shall meet weight ranges in Table 4.

Source: Michigan Potato Industry Commission, Potato Graders Handbook, Lansing, Michigan, 1985.

institutions. Strippers are usually packed in 5 and 10 lb. bags and sold in retail stores alongside 5 and 10 lb. bags of round white potatoes. Stripper and count pack russets are round white potatoes' major competitor in the fresh tablestock market.

Michigan russets may become increasingly more competitive as more packers begin to closely size russets which have a distinct freight advantage to midwest and eastern densely populated areas over russets from northwestern states. Increased quantities of lower priced Michigan russets may enter the market as Michigan expands its russet acreage. Although russet varieties have typically been more expensive than round white potatoes, they offer uniform sizing which is a characteristic desired by consumers, particularly the institutional trade[5].

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5 [5]Kelly, R. A., et al., Relationship of Price and Quality of Potatoes at Retail Level, Agricultural Experiment Station, University of Minnesota, North Central Regional Publication No. 16, page 28, June 1950.

Michigan Department of Agriculture, Marketing Uniform Sized Michigan Potatoes: What Do Consumers Say?, Marketing Section, Foods and Standards Division, page 9, September 1960.

The Potato Board, An Analysis of Potato Usage, Perceptions and Buying Attitudes by the Household User, The Potato Board, Denver, Colorado, page 2, January 1976.

4.1.2 Michigan Potato Packing Industry

The potato packing industry in Michigan is composed of many independently owned packing plants[6]. There are no published statistics, but the Chairman of the Michigan Fresh Tablestock Potato Committee estimates there are approximately 100 potato packing plants in Michigan. Nearly all are owned and operated by potato growers, usually on the farm site. Exceptions are two large packing plants. They both began as commercial operations designed to pack potatoes for producers without their own packing facilities. One is now owned by a group of growers, the other by non-growers.

The majority of potatoes packed are the farmer/packer's own. In some years, additional potatoes from neighboring growers or out-of-state may be packed. Packing is done either for a charge per hundredweight (cwt) or the potatoes are purchased outright by the packer. As the supply of Michigan storage potatoes runs out in late April, California potatoes in 100 lb. sacks may be repacked in consumer size packs for retail chains by some of the larger packers.

Sizes of packing operations run from small packing plants which pack less than 1 semiload per 8 hour day to larger packing plants which pack up to 5 semiloads per 8 hour day at full capacity. Both round white and russet

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[6]For the purposes of this study; a potato packing plant is an operation which is set up to pack fresh tablestock potatoes into 3 lb., 5 lb., 10 lb. and larger bags. Those operations which pack only 50 lb. or 100 lb. bags are thus excluded.

potatoes are packed, however a packing plant usually packs one or the other type.

Potato packing operations take place throughout the state, but some regions have a more concentrated industry and/or tend to have larger packing facilities than others. Varieties packed and packing season lengths also differ from region to region. Packing plants in russet growing regions of the state, the midwestern counties of the lower peninsula (Figure 1, Region 5) and the upper peninsula (Region 1), tend to be fewer and larger than packing plants in the summer round white potato growing region in the mideastern counties of the lower peninsula (Region 4). The northeast region of the lower peninsula (Region 2) has many small packing plants. The northwest region of the lower peninsula (Region 3) is primarily composed of seed potato growers with one large packing plant. The southeast region of the lower peninsula (Region 6) has a mixture of large and small packing plants. There are also a few isolated potato growers in other counties who run small packing plants.

Michigan russet packing operations are meeting marketing challenges of closely sized russets produced in western states by installing their own close sizing or count pack machines. These plants may offer more than twelve different sizes and/or grades of packs to their customers. Round white packers, on the other hand, do

not employ close sizing, but may separate out the "jumbo"[7] potatoes either by hand or machine. They typically offer about six different sizes and/or grades of packs to their customers (Section 4.5).

The potato packing industry in Michigan is decentralized and composed of many independent operations. Both round white and russet potatoes are packed, but the number of round white packing plants far exceeds the number of russet packing plants. This is due, in part, to the greater quantity of round white potatoes sold to the fresh market, also, russet packing plants are typically larger.

The relatively smaller size of round white versus russet packing plants also holds true in other states. In states which produce primarily or exclusively russet potatoes, packing industries tend to be centralized and composed of a few large packing plants. The economics of more complicated and thus more expensive equipment to pack russet potatoes into count packs may have dictated development of larger packing plants. Round white packers in Michigan and other states have not been faced with the same economic necessity and have, in many cases, preferred to maintain their independence from other packers.

Trends over the past ten years for sizes of packing lines and types of packs were summarized by John Johnson[8] of

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[7]"Jumbo" or "Chefs" is a term applied to large potatoes usually greater than 3 to 3 1/2 inches in diameter.

[8]Letter to the author, July 1985.

Lockwood Corporation, an international equipment manufacturer with headquarters in Gering, Nebraska. He stated:

> "The changes that have been going on during the past 10 years seem to be for equipment with more capacity. The average warehouse line we produce will handle 5000 cwt/day - 10 semiloads. The trend has also been for count carton - 60-70-80-90-100 count boxes - [as a] result of [the use of potatoes by] Wendy's, Arby's, etc."

4.2 Grading and Sizing Practices

Grading and sizing practices for round white potatoes in Michigan have been established by federal laws, voluntary state standards, historical precedent and innovation on the part of some packers. Federal standards for grades of potatoes set minimum standards and define grades and sizes commonly used throughout the United States (Table 5).

4.2.1 Federal and State Standards for Grades of Potatoes

The United States Department of Agriculture, Agricultural Marketing Service, has established "United States Standards for Grades of Potatoes", Revised, Effective February 5, 1972. The original standards were established in 1958. This publication sets forth and defines: 1) grades; 2) unclassified; 3) sizes; 4) tolerances for defects and off-size; 5) application of tolerances and 6) sampling procedures for grade and size determination. Provisions of the Federal Food, Drug and Cosmetic Act or applicable state laws and regulations may override federal standards.

Table 5 . U.S. Standards: Size Designation

U.S. Extra No. 1

2 1/4 inches or 5 ounces minimum and shall not vary more than 1 1/4 inches (if reported in diameter) or 6 ounces (if reported in weight).

U.S. No. 1

1 7/8 inches minimum unless otherwise specified with grade. "U.S. No. 1, 1 1/2 inch minimum."

U.S. No. 2

1 1/2 inches minimum unless otherwise specified.

Size Designation	Minimum Diameter[1] or Weight		Maximum Diameter[1] or Weight	
	In.	Oz.	In.	Oz.
Size A[2]	1 7/8	(3)	(3)	(3)
Size B	1 1/2	(3)	2 1/4	(3)
Small	1 3/4	(3)	2 1/2	6
Medium	2 1/4	5	3 1/4	10
Large	3	10	4 1/4	16

[1]Diameter means the greatest dimension at right angles to the longitudinal axis, without regard to the position of the stem end.

[2]In addition to the minimum size specified, a lot of potatoes designated as Size A shall contain at least 40% of potatoes which are 2 1/2 inches in diameter or larger or 6 ounces in weight or larger.

[3]No requirement.

Source: Michigan Potato Industry Commission, Potato Graders Handbook, Lansing, Michigan, 1985.

Additional standards for grades of potatoes, may be set by state regulations. Five states, Colorado, Northern California, Idaho, Oregon and Maine, have marketing orders which allow them to set minimum requirements for sizes and grades.[9] Michigan does not have a marketing order, however it has a Potato Industry Commission which is authorized to collect a fee per hundredweight of potatoes sold to be used for promotion and research. In addition, the Commission has attempted to establish voluntary standards for special packs of Michigan potatoes such as the "Golden Bake". Growers/packers of golden bake potatoes sign a voluntary agreement to sell and pack to specified standards which are higher than U.S. No. 1. A specific logo or "premium" label is displayed on the special packs.

4.3 Grades of Potatoes Packed in Michigan

Michigan potato packers most often pack to the U.S. No. 1 grade (Table 5) or use the Unclassified label. "Unclassified" consists of potatoes which have not been classified in accordance with any grade. The term "unclassified" is not a grade within the meaning of the standards but is provided as a designation to show that no grade has

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[9]Armbruster, W. J., Henderson, D. R. and Knutson, R. D., Federal Marketing Programs in Agriculture: Issues and Options, The Interstate Printers and Publishers, Inc., Danville, Illinois 61832, pages 128-129, 1983.

been applied to the lot.[10] Approximately 70-80% of round white potatoes meet the U.S. No. 1 grade standards, and approximately 5-12.5% are packed under the Unclassified label.[11]

In general, the Michigan industry sees a strong incentive to pack to the minimum of the U.S. No. 1 standard. This allows them to pack as large a proportion of potatoes as possible in U.S. No. 1 bags. The price received for U.S. No. 1 potatoes averages nearly twice the price received for Unclassified potatoes.

4.4 Sizes and Weights of Potatoes Packed in Michigan

Sizes and weights are specified in conjunction with each grade (Table 5). U.S. No. 1 potatoes, for example, shall not be less than 1 7/8 inches in diameter, unless otherwise specified in connection with the grade. There are no weight minimums nor size or weight maximums for the U.S. No. 1 grade. There are, however, size designations which may be specified with the grade, such as "U.S. No. 1, Small, 1 3/4 Inches to 2 1/2 Inches". Small, Medium and

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[10]United States Department of Agriculture, United States Standards for Grades of Potatoes, Agricultural Marketing Service, Washington, D. C., Section 51.1544, February 1972.

[11]Estimated by packing plant owners/managers interviewed. Variety, cultivation and environmental factors influence the grade and size of potatoes. The ranges above are estimates of average percentages.

Large size categories (Table 6) have been used in this study to designate the ranges for the closely sized packs.

Size designations most commonly used for Michigan round white potatoes are "B" size and "Jumbos". "B" sized potatoes are less than 2 1/4 inches in diameter and sold in bulk, often at a low price to canners. Approximately 3-10% of round white potatoes are "B" size. "Jumbo" potatoes are larger than 3" in diameter and may meet "Large" size specifications or be even larger than 4 1/4 inches in diameter. They may be sold to institutions or restaurants at a premium price for baking, french frying or other preparations where less peeling per cooking portion of the potato is desirable. Approximately 2.5-10% of round white potatoes are "Jumbo" size.[12]

4.5 Sizes and Types of Potato Packs in Michigan

A "pack" is a unique combination of grade, size and sales unit weight. Approximately 80% of round white potatoes in Michigan are sold as 10 lb. bags of U.S. No. 1 grade potatoes.[13] Other common packs include 20 lb. bags of U.S. No. 1 and 50 lb. bags of Unclassified. "Jumbo" potatoes are usually packed in 50 lb. bags. Approximately 10% of round white tablestock potatoes are sold as Unclassified and approximately 5% as "Jumbos".

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[12]Estimated by packing plant owners/managers interviewed.

[13]Average of estimates by packing plant owner/manager's interviewed.

Table 6. U.S. Standards for Grades of Potatoes

U.S. Extra No. 1

"U.S. Extra No. 1" consists of potatoes which meet the following requirements:

(a) Similar varietal characteristics;
(b) Firm;
(c) Clean;
(d) At least fairly well matured;
(e) Fairly well shaped, with 50% or more well shaped;
(f) Free from:
  (1) Freezing;
  (2) Blackheart;
  (3) Late blight, southern bacterial wilt and ring rot; and
  (4) Soft rot and wet breakdown;
(g) Free from injury caused by:
  (1) Sprouts; and
  (2) Internal defects;
(h) Free from damage by any other cause;
(i) Size -- The potatoes shall be not less than 2 1/4 inches in diameter or 5 ounces in weight and shall not vary more than 1 1/4 inches in diameter or more than 6 ounces in weight.

U.S. No. 1

"U.S. No. 1" consists of potatoes which meet the following requirements:

(a) Similar varietal characteristics;
(b) Firm;
(c) Fairly clean[1];
(d) Fairly well shaped;
(e) Free from:
  (1) Freezing;
  (2) Blackheart;
  (3) Late blight, southern bacterial wilt and ring rot; and
  (4) Soft rot and wet breakdown;
(f) Free from damage by any other cause;
(g) Size -- Not less than 1 7/8 inches in diameter; unless otherwise specified in connection with the grade.

U.S. No. 2

"U.S. No. 2" consists of potatoes which meet the following requirements:

(a) Similar varietal characteristics;
(b) Not seriously misshapen;
(c) Free from:
  (1) Freezing;
  (2) Blackheart;
  (3) Late blight, southern bacterial wilt and ring rot; and
  (4) Soft rot and wet breakdown;
(d) Free from serious damage by any other cause;
(e) Size -- Not less than 1 1/2 inches in diameter, unless otherwise specified in connection with the grade.

Unclassified

"Unclassified" consists of potatoes which have not been classified in accordance with any of the foregoing grades. The term "unclassified" is not a grade within the meaning of these standards, but is provided as a designation to show that no grade has been applied to the lot.

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[1] Potatoes in containers bearing official State Seed Certification Tags and Seals are not required to be fairly clean, but shall be free from damage by dirt.

Source: United States Department of Agriculture, United States Standards for Grades of Potatoes, Agricultural Marketing Service, Washington, D.C., February 1972.

4.6 Non-Traditional and Innovative Packing Practices

Several packers are packing non-traditional packs, in addition to the traditional packs described above, which range from slight variations from traditional packs to truly innovative packing. The following variations from traditional packs were discussed during interviews with packing plant owners/managers.

The grade above U.S. No. 1 is U.S. Extra No. 1 (Table 5). The previously mentioned "Golden Bake" potato is packed to this higher grade standard. Some retail chain stores have expressed an interest in a U.S. Extra No. 1 or "premium" grade round white potato, but the higher grade is not yet packed in large quantities in Michigan.

In conjunction with a higher grade is a higher minimum size per pack. Several packers already pack a 2" minimum size. Seed growers who also pack tablestock potatoes may use a 2 1/4" minimum for tablestock, selling the smaller potatoes for seed which returns a premium to the grower. Other packers create a specialty item out of "B" size potatoes. They are packed in 3-5 lb. bags and sold as "new" potatoes or "boil with the skins on" potatoes. A premium price is often received for these small potatoes.

Large potatoes are being marketed to consumers by one innovative packer in 10 lb. white corrugated cardboard boxes with attractive labeling. Other sizes of U.S. No. 1 packs include, 5, 8 and 15 lb. packs. In some cases, packaging has been changed from the traditional paper bag to

a multicolored plastic bag. Round white varieties have not been packed in count cartons, but some packers are considering this option with a premium grade product.

Nutritional labeling has become standard feature on potato bags and some packers include recipes and historical information on potatoes. All of the above examples point to packers who are taking a marketing approach to packing round white potatoes in an effort to either create new markets or maintain established markets.

A marketing orientation, in part, involves designing products with particular customers and groups in mind. Tablestock potatoes can be differentiated through washing, higher grade standards, fewer defects, larger size minimums, close sizing, packaging and advertising. Many of these were mentioned above, but one practice, close sizing, deserves more attention since it is one focus of the cost analyses of this study.

Close sizing is becoming standard practice in the fresh fruit and vegetable industry. As mentioned earlier in this chapter, most tablestock russet potatoes are closely sized. Reasons given by round white potato packers for not closely sizing round white potatoes are additional costs of sizing and market challenges of selling a different product. Chapter V addresses the cost issue. A section in Chapter VI discusses some of the marketing challenges for closely sized potatoes.

4.7 Grading and Sizing of Potatoes in Other States

Grading and sizing of round white potatoes in other states is dominated, as it is in Michigan, by packers meeting the minimum standards for U.S. No. 1 grade, although some states with marketing orders have established a 2 inch minimum size for U.S. No. 1 potatoes. There are, however, individual potato packers who take a marketing orientation in selling their products.

A few round white potato packers in Maine and New York closely size potatoes into as many as five categories: 1) less than 2 inches; 2) 2 to 2 1/4 inches; 3) 2 1/4 to 2 1/2 inches; 4) 2 1/2 to 3 1/2 inches and 5) greater than 3 1/2 inches. These are packed primarily into 5 and 10 lb. bags for sale at retail food stores with positive results of increased sales at a premium price over standard packs.[14]

4.8 Grading and Sizing of Potatoes Out of Storage

The greatest volume of potatoes are graded and sized out of storage. Very small potatoes (less than 1 1/2 inches) usually fall through the harvesting equipment and

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[14]A letter from Cornell University Professor Emeritus, Dr. Arthur Pratt, and a telephone conversation with Dr. Duane Smith, Extension Economist and Cooperating Associate Professor of the Department of Agricultural and Resource Economics, University of Maine at Orono, about, respectively, his own personal experience and the results of a market research study in Maine to be published in September 1985 have both indicated positive retailer and packer profits with respect to close sizing of tablestock potatoes.

are left in the field along with stones and debris, thus fall potatoes ranging from about 1 1/2 inches to over 4 inches are stored until a market is available for their sale.

Potatoes from storage are usually graded and sized into two or three categories: 1) minimums of 1 7/8, 2 or 2 1/4 inches (B size); 2) 1 7/8 to 3 1/2 or 4 inches (U.S. No. 1 or No. 2) and 3) greater than 3 inches (Jumbos). Then they are packed into either bags or bulk boxes and sold to wholesale/retail buyers or processors before sale to the final consumer.

4.9 Pre-storage Sizing of Potatoes

Another aspect of sizing which has been of interest to some packers considering innovative marketing is sizing potatoes before they go into storage. This practice is currently done by very few packers with specific market objectives in mind. Round white potato packers may strip off small potatoes (less than 2 to 2 1/4 inches) at harvest for either fresh market or seed purposes. Fresh market demand for so called "new" potatoes is high in summer and fall when small potatoes may be sold for a higher price than after storage when their skins harden.

Seed potato growers who also pack fresh tablestock potatoes may size out "seed size" potatoes for separate storage from tablestock potatoes. This may be done either to decrease the risk of disease contamination of seed

potatoes or because fresh packing facilities may be closer to a different storage facility. Similarly, seed potato growers who don't pack for the fresh market may size out potatoes too large for seed purposes (over 12 oz.) and sell them to fresh tablestock packers in the fall to avoid incurring storage and/or cold weather transportation costs. The above marketers have found advantages of pre-storage sizing to exceed disadvantages.

The main reasons given by the majority of packers who do not size before storage are the following: 1) extra time and labor requirements at harvest; 2) injury from additional handling; 3) storage/inventory management problems; 4) marketing disadvantages and 5) uncertainty of volumes.

During the potato harvest, most of the farm labor is hired to promptly get potatoes from the field into storage due to weather conditions. Sizing and grading potatoes as they go into storage would require additional labor and slow the process from the field to storage when time is an important factor. In contrast, grading and sizing during late fall and winter months may occupy otherwise idle labor. Packing lines may be set up in the winter adjacent to storage facilities in the aisle area, which may be needed at harvest to fill storages. Thus work space may also be a limiting factor for pre-storage sizing.

Additional handling of potatoes fresh from the field before the skins have suberized may lead to skinning and bruises which could increase disease problems during

storage. Layout of the storage facility may make inventory management of several sizes of potatoes difficult. Unless storage areas are separable and readily accessible when filled, such as would be possible with a pallet box storage system, it may be impractical to separate sizes of potatoes before storage.

4.10 Potato Packing Equipment and Activity Stages

Packing potatoes includes eight activity stages: 1) transportation from storage; 2) receiving onto the packing line; 3) pre-sizing; 4) cleaning; 5) grading; 6) sizing; 7) packaging the various grades and sizes and 8) loading bags onto pallets for temporary storage and transport to market. Figure 2 is a flow chart of potato packing activity stages specifying where each grade and/or size is separated.

Equipment used to pack potatoes will vary depending on the characteristics of an individual packing plant, such as: 1) size of the operation; 2) diversity of packs to be made and 3) proximity of the packing line to storage and loading docks. In this study, four synthetic packing plants were designed utilizing sizes of operations and equipment commonly found in Michigan packing plants. Figures 3-6 are diagrams of the equipment layouts of synthetic Plants #1-#4 with dots noting worker positions. Table 7 lists equipment dimensions and prices for Plants #1-#4. A straight line layout of equipment was used, although actual layouts were

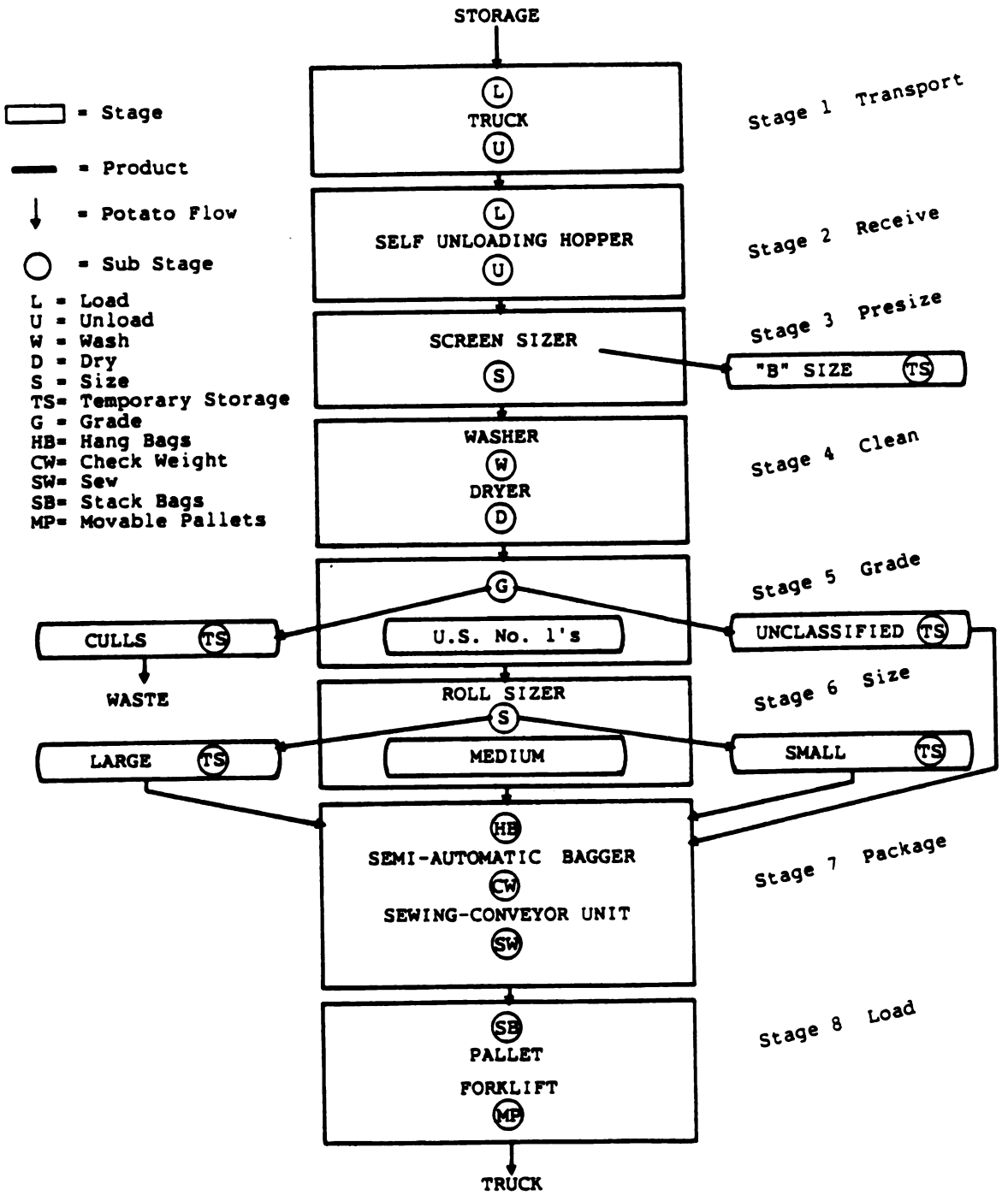

Figure 2. Potato Packing Activity Stages.

DESCRIPTION

1. Self unloading hopper
2. 24" Draper chain elevator
3. 36" Screen sizer with
   18" rubber belt conveyors for B's
4. 36" Washer and sponge dryer
5. 36" Metal roller grading table with:
   18" rubber belt conveyor for culls
   18" rubber belt conveyor for Unclassified
6. Manual two chute 50 lb bagger
7. Scale
8. Sewing-conveyor unit: single thread
9. 10 head rotary bagger
10. Sewing-conveyor unit: dual thread
11. Forklift
12. Pallet

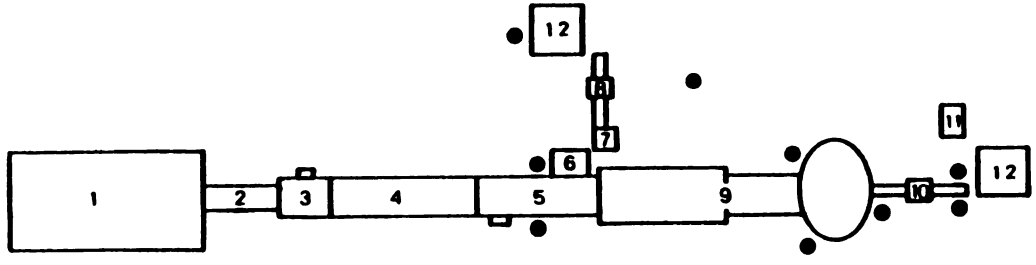

Figure 3. Plant #1-Small Plant Packing Assorted Packs

DESCRIPTION

1. Self unloading hopper
2. 24" Draper chain elevator
3. 36" Screen sizer for < $1^{3}/_{4}$" with:
   18" rubber belt conveyor for B's
4. 36" Washer and sponge dryer
5. 36" Metal roller grading table with
   18" rubber belt conveyor for culls
   18" rubber belt conveyor for Unclassified
6. Manual two chute 50 lb bagger
7. Scale
8. Sewing-conveyor unit single thread
9. 10 head rotary bagger
10. Sewing-conveyor unit dual thread
11. Forklift
12. Roll sizer separating three sizes:
    Small - $1^{3}/_{4}$" - $2^{1}/_{2}$"
    Medium- $2^{1}/_{4}$" - $3^{1}/_{2}$"
    Large - 3" - $4^{1}/_{4}$"
13. Even flow bulk box for small potatoes
14. Even flow bulk box for large potatoes
15. Pallet

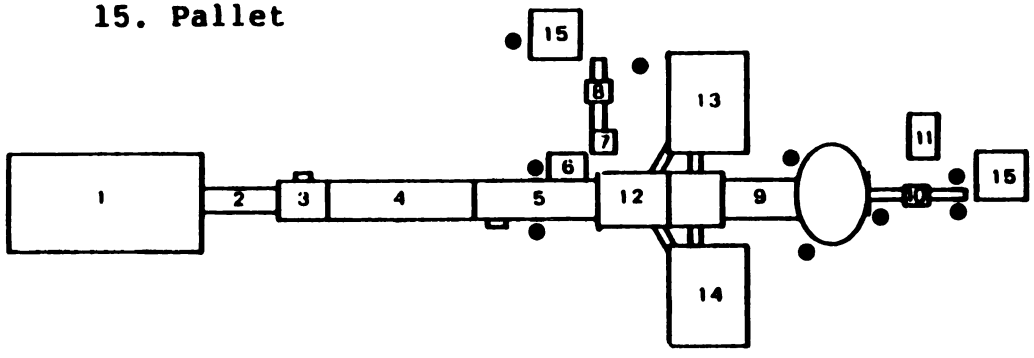

Figure 4. Plant #2-Small Plant Packing Closely Sized Packs.

DESCRIPTION

1. Self unloading hopper
2. 36" roller conveyor
3. 36" Draper-chain elevator
4. Soak tank
5. 36" Draper chain elevator
6. 48" Screen sizer with
   18" rubber belt conveyor for B's
7. 48" Washer and sponge dryer
8. 48" Hot air dryer
9. 48" Metal roller grading table with
   18" rubber belt conveyor for culls
   18" rubber belt conveyor for
   Unclassified
10. Two head 50 lb bagger
11. Sewing-conveyor unit: single thread
12. 60" roll sizer
13. 16 head rotary bagger
14. Sewing-conveyor unit: dual thread
15. 24" Rubber belt conveyor
16. Rotating accumulation table
17. Forklift
18. Pallet

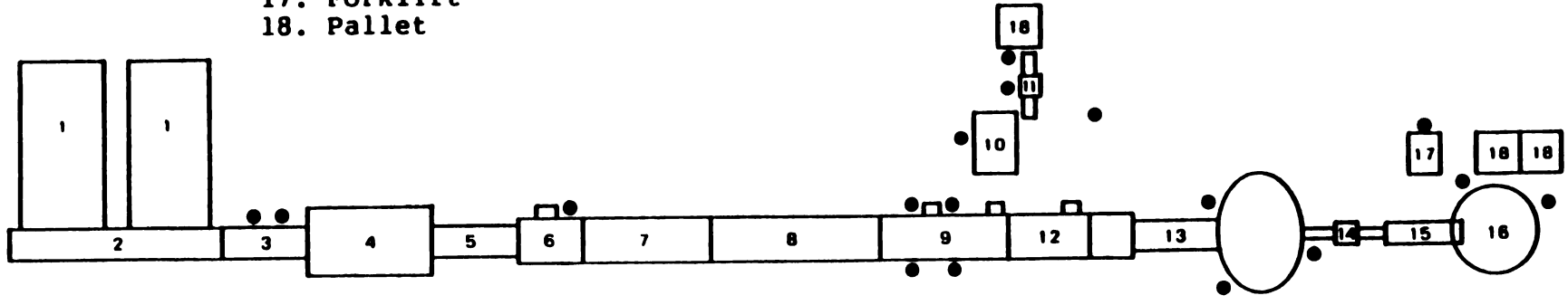

Figure 5. Plant #3-Large Plant Packing Assorted Packs

DESCRIPTION

1. Self unloading hopper
2. 36" roller conveyor
3. 36" Draper-chain elevator
4. Soak tank
5. 36" Draper chain elevator
6. 48" Screen sizer for < $1^{3}/_{4}$ with
   18" rubber belt conveyor for B's
7. 48" Washer and sponge dryer
8. 48" Hot air dryer
9. 48" Metal roller grading table with:
   18" rubber belt conveyor for culls
   18" rubber belt conveyor for
   Unclassified
10. Two head 50 lb bagger
11. Sewing-conveyor unit: single thread
12. Pallet
13. 16 head semi-automatic rotary bagger
14. Sewing-conveyor unit: dual thread
15. 24" Rubber belt conveyor
16. 60" Rotating accumulation table
17. Forklift
18. Roll sizer separating three sizes:
    Small - $1^{3}/_{4}$" - $2^{1}/_{2}$"
    Medium- $2^{1}/_{4}$" - $3^{1}/_{2}$"
    Large - 3" - $4^{1}/_{4}$"
19. Even flow bulk box for small potatoes
20. Even flow bulk box for large potatoes

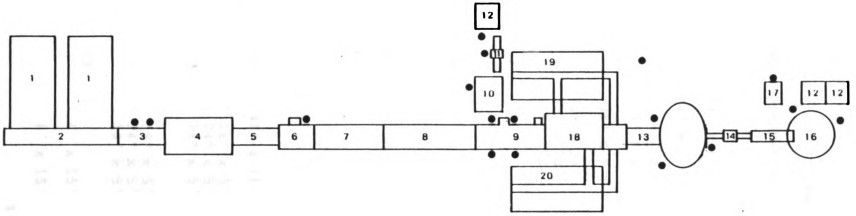

Figure 6. Plant #4-Large Plant Packing Closely Sized Packs.

Table 7. Equipment Description and Prices

DESCRIPTION	ITEM NO.	DIMENSIONS	NEW PRICE
PACKING PLANT #1			
self unloading hopper	1	8′ x 10′	$5,000.00
draper chain elevator	2	24" x 12′	$2,375.00
screen sizer w/	3	36" x 5′	$4,500.00
rubber belt conveyors for B′s		18" x 8′	included
washer and sponge dryer	4	36" x 9′	$6,500.00
metal roller grading table w/	5	18" x 10′	$8,200.00
conveyor for culls		12" x 10′	included
conveyor for U.S. no. 2′s		18" x 2′	included
two chute 50 lb. manual bagger	6		$375.00
scale	7		$1,014.00
sewing-conveyor unit	8		$10,235.00
ten head rotary bagger	9		$32,100.00
sewing-conveyor unit	10		$13,815.00
forklift	11		$15,000.00
Total Plant #1			$99,114.00
PACKING PLANT #2 additional equipment only			
roller sizer for three sizes	12	48" x 11′	$17,950.00
w/ conveyor to bulk box for			
small		18" x 5′	$600.00
medium		24" x 5′	$800.00
large		18" x 5′	$600.00
conveyor to bagger from bulk			
small		18" x 5′	$600.00
medium		24" x 5′	$800.00
large		18" x 5′	$600.00
even flow box for	13		
small		6′ x 15′	$6,600.00
medium direct to bagger			
large		6′ x 15′	$6,600.00
Total Plant #2			$134,264.00

Table 7. (cont.)

DESCRIPTION	ITEM NO.	DIMENSIONS	NEW PRICE
PACKING PLANT #3			
self unloading hopper	1	8' x 10'	$5,000.00
metal roller conveyor	2	36" x 20'	$5,300.00
draper chain elevator	3	36" x 10'	$3,200.00
soak tank w/	4	5' x 10'	
draper chain elevator	5	36" x 10'	$3,800.00
screen sizer w/	6	48" x 5'	$5,200.00
rubber belt conveyor for B's		18" x 8'	included
washer and sponge dryer	7	48" x 9'	$7,700.00
hot air dryer (gas)	8	48" x 20'	$30,000.00
metal roller grading table w/	9	18"+18" x 14'	$9,700.00
center conveyor for culls		12" x 14'	included
conveyor for U.S. no. 2's		18" x 6'	included
two head 50 lb. bagger	10		$13,000.00
sewing-conveyor unit	11		$10,235.00
roller sizer w/	12	48" x 11'	$17,500.00
conveyor for jumbos		24" x 8'	included
sixteen head rotary bagger	13		$41,650.00
sewing-conveyor unit	14		$13,815.00
rubber belt conveyor	15	24" x 8'	$1,000.00
rotating accumulation table	16	60" across	$1,500.00
two forklifts	17		$30,000.00
Total Plant #3			$198,600.00
PACKING PLANT #4			
additional equipment only			
roller sizer for three sizes	18	60" x 11'	$19,950.00
w/ conveyor to bulk box for			
small		18" x 10'	$800.00
medium		24" x 10'	$900.00
large		18" x 20'	$800.00
conveyor from bulk to bagger			
small		18" x 10'	$800.00
medium		24" x 10'	$900.00
large		18" x 20'	$800.00
even flow bulk box for			
small	19	8' x 20'	$9,000.00
medium direct to bagger			
large		8' x 20'	$9,000.00
Total Plant #4			$241,550.00

adapted to existing buildings and had their own unique characteristics.

Equipment used to pack potatoes is described below in conjunction with the packing activity stages in which it is used. Fall varieties of round white potatoes are placed in storage after harvest. Storage facilities control the temperature, humidity and air flow to maintain potato quality. Prior to sale to wholesale/retail customers, potatoes are unloaded from storage facilities into insulated or temperature controlled trucks, if the storage building is separate from the packing plant and transported to the packing plant where they are unloaded into self-unloading hoppers. If the storage building is attached to the packing building the potatoes are unloaded directly from storage into self-unloading hoppers.

Self-unloading hoppers are placed so they unload onto a conveyor or elevator which begins the packing line. The next two activity stages are pre-sizing and cleaning. Either may be done first. If the packer wishes to clean "B" size potatoes, pre-sizing will follow cleaning. Pre-sizing separates potatoes which are too small to meet U.S. No. 1 grade from the rest of the potatoes by moving the potatoes across a screen with holes set at either 1 7/8 or 2 inches. "B" size potatoes which fall through the screen are conveyed to a temporary holding bin.

Potatoes to be cleaned may be soaked in a water filled soak tank, first, or run over rollers with rubber

fingers while being sprayed by water. After this cleaning process, potatoes are dried by sponge covered rollers, forced air or a hot air dryer.

Potatoes are graded as they roll by 2-4 people on a metal roller grading table. Defective potatoes due to greening, rot, scab, sprouting, worm holes, skinning, bruising, cuts, shriveling and/or misshape are removed either to cull bins or if the degree of damage is within certain allowances to U.S. No. 2 or Unclassified bins.

U.S. No. 2, Unclassified or "B" size potatoes to be packed are run through bagging machines after U.S. No. 1 potatoes are packed or once they have accumulated in sufficient volume.

Remaining potatoes, U.S. No. 1 grade, may be further sized by hand picking, additional screen sizers or roller sizers which separate out as many as four size groups. Potatoes are then conveyed either to temporary holding bins or directly into a bagging unit. Bagging units range from simple chutes to complex rotary machines which weigh, bag and seal potatoes automatically.

Most Michigan operations have manually controlled bagging chutes with scales for 50 and 100 lb. sacks of potatoes. 20 to 5 lb. bags are filled by semi-automated rotary bagging machines, which require three people to load empty bags, check the weight of each bag and guide the full bags into a sewing or wire closure machine for sealing.

Bags of potatoes are then either accumulated on a rotating table or stacked directly onto pallets. Pallets may be wrapped with netting or tape to hold the bags in place during transport. They are then moved to a loading dock or temporary storage by a forklift and eventually loaded into a truck which delivers the packed potatoes to wholesalers, retailers, institutions, restaurants and/or a central market.

CHAPTER V

COST ANALYSIS RESULTS

This chapter reports packing costs per 10 lb. consumer bag of round white potatoes, total annual operating costs and costs of major resources used per activity stage within the packing operation for Plants #1-#4. This chapter also demonstrates via fixed and variable cost analysis possible cost savings to the Michigan potato industry associated with greater utilization of plant and equipment, provides a capacity utilization chart for different lengths of packing season and determines the sensitivity of total costs to transport costs as transport distance increases.

5.1 Outline of the Cost Analysis

Costs are analyzed for three levels of plant utilization: 1) full capacity; 2) average Michigan and 3) varying plant utilization (Figure 7). Costs with typical equipment are evaluated at these levels of plant utilization. In addition, costs with the same types of equipment in small and large plants are evaluated at full capacity.

Total packing costs per year and per 10 lb. bag as well as fixed costs as a percentage of total costs are determined for full capacity and average Michigan

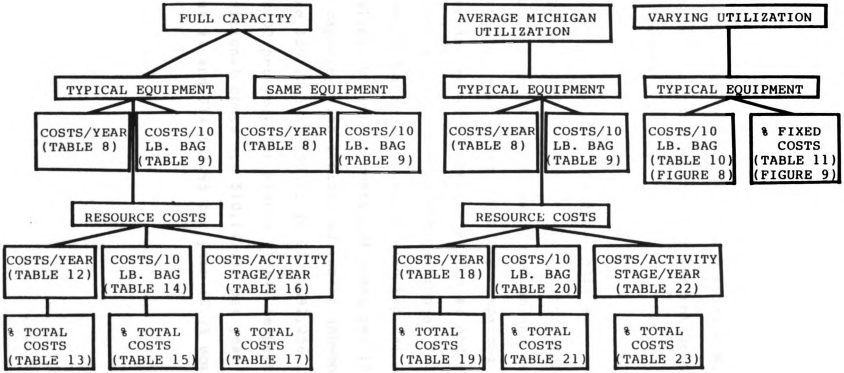

Figure 7. Flowchart of Cost Analysis

utilization. Packing costs per 10 lb. bag and fixed costs as a percentage of total costs are calculated at varying utilization. In addition, resource costs per year, per 10 lb. bag and per activity stage per year are determined for plants packing at full capacity and average Michigan utilization. Resource costs as a percentage of total costs are also presented.

5.2 Testing Hypothesis #1

Hypothesis #1 is that it will be more costly to pack potatoes in closely sized small, medium and large packs than in assorted packs. It is tested by comparing costs in Plants #2 and #4 with costs in Plants #1 and #3. Cost comparisons are made for plants packing at full capacity and at average Michigan utilization with typical equipment.

Analysis of annual costs and costs per 10 lb. bag at full capacity with typical equipment showed: packing costs are $207,005.11, $217,148.02, $392,256.12 and $406,858.07 per year for Plants #1-#4, respectively (Table 8). Additional costs are $10,142.91 per year (4.9% more) for Plant #2 and $14,601.95 per year (3.7% more) for Plant #4.

TABLE 8. Costs per Year

Category	Plant #1 Small Assorted	Plant #2 Small Close	Plant #3 Large Assorted	Plant #4 Large Close
Full Capacity of Plant Utilization				
Typical Equipment	$207,005.11	$217,148.02	$392,256.12	$406,858.07
Same Type Equipment	$207,005.11	$217,148.02	$375,098.30	$389,700.25
Average Michigan Capacity of Plant Utilization	$103,848.17	$112,664.53	$316,634.21	$331,236.16

Packing costs per 10 lb. bag at full capacity are $0.1623, $0.1702, $0.1612 and $0.1671 for Plants #1-#4, respectively (Table 9). Additional costs per 10 lb. bag are $0.0079 (4.9% more) for Plant #2 and $0.0059 (3.7% more) for Plant #4.

Analysis of annual costs and costs per 10 lb. bag at average Michigan utilization with typical equipment showed: packing costs per year are $103,848.17, $112,664.53, $316,634.21 and $331,236.16 for Plants #1-#4, respectively (Table 8). Additional costs are $8,816.36 per year (8.5% more) for Plant #2 and $14,601.95 per year (4.6% more) for Plant #4.

Packing costs per 10 lb. bag at average Michigan utilization are $0.2166, $0.2350, $0.2046, $0.2140 for Plants #1-#4, respectively (Table 9). Additional costs per 10 lb. bag are $0.0184 (8.5% more) for Plant #2 and $0.0094 (4.6% more) for Plant #4.

In summary, total costs per year as well as costs per 10 lb. bag are higher for plants packing closely sized packs than assorted packs, both at full capacity and at average Michigan utilization. Additional costs per 10 lb. bag are higher for small plants than for large plants. These results do not contradict Hypothesis #1 that it is more costly to pack closely sized small, medium and large packs than assorted packs.

TABLE 9. Costs per 10 lb. Bag

Category	Plant #1 Small Assorted	Plant #2 Small Close	Plant #3 Large Assorted	Plant #4 Large Close
Full Capacity of Plant Utilization				
Typical Equipment	$0.1623	$0.1702	$0.1612	$0.1671
Same Type Equipment	$0.1623	$0.1702	$0.1544	$0.1604
Average Michigan Capacity of Plant Utilization	$0.2166	$0.2350	$0.2046	$0.2140

5.3 Testing Hypothesis #2

Hypothesis #2 is larger plants will have lower unit packing costs than small plants when operated at the same percentage utilization of capacity. It is tested by comparing costs in large Plants #3 and #4 with costs in small Plants #1 and #2. Cost comparisons are made at full capacity with the same types and typical equipment as well as at average Michigan utilization with typical equipment.

Analysis at full capacity with the same types of equipment in small and large plants showed: packing costs per 10 lb. bag are $0.1623, $0.1702, $0.1544 and $0.1604 for Plants #1-#4, respectively (Table 9). Costs per 10 lb. bag are $0.0079 less (4.9% less) for Plant #3 and $0.0098 less (5.8% less) for Plant #4.

Analysis at full capacity with the typical equipment in small and large plants showed: Packing costs per 10 lb. bag are $0.1623, $0.1702, $0.1612 and $0.1671 for Plants #1-#4, respectively (Table 9). Costs per 10 lb. bag are $0.0011 less (6.8% less) for Plant #3 and $0.0031 less (1.8% less) for Plant #4.

Analysis at average Michigan utilization with the typical equipment in small and large plants showed: packing costs per 10 lb. bag are $0.2166, $0.2350, $0.2046, $0.2140 for Plants #1-#4, respectively (Table 9). Costs per 10 lb. bag are $0.0012 less (5.5% less) for Plant #3 and $0.0021 less (8.9% less) for Plant #4.

In summary, cost analysis at: 1) full capacity in small and large plants with; a) the same types of equipment and b) typical equipment as well as at; 2) average Michigan utilization with typical equipment indicates packing costs per 10 lb. bag are lower for large plants than for small plants. Moving from small to large plants reduces costs more for plants packing closely sized packs than for plants packing assorted packs. These results do not contradict Hypothesis #2 that larger packing plants will have lower unit packing costs than small plants when operating at the same percentage utilization of capacity.

5.4 Testing Hypothesis #3

Hypothesis #3 is that a longer packing season as well as greater utilization of capacity will lead to reduced costs per unit of output for any size packing plant. It is tested by comparing costs within each plant, #1-#4, as the packing season lengthens from 2-10 months.

Packing costs for a 2 month packing season are $0.2519, $0.2765, $0.2363 and $0.2531 per 10 lb. bag for Plants #1-#4, respectively (Table 10). Packing costs for a 10 month packing season are $0.1564, $0.1632, $0.1562 and $0.1614 per 10 lb. bag for Plants #1-#4, respectively. Packing costs per 10 lb. bag decrease as the packing season lengthens from 2-10 months by $0.0955 (38% decrease), $0.1133 (41% decrease), $0.0801 (34% decrease) and $0.0917 (36% decrease) for Plants #1-#4, respectively. Costs per 10

TABLE 10. Capacity of Utilization: Costs per 10 lb. Bag

Months	U.S. No 1's Cwt Packed	Plant #1 Sm Assort	Plant #2 Sm Close	U.S. No 1's Cwt Packed	Plant #3 Lg Assort	Plant #4 Lg Close
2	31500	$0.2519	$0.2765	59850	$0.2363	$0.2531
3	46875	$0.2127	$0.2300	89062.5	$0.2031	$0.2155
4	62250	$0.1928	$0.2064	118275	$0.1868	$0.1964
5	77625	$0.1808	$0.1922	147487.5	$0.1767	$0.1849
6	93750	$0.1722	$0.1819	178125	$0.1694	$0.1766
7	109125	$0.1666	$0.1753	207337.5	$0.1647	$0.1712
8	124500	$0.1623	$0.1702	236550	$0.1612	$0.1671
9	139750	$0.1590	$0.1663	265762.5	$0.1584	$0.1640
10	155250	$0.1564	$0.1632	294975	$0.1562	$0.1614

lb. bag decrease as the packing season lengthens for all plants. Costs decline most rapidly from 2-6 months (Figure 8). From 7-10 months, costs per 10 lb. bag continue to decline, but at a slower rate.

The decline in packing costs per 10 lb. bag as season lengthens can be attributed to fixed costs being divided by more units of output resulting in lower fixed costs per unit while variable costs per unit remain approximately constant. This is illustrated by analyzing fixed costs as a percentage of total costs. Fixed costs as a percentage of total costs for a 2 month packing season are 47%, 51%, 42% and 45% for Plants #1-#4, respectively (Table 11). Fixed costs as a percentage of total costs for a 10 month packing season are 15%, 18%, 13% and 14% for Plants #1-#4, respectively. Fixed costs as a percentage of total costs decrease as the packing season lengthens from 2-10 months by 32% (68% decrease), 33% (65% decrease), 29% (69% decrease) and 31% (69% decrease) for Plants #1-#4, respectively.

Fixed costs as a percentage of total costs decline for Plants #1-#4 as the packing season lengthens from 2-10 months. The rate of decline is most rapid from 2-6 months (Figure 9). From 7-10 months, fixed costs as a percentage of total costs continue to decline, but at a slower rate.

In summary, costs per 10 lb. bag decrease as the packing season lengthens. The most rapid period of decline is from 2-6 months. From 7-10 months the costs per 10 lb. bag continued to decrease, but at a slower rate. The

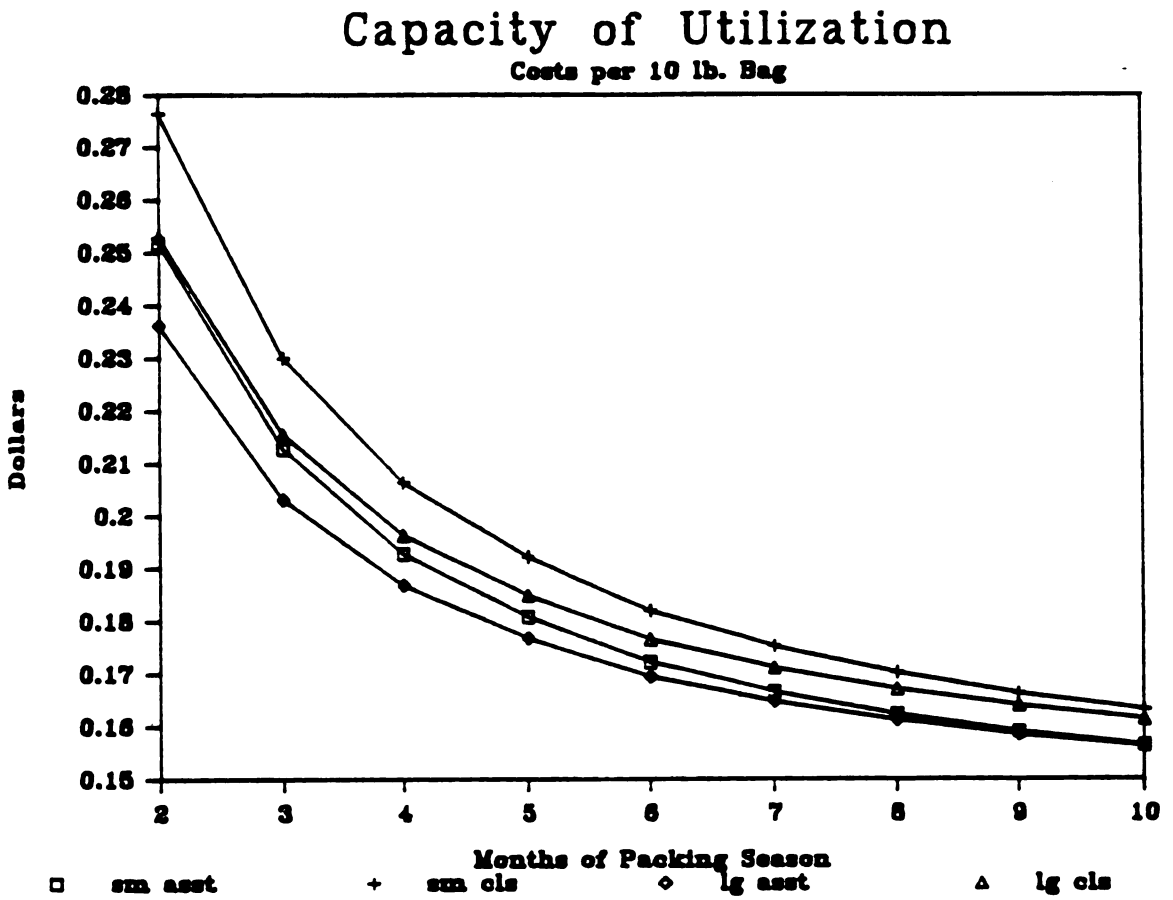

Figure 8 . Costs Per 10 lb. Bag as Packing Season Length Changes

TABLE 11. Capacity of Utilization: Percentage Fixed Costs

Months	U.S. No 1's Cwt Packed	Plant #1 Sm Assort	Plant #2 Sm Close	U.S. No 1's Cwt Packed	Plant #3 Lg Assort	Plant #4 Lg Close
2	31500	47%	51%	59850	42%	45%
3	46875	37%	41%	89062.5	33%	36%
4	62250	31%	35%	118275	27%	30%
5	77625	27%	30%	147487.5	23%	25%
6	93750	23%	26%	178125	20%	22%
7	109125	21%	23%	207337.5	18%	19%
8	124500	19%	21%	236550	16%	17%
9	139750	16%	19%	265762.5	14%	16%
10	155250	15%	18%	294975	13%	14%

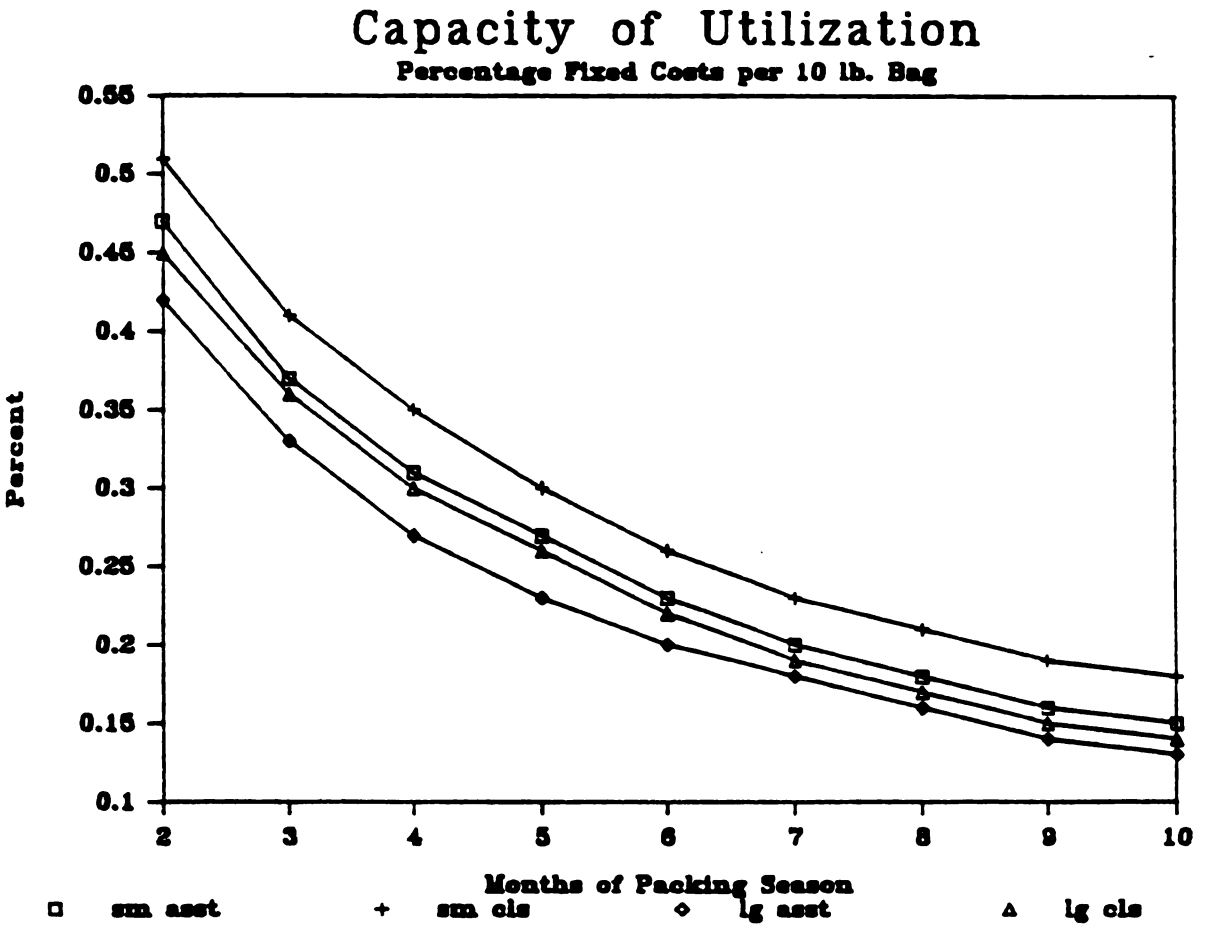

Figure 9 . Percentage Fixed Costs Per 10 lb. Bag as Packing Season Length Changes

results do not contradict Hypothesis #3 that a longer packing season as well as greater utilization of capacity will lead to reduced costs per unit of output for any size packing plant.

5.4.1 Cost Differences as the Packing Season Lengthens

Cost differences between small and large plants as the packing season lengthens are: packing costs per 10 lb. are $0.0156 (6.2% less) for Plant #3 and $0.0234 (8.5% less) for Plant #4 with a 2 month packing season, but only $0.0002 (.13% less) for Plant #3 and $0.0018 (1.1% less) for Plant #4 with a 10 month packing season (Table 10). The greatest difference in packing costs between large and small plants is with the shortest packing season length, as the packing season lengthens to 10 months cost differences between large and small plants become minimal as costs decline more rapidly for small plants than for large plants as the packing season lengthens (Figure 8).

Cost differences between plants packing assorted and closely sized packs as the season lenghtens are: packing costs per 10 lb. bag are $0.0246 (9.8% more) for Plant #2 and $0.0168 (7.1% more) for Plant #4 for a 2 month packing season, but only $0.0068 (4.4% more) for Plant #2 and $0.0052 (3.3% more) for Plant #4 with a 10 month packing season (Table 10). The greatest difference in packing costs between plants packing assorted and closely sized packs is with the shortest packing season length, as the packing

season lengthens to 10 months, cost differences between plants packing assorted and closely sized packs decline (Figure 8).

5.5 Resource Costs

Cost analysis to this point has been in terms of fixed, variable and total costs which were arrived at by considering costs of major resources used per packing activity stage. Costs were broken down into business accounting cost categories; land, buildings, property taxes, insurance, building repairs, utilities, materials, transport, equipment, equipment repairs, forklift fuel, labor and operating capital. These "resource" costs, as they will be referred to hereafter, were then assigned to the packing activity stage in which they are used; transport, receive, pre-size, clean, grade, size, package or load. Resource costs shared among all packing stages, including; land, buildings, property taxes, insurance, building repairs, utilities, equipment repairs, operating capital and supervisor/manager labor, are assigned to the category of shared costs. A review of Table 2, Cost Collection Matrix, in Chapter II will familiarize the reader with how these costs were organized.

In the sections that follow, resource costs per year, per 10 lb. bag and per activity stage per year are

reported[1] and ranked by relative contribution to total costs for Plants #1-#4 packing at full capacity and at average Michigan utilization.

5.6 Resource Costs per Year for Plant #1 at Full Capacity

This section reports and ranks resource costs per year, per 10 lb. bag and per activity stage per year for Plant #1 at full capacity by relative contribution to total costs.

The highest resource cost per year for Plant #1 at full capacity is materials (Table 12) at 51.83% of total costs (Table 13). Labor costs are second at 31.08%; equipment, third at 7.12%; building, fourth at 3.14%; utilities, fifth at 2.61%; equipment repair, sixth at 1.44%; property tax, seventh at 0.64%; forklift fuel, eighth at 0.60%; building repair, ninth at 0.54%; insurance, tenth at 0.35%; operating costs, eleventh at 0.29%; land, twelfth at 0.22% and transport, thirteenth at 0.13% of total costs.

Resource costs per 10 lb. bag for plants packing at full capacity (Tables 14 and 15) rank the same as resource costs per year for Plants #1-#4 packing at full capacity (Tables 12 and 13).

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[1]Tables 12-23 are placed together for easier referral.

TABLE 12. Cost of Resources per Year at Full Capacity of Plant Utilization

Resource	Plant #1 Small Assorted	Plant #2 Small Close	Plant #3 Large Assorted	Plant #4 Large Close
Land	$462.00	$462.00	$693.00	$693.00
Building	$6,508.81	$7,438.64	$9,763.22	$11,018.49
Property Taxes	$1,324.40	$1,500.40	$1,986.60	$2,224.19
Insurance	$729.03	$931.84	$1,328.22	$1,580.85
Building Repairs	$1,120.00	$1,280.00	$1,680.00	$1,896.00
Utilities	$5,400.00	$6,200.00	$9,600.00	$11,200.00
Materials	$107,295.96	$107,295.96	$203,862.34	$203,862.34
Transport	$259.99	$259.99	$1,397.12	$1,397.12
Equipment	$14,746.77	$19,976.60	$29,548.91	$35,939.25
Equipment Repairs	$2,973.42	$4,027.93	$5,958.00	$7,246.50
Forklift Fuel	$1,245.00	$1,245.00	$2,490.00	$2,490.00
Labor	$64,339.73	$65,929.66	$123,048.71	$126,410.33
Operating Capital	$600.00	$600.00	$900.00	$900.00
Total Costs	$207,005.11	$217,148.02	$392,256.12	$406,858.07

TABLE 13. Percentage Cost of Resources per Year at Full Capacity of Plant Utilization

Resource	Plant #1 Sm Assorted	Plant #2 Sm Close	Plant #3 Lg Assorted	Plant #4 Lg Close
Land	0.22%	0.21%	0.18%	0.17%
Building	3.14%	3.43%	2.49%	2.71%
Property Taxes	0.64%	0.69%	0.51%	0.55%
Insurance	0.35%	0.43%	0.34%	0.39%
Building Repairs	0.54%	0.59%	0.43%	0.47%
Utilities	2.61%	2.86%	2.45%	2.75%
Materials	51.83%	49.41%	51.97%	50.11%
Transport	0.13%	0.12%	0.36%	0.34%
Equipment	7.12%	9.20%	7.53%	8.83%
Equipment Repairs	1.44%	1.85%	1.52%	1.78%
Forklift Fuel	0.60%	0.57%	0.63%	0.61%
Labor	31.08%	30.36%	31.37%	31.07%
Operating Capital	0.29%	0.28%	0.23%	0.22%
Total Costs	100.00%	100.00%	100.00%	100.00%

TABLE 14. Cost of Resources per 10 lb. Bag at Full Capacity of Plant Utilization

Resource	Plant #1 Small Assorted	Plant #2 Small Close	Plant #3 Large Assorted	Plant #4 Large Close
Land	$0.0003414	$0.0003414	$0.0002695	$0.0002695
Building	$0.0048097	$0.0054968	$0.0037972	$0.0042854
Property Taxes	$0.0009787	$0.0011087	$0.0007726	$0.0008650
Insurance	$0.0005387	$0.0006886	$0.0005166	$0.0006148
Building Repairs	$0.0008276	$0.0009459	$0.0006534	$0.0007374
Utilities	$0.0039904	$0.0045815	$0.0037337	$0.0043560
Materials	$0.0861815	$0.0861815	$0.0861815	$0.0861815
Transport	$0.0001921	$0.0001921	$0.0005434	$0.0005434
Equipment	$0.0113362	$0.0155369	$0.0118720	$0.0145735
Equipment Repairs	$0.0021972	$0.0029765	$0.0023172	$0.0028163
Forklift Fuel	$0.0009200	$0.0009200	$0.0009684	$0.0009684
Labor	$0.0495786	$0.0508173	$0.0492149	$0.0505650
Operating Capital	$0.0004434	$0.0004434	$0.0003500	$0.0003500
Total Costs	$0.1623355	$0.1702306	$0.1611905	$0.1671263

TABLE 15. Percentage Cost of Resources per 10 lb. Bag at Full Capacity of Plant Utilization

Resource	Plant #1 Sm Assorted	Plant #2 Sm Close	Plant #3 Lg Assorted	Plant #4 Lg Close
Land	0.21%	0.20%	0.17%	0.16%
Building	2.96%	3.23%	2.36%	2.56%
Property Taxes	0.60%	0.65%	0.48%	0.52%
Insurance	0.33%	0.40%	0.32%	0.37%
Building Repairs	0.51%	0.56%	0.41%	0.44%
Utilities	2.46%	2.69%	2.32%	2.61%
Materials	53.09%	50.63%	53.47%	51.57%
Transport	0.12%	0.11%	0.34%	0.33%
Equipment	6.98%	9.13%	7.37%	8.72%
Equipment Repairs	1.35%	1.75%	1.44%	1.69%
Forklift Fuel	0.57%	0.54%	0.60%	0.58%
Labor	30.54%	29.85%	30.53%	30.26%
Operating Capital	0.27%	0.26%	0.22%	0.21%
Total Costs	100.00%	100.00%	100.00%	100.00%

TABLE 16. Cost per Activity Stage per Year at Full Capacity of Plant Utilization

Activity Stage	Plant #1 Small Assorted	Plant #2 Small Close	Plant #3 Large Assorted	Plant #4 Large Close
Transport	$259.99	$259.99	$1,397.12	$1,397.12
Receive	$1,097.30	$1,097.30	$15,396.35	$15,816.56
Presize	$669.54	$669.54	$773.69	$773.69
Clean	$967.11	$967.11	$6,174.62	$6,174.62
Grade	$13,884.12	$14,281.60	$28,218.70	$29,059.09
Size	$0.00	$5,229.83	$2,603.75	$8,994.09
Package	$135,707.10	$136,502.07	$238,632.93	$239,683.44
Load	$21,618.87	$22,016.35	$51,203.08	$52,253.59
Shared Costs	$32,801.08	$36,124.23	$47,855.88	$52,705.87
Total Costs	$207,005.11	$217,148.02	$392,256.12	$406,858.07

TABLE 17. Percentage Cost per Activity Stage per Year at Full Capacity of Plant Utilization

Activity Stage	Plant #1 Sm Assorted	Plant #2 Sm Close	Plant #3 Lg Assorted	Plant #4 Lg Close
Transport	0.13%	0.12%	0.36%	0.34%
Receive	0.53%	0.51%	3.93%	3.89%
Presize	0.32%	0.31%	0.20%	0.19%
Clean	0.47%	0.45%	1.57%	1.52%
Grade	6.71%	6.58%	7.19%	7.14%
Size	0.00%	2.41%	0.66%	2.21%
Package	65.56%	62.86%	60.84%	58.91%
Load	10.44%	10.14%	13.05%	12.84%
Shared Costs	15.85%	16.64%	12.20%	12.95%
Total Costs	100.00%	100.00%	100.00%	100.00%

TABLE 18. Cost of Resources per Year at Average Michigan Plant Utilization

Resource	Plant #1 Small Assorted	Plant #2 Small Close	Plant #3 Large Assorted	Plant #4 Large Close
Land	$462.00	$462.00	$693.00	$693.00
Building	$6,508.81	$7,438.64	$9,763.22	$11,018.49
Property Taxes	$1,324.40	$1,500.40	$1,986.60	$2,224.19
Insurance	$729.03	$931.84	$1,328.22	$1,580.85
Building Repairs	$1,120.00	$1,280.00	$1,680.00	$1,896.00
Utilities	$3,456.00	$3,840.00	$9,600.00	$11,200.00
Materials	$40,022.69	$40,022.69	$128,755.16	$128,755.16
Transport	$96.98	$96.98	$882.39	$882.39
Equipment	$14,746.77	$19,976.60	$29,548.91	$35,939.25
Equipment Repairs	$2,226.12	$3,015.60	$5,958.00	$7,246.50
Forklift Fuel	$619.20	$619.20	$2,490.00	$2,490.00
Labor	$31,936.17	$32,880.58	$123,048.71	$126,410.33
Operating Capital	$600.00	$600.00	$900.00	$900.00
Total Costs	$103,848.17	$112,664.53	$316,634.21	$331,236.16

TABLE 19. Percentage Cost of Resources per Year at Average Michigan Plant Utilization

Resource	Plant #1 Sm Assorted	Plant #2 Sm Close	Plant #3 Lg Assorted	Plant #4 Lg Close
Land	0.44%	0.41%	0.22%	0.21%
Building	6.27%	6.60%	3.08%	3.33%
Property Taxes	1.28%	1.33%	0.63%	0.67%
Insurance	0.70%	0.83%	0.42%	0.48%
Building Repairs	1.08%	1.14%	0.53%	0.57%
Utilities	3.33%	3.41%	3.03%	3.38%
Materials	38.54%	35.52%	40.66%	38.87%
Transport	0.09%	0.09%	0.28%	0.27%
Equipment	14.20%	17.73%	9.33%	10.85%
Equipment Repairs	2.14%	2.68%	1.88%	2.19%
Forklift Fuel	0.60%	0.55%	0.79%	0.75%
Labor	30.75%	29.18%	38.86%	38.16%
Operating Capital	0.58%	0.53%	0.28%	0.27%
Total Costs	100.00%	100.00%	100.00%	100.00%

TABLE 20. Cost of Resources per 10 lb. Bag at Average Michigan Plant Utilization

Resource	Plant #1 Small Assorted	Plant #2 Small Close	Plant #3 Large Assorted	Plant #4 Large Close
Land	$0.0009153	$0.0009152	$0.0004267	$0.0004267
Building	$0.0128943	$0.0147363	$0.0060122	$0.0067851
Property Taxes	$0.0026237	$0.0029724	$0.0012233	$0.0013697
Insurance	$0.0014444	$0.0018460	$0.0008179	$0.0009735
Building Repairs	$0.0022188	$0.0025357	$0.0010345	$0.0011675
Utilities	$0.0068465	$0.0076072	$0.0059116	$0.0068961
Materials	$0.0861815	$0.0861815	$0.0861815	$0.0861815
Transport	$0.0001921	$0.0001921	$0.0005434	$0.0005434
Equipment	$0.0303909	$0.0416524	$0.0187973	$0.0230746
Equipment Repairs	$0.0044101	$0.0059741	$0.0036689	$0.0044624
Forklift Fuel	$0.0012267	$0.0012267	$0.0015334	$0.0015334
Labor	$0.0660403	$0.0680129	$0.0779236	$0.0800612
Operating Capital	$0.0011886	$0.0011886	$0.0005543	$0.0005543
Total Costs	$0.2165732	$0.2350411	$0.2046286	$0.2140294

TABLE 21. Percentage Cost of Resources per 10 lb. Bag at Average Michigan Plant Utilization

Resource	Plant #1 Sm Assorted	Plant #2 Sm Close	Plant #3 Lg Assorted	Plant #4 Lg Close
Land	0.42%	0.39%	0.21%	0.20%
Building	5.95%	6.27%	2.94%	3.17%
Property Taxes	1.21%	1.26%	0.60%	0.64%
Insurance	0.67%	0.79%	0.40%	0.45%
Building Repairs	1.02%	1.08%	0.51%	0.55%
Utilities	3.16%	3.24%	2.89%	3.22%
Materials	39.79%	36.67%	42.12%	40.27%
Transport	0.09%	0.08%	0.27%	0.25%
Equipment	14.03%	17.72%	9.19%	10.78%
Equipment Repairs	2.04%	2.54%	1.79%	2.08%
Forklift Fuel	0.57%	0.52%	0.75%	0.72%
Labor	30.49%	28.94%	38.08%	37.41%
Operating Capital	0.55%	0.51%	0.27%	0.26%
Total Costs	100.00%	100.00%	100.00%	100.00%

TABLE 22. Cost per Activity Stage per Year at Average Michigan Plant Utilization

Activity Stage	Plant #1 Small Assorted	Plant #2 Small Close	Plant #3 Large Assorted	Plant #4 Large Close
Transport	$96.98	$96.98	$882.39	$882.39
Receive	$1,097.30	$1,097.30	$15,396.35	$15,816.56
Presize	$669.54	$669.54	$773.69	$773.69
Clean	$967.11	$967.11	$6,174.62	$6,174.62
Grade	$7,659.31	$7,895.41	$28,218.70	$29,059.09
Size	$0.00	$5,229.83	$2,603.75	$8,994.09
Package	$59,418.85	$59,891.07	$167,360.35	$168,410.86
Load	$11,333.62	$11,569.71	$47,368.48	$48,418.99
Shared Costs	$22,605.46	$25,247.58	$47,855.88	$52,705.87
Total Costs	$103,848.17	$112,664.53	$316,634.21	$331,236.16

TABLE 23. Percentage Cost per Activity Stage per Year at Average Michigan Plant Utilization

Activity Stage	Plant #1 Sm Assorted	Plant #2 Sm Close	Plant #3 Lg Assorted	Plant #4 Lg Close
Transport	0.09%	0.09%	0.28%	0.27%
Receive	1.06%	0.97%	4.86%	4.78%
Presize	0.64%	0.59%	0.24%	0.23%
Clean	0.93%	0.86%	1.95%	1.86%
Grade	7.38%	7.01%	8.91%	8.77%
Size	0.00%	4.64%	0.82%	2.72%
Package	57.22%	53.16%	52.86%	50.84%
Load	10.91%	10.27%	14.96%	14.62%
Shared Costs	21.77%	22.41%	15.11%	15.91%
Total Costs	100.00%	100.00%	100.00%	100.00%

The highest activity stage cost per year for Plant #1 at full capacity is packaging (Table 16) at 65.56% of total costs (Table 17). Shared costs are second at 15.85%; loading, third at 10.44%; grading, fourth at 6.71%; receiving, fifth at 0.53%; cleaning, sixth at 0.47%; pre-sizing, seventh at 0.32% and transport, eighth at 0.13% of total costs.

5.6 Resource Cost Comparisons

The next three sections compare resource costs as: 1) close sizing operations are added to Plants #1 and #3 and 2) plant size increase from small to large at full capacity and at average Michigan utilization as well as comparing; 3) plants at full capacity with those at average Michigan utilization.

5.6.1 Comparisons as Close Sizing Operations are Added

As close sizing operations are added to small plants, ranks of resource costs per year remained unchanged for small plants packing at average Michigan utilization (Table 19). Buildings moved from ninth to eighth place in small plants packing at full capacity (Table 13).

As close sizing operations are added to large plants, ranks of resource costs per year remained unchanged except utilities moved from fifth to fourth place for large plants packing at average Michigan utilization and plants packing at full capacity. Additionally, insurance moved

from eleventh to tenth place in large plants packing at full capacity.

Rankings of resource costs per activity stage per year as close sizing operations are added to small plants remained unchanged except sizing moved from ninth to fifth place both in small plants packing at full capacity (Tables 16 and 17) and in small plants packing at average Michigan utilization (Tables 22 and 23).

Rankings of resource costs per activity stage per year as close sizing operations are added to large plants remained unchanged except sizing moved from ninth to sixth place both in large plants packing at full capacity (Table 17) and in large plants packing at average Michigan utilization (Table 20).

Comparing resource costs as a percentage of total costs for plants packing at full capacity and at average Michigan utilization (Tables 15 and 21): plants packing closely sized packs had a higher percentage of total costs in equipment, buildings, utilities, equipment repairs, property taxes, building repairs and insurance, but lower percentage costs in materials, labor, forklift fuel, operating capital, land and transport than plants packing assorted packs.

Comparing resource costs per activity stage per year as a percentage of total costs for plants packing at full capacity (Table 17): plants packing closely sized packs had a higher percentage of total costs in shared costs, receiving and sizing activity stages, but lower percentage

costs in packaging, loading, grading, cleaning, presizing and transport activity stages than plants packing assorted packs. As close sizing operations are added to plants packing at average Michigan utilization (Table 23), results are the same, except receiving costs are a lower percentage of total costs.

5.6.2 Comparisons as Plant Size Increases

As plant size increases, ranks of resource costs per year remained unchanged for plants packing assorted packs at full capacity and average Michigan utilization, except forklift fuel moved from eighth to seventh place and transport moved from thirteenth to tenth place at full capacity and from twelfth to thirteenth place at average Michigan utilization (Tables 15 and 21).

Rankings of resource costs per activity stage per year as plant size increases from small to large remained unchanged except sizing moved from ninth to seventh place in plants packing assorted packs at full capacity (Tables 16 and 17) and at average Michigan utilization (Tables 22 and 23).

As plant size increases for plants packing closely sized packs, ranks of resource costs per year remained unchanged for plants packing at full capacity and average Michigan utilization, except utilities moved from fifth to fourth place, forklift fuel moved from ninth to seventh at full capacity and from tenth to seventh at average Michigan

utilization. Additionally, transport moved from thirteenth to eleventh place at full capacity and from thirteenth to twelfth place at average Michigan utilization.

Rankings of resource costs per activity stage per year as plant size increases for plants packing closely sized packs remained unchanged except receiving moved from sixth to fifth place at full capacity and average Michigan utilization (Tables 19 and 25). Additionally, transport costs moved from ninth to eighth place in plants packing at full capacity.

Comparing resource costs per year as a percentage of total costs at full capacity (Table 13): large plants had a higher percentage of total costs in materials, labor, equipment, equipment repairs, transport and forklift fuel than small plants, but lower percentages for land, buildings, property taxes, insurance, building repairs, utilities, and operating capital. Results for average Michigan utilization are the same as at full capacity, except equipment and equipment repairs are a lower percentage of total costs (Table 19).

Comparing resource costs per activity stage per year as a percentage of total costs at full capacity and average Michigan utilization (Tables 19 and 25): large plants had a higher percentage of total costs in loading, grading, receiving, cleaning, transport and sizing activity stages than small plants, but lower percentages for packaging, shared costs and pre-sizing activity stages.

5.6.3 Comparisons at Average Michigan Utilization

This section compares resource costs per year and per activity stage per year between plants packing at full capacity and average Michigan utilization[2]. Results which are the same for plants packing at average Michigan utilization and full capacity include: resource costs per 10 lb. bag (Tables 20 and 21) rank the same as resource costs per year (Tables 18 and 19). Materials, labor and equipment are the highest resource costs. However at average Michigan utilization, materials are a lower percentage of total costs, only 35.52%-40.66% (Table 21) versus 49.41%-51.97% (Table 13). Labor costs are nearly the same. Equipment costs are higher, especially for small plants at 9.33%-17.73% versus 7.12%-9.20%.

Results which are different for plants packing at average Michigan utilization and full capacity include: 1) resource costs per year for building repairs and insurance become relatively more important for small plants at average Michigan utilization and 2) resource costs per year for insurance and operating costs became relatively more important for plants packing at average Michigan utilization.

Activity stage costs results which are the same among plants packing at average Michigan utilization and full capacity include; activity stage costs per year ranked the same for Plants #1, #2 and #4.

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[2]Comparisons made above will not be repeated here.

Activity stage costs per year which are different between plants packing at average Michigan utilization and full capacity include; shared costs become relatively more important for Plant #3 at average Michigan utilization.

5.6.4 Summary of Cost Comparisons

Summarizing the important results from the comparisons above: as close sizing operations are added to small and large plants, resource costs for utilities, insurance and buildings and the activity stage of sizing become a larger percentage of total costs. As plant size increases from small to large plants, resource costs for utilities, forklift fuel and transport and activity stages of sizing, receiving and transport become a larger percentage of total costs. Major resource costs rank the same for plants packing at average Michigan utilization and full capacity. However, materials costs are a lower percentage of total costs and equipment costs are a higher percentage of total costs for plants packing at average Michigan utilization.

5.7 Transport Costs Analysis

Effects of increasing transport distance on total packing costs per 10 lb. bag are listed in Table 24. Increasing transport distance from 3 to 50 miles increases the cost of transporting potatoes from storage to the packing line from $0.0005434 to $0.0090567 per 10 lb. bag. Transport costs increase from an insignificant 0.33% to 5.4%

of total packing costs per 10 lb. bag for a Plant #4 with typical equipment at full capacity.

TABLE 24. Transport Cost Sensitivity Analysis

		Transport Cost per 10 lb. Bag	Total Cost per 10 lb. Bag for Plant #4 at Full Capacity	Transport % of Total Costs
Miles Transported	3	$0.0005434	$0.1671263	0.33%
	6	$0.0010868	$0.1676697	0.65%
	10	$0.0018113	$0.1683942	1.10%
	20	$0.0036227	$0.1702055	2.10%
	30	$0.0054340	$0.1720169	3.20%
	50	$0.0095670	$0.1761499	5.40%

CHAPTER VI

CONCLUSIONS

This chapter presents the conclusions of this research and addresses marketing challenges of closely sized potatoes. It also identifies limitations of the research methods and offers suggestions for future research.

6.1 Conclusions

Michigan round white potato packers face a declining share in the fresh tablestock potato market. To improve the quality of round white potato packs in an effort to maintain or possibly increase market share, close sizing of round white potatoes has been proposed. Packers expressed concern about the increased costs of close sizing. Cost analysis results of this study show that small packers have higher per unit packing costs than large plants, and plants with shorter packing seasons have higher per unit costs than plants with longer packing seasons.

Packing closely sized packs is slightly more costly than packing assorted sized packs for both sizes of plants. Increased costs for close sizing are most significant for small plants operating at Michigan's relatively low average utilization. Packing costs under these circumstances are

$0.2350 per 10 lb. bag, which is 8 percent more than packing assorted packs under the same conditions (Table 9). Increasing plant size from small to large and increasing the percent utilization of plant capacity from average Michigan utilization to full capacity, reduces packing costs of closely sized potatoes 30 percent, from $0.2350 to $0.1671 per 10 lb. bag (Table 9). Lengthening the packing season to 10 months reduces costs an additional 3 percent to $0.1614 (Table 10), which is 21 percent less than costs to pack assorted packs in large plants operating at average Michigan utilization, $0.2046 (Table 9).

The Michigan round white packing industry is composed mainly of many small independent packers. Thus the industry is characterized by high packing costs in addition to an overall low quality image. Study results indicate fewer, larger packing plants with longer packing seasons would reduce packing costs. Furthermore, results indicate that larger, more efficient plants operating for a longer season could pack closely sized potatoes at significantly lower costs than current operations packing assorted sized potatoes.

6.2 Marketing Challenges of Closely Sized Potatoes

Round white potato packers and shippers are also concerned about marketing challenges of closely sized potatoes. Typically packers/shippers estimate the quantities of different packs that can be sold in a given time

period. Those packs may be packed in anticipation of sales orders or packers may wait until orders are received before packing.

A concern about closely sized packs, where small, medium and large sizes are packed concurrently, is that the order may only be for two sizes, leaving the third size unsold. Once packed, potatoes become much more perishable than they were in storage. Packers/shippers must now find buyers for the third pack in a relatively short time period, possibly having to sell at a discount.

This problem is similar to that currently faced with different grades of potatoes. Packers may divert the unrequested grade from the packing line into bulk boxes to be put back in storage and packed at a later time when that grade is requested. This technique could be applied to unrequested sizes of potatoes.

Packers/shippers may also be uncertain in a given year as to how many packs of each size potato can be packed out of the potatoes in storage. Varieties grown, weather and cultural practices, such as irrigation, spacing of plants and time of harvest, can influence the size and grade of potatoes.

Again there is a parallel between the problem with different sizes and that with different grades. Packers examine samples of the potatoes in storage to estimate the percentage of the total quantity of each grade before the sales person seeks orders for the packed potatoes. This

technique could also be applied to different sizes of potatoes.

Packers and shippers are faced with uncertainty regarding both the demand for and supply of closely sized potatoes. These problems are not unlike those faced for any "new" fruit or vegetable, however, and similar procedures and techniques used by packers/shippers in the past to supply and sell potatoes may be applicable for closely sized potatoes.

6.3 Limitations of Research Methods

Several assumptions were made to allow direct comparisons among packing costs in the four representative synthetic packing plants in this study. Cost analyses were for 10 lb. consumer bags since 60-80 percent of round white tablestock potatoes are packed in 10 lb. bags and, in general, packers can readily compare costs of other packs to those of 10 lb. bags.

Costs calculated at replacement value for equipment and buildings and subjected to a discounted cash flow technique will likely be higher than the costs experienced by packers who have older, highly depreciated equipment, but a comparison made in present dollars reflects the entire economic costs of owning and operating a potato packing plant today. These cost figures will clearly be different than accounting cost figures, especially those used for income tax preparation.

Costs of office space, equipment and labor were omitted because they were expected to be a very small percentage of total costs. In most packing plants, office space is shared with other operations of the farm business or used primarily for sales. Management costs in the office were included in the total number of manager hours dedicated to the packing operation.

Although tax benefits of depreciation were accounted for, the investment tax credit of up to 10 percent of the purchase price of depreciable capital assets allowed the year of purchase was not deducted from annual ownership costs. This omission along with the use of straight line depreciation permitted calculation of annual ownership costs which are the same each year over the useful life of the asset.

A 1977 study entitled "Operating Costs At Four Potato Packing Plants"[1] found the man-hour production rate was not directly correlated with the size of the operation but depended on quality of management, mechanization of operations, plant layout, grade-out variation of potatoes and various other factors. Representative Michigan management, labor, equipment and output levels were used in this study, which may result in less than full capacity use of equipment, but is likely to result in costs closer to actual

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[1]U.S.D.A. Agricultural Research Service Marketing Research Report No. 1072, November 1977.

costs than would result from relying more heavily upon machinery manufacturers' output specifications.

For simplicity, transportation costs were assumed to be a linear function of distance traveled and volume transported. In fact, the transport function is likely to be nonlinear with costs per mile declining somewhat as mileage increases.

Limitations imposed by the cost analysis of four representative synthetic potato packing plants in this study imply that any individual packer's cost will differ from those reported in this research, but plant layouts and costs should approximate actual packing operations closely enough that the results of the cost analysis will be useful for firm and industry decisionmakers.

Only packing costs were measured. Since benefits were not measured in this study, no statements about the revenues of packing closely sized potatoes, increasing plant size or greater utilization of plant capacity can be made.

6.4 Suggestions for Future Research

Questions concerning the profitability of Michigan potato packing operations that closely size round white potatoes can be answered only by examining both the costs and benefits of this practice. This study focused on costs of closely sizing round white potatoes. A suggestion for future research is to examine the likely benefits of closely

sizing round white potatoes throughout the potato marketing channel from growers to consumers.

This study identified cost efficiencies associated with larger plant size and greater utilization of plant capacity, indicating a more centralized packing industry could be more cost efficient, however transport costs are likely to be higher with a centralized packing industry. A second suggestion for future research is to determine if more centralized packing operations within the Michigan potato packing industry might be more cost efficient as well as providing more consistency in the overall quality of Michigan round white potatoes.

APPENDICES

APPENDIX A

QUESTIONS FOR POTATO PACKING PLANT MANAGERS

OUTPUT

How many bags (cwt) of potatoes do you pack in an average year?

cwt onto line_____

% culls_____

cwt packed out_____

How would you rank the sizes of packing plants in Michigan?

What percent of total tablestock potatoes are packed in 10 lb. bags?

percent of total_____

cwt of 10 lb. bags per season_____

What is the length of your packing season?

months packing	J	F	M	A	M	J	J	A	S	O	N	D
weeks per month												
days per week												
hours per day												

total hours spent packing per season_____

If you were primarily packing 10 lb. bags of potatoes, how many pallets (200 10 lb. bags per pallet) could you pack in an hour running at full capacity?

What are the relative percentages (or cwt packed in an 8 hr day) of the following grades and sizes if you were packing primarily 10 lb. bags, but would have to jointly pack these other grades and sizes?

U.S. #1's, 10 lb. bags_____

50 lb. bags of Unclassified or #2's_____

B sized potatoes_____

Jumbos_____

Culls_____

Total cwt packed in a day (100%) _____

What are the relative prices (or formula for determining prices) received for each of the following grades or sizes in comparison with the price for 10 lb. bags of U.S. #1 potatoes?

10 lb. bags #1's_____

#2's or Unclassified_____

B's_____

Jumbo's_____

Other, if any_____ (Premium pack)

If you were to separate what now goes into a 10 lb. bag into small, medium and large sizes (see USDA Standards) do you have any idea what the relative quantities of each size would be?

LABOR AND MANAGEMENT

How many people work in the packing plant when you are running full capacity packing primarily 10 lb. bags?

total # of workers_____

How many are foremen?

How many at each position?

Unloading and rough grading_____

Grading_____

Removing or packing B's_____

Removing or packing Unclassified or #2's_____

Packing Jumbos_____

Bagging 10 lb._____

Sewing 10 lb._____

Stacking 10 lb._____

Running forklift(s)_____

Other_____

What is the hourly wage of the workers? of the foremen?

range_____to_____ range _____to _____

average wage_____ average wage_____

What other nonwage labor expenses do you pay (social security, unemployment, etc.)? What percentage is it of hourly wages paid?

How many hours per year does the manager(s) spend working on the packing operation (not including sales time)? What are the average hours per day?

What is an equitable hourly wage for a manager?

MATERIALS

For each of the following materials for 10 lb bags,

What is the:	Bags 10 lb.	String/ Wire	Pallet Wrap	Other
Unit size				
Price per unit				
Quantity purchased				
Shipping charge				
Manufacturer				
How many 10 lb. bags will one unit sew or wrap?				
How many (much) are (is) wasted?				

LAND

How many square feet of land are used for the building, parking, loading and unloading?

What is the 1985 market value of the land?

BUILDING

How many square feet is this building?

How many years is it's useful life?
What would you estimate its salvage value to be?

Taxes

How much do you pay in property taxes per year on packing plant land and building?

What tax bracket does this packing plant fall under: an individual proprietor, partnership or corporation?

Insurance

What value is placed on the building and equipment for insurance purposes?

What is the insurance rate per year and deductible?

Repairs

How much is spent on materials for building repair averaging over the past five years?

How much labor time is spent on repairs?

What is the wage per hour of repairmen?

Utilities

Is the packing plant metered separately for utilities?

If not, can a comparison be made between months when the packing line is operating vs. months when it is not to approximate monthly utility charges when the plant is operating at full capacity?

What is cost per unit for gas for dryer?

How many cylinders (or gallons) are used per season?

EQUIPMENT

Have you or are you planning to purchase or price any new packing plant equipment in 1985? If so, what were the items and what was (is) their cost?

What is the useful life of the various types of equipment?

Hopper Elevators Conveyors Washer Dryer Sizer Grading Table

50/100 lb Bagger 5-20 lb Bagger Forklift Other

What is their salvage value, if any?

How much is spent in an average year on repair parts and materials?

How many labor hours are spent on repairs?

What is the wage per hour of repair labor?

TRANSPORT COSTS

What percent of the potatoes you pack are taken from an on site storage vs. trucked in?

What distance do you transport potatoes from storage to the packing line?

If the distance is significant do you know how much transportation costs are per cwt?

What type of equipment do you use to haul the potatoes?

How many cwt of potatoes are transported in one vehicle?

OPERATING CAPITAL

Is a large initial sum of money required at the beginning of the season to purchase materials, insurances, etc?

How many months of operation until receipts are paying for cash expenses?

What amount of money is required to get started?

If you borrow the initial operating capital, what interest rate are you paying?

What is the length of the loan repayment period?

APPENDIX B

DATA TO GATHER FROM OBSERVATION OF PACKING LINE

Equipment:

*width of packing line

*# of lines for grading and sizing

*length of packing line

*manufacturers names and addresses

*what types of equipment are on the line; especially sizing equipment

Labor:

*how many workers at each operation

*joint operations

*10 lb. bag operations

Pictures and/or drawings:

LIST OF REFERENCES

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