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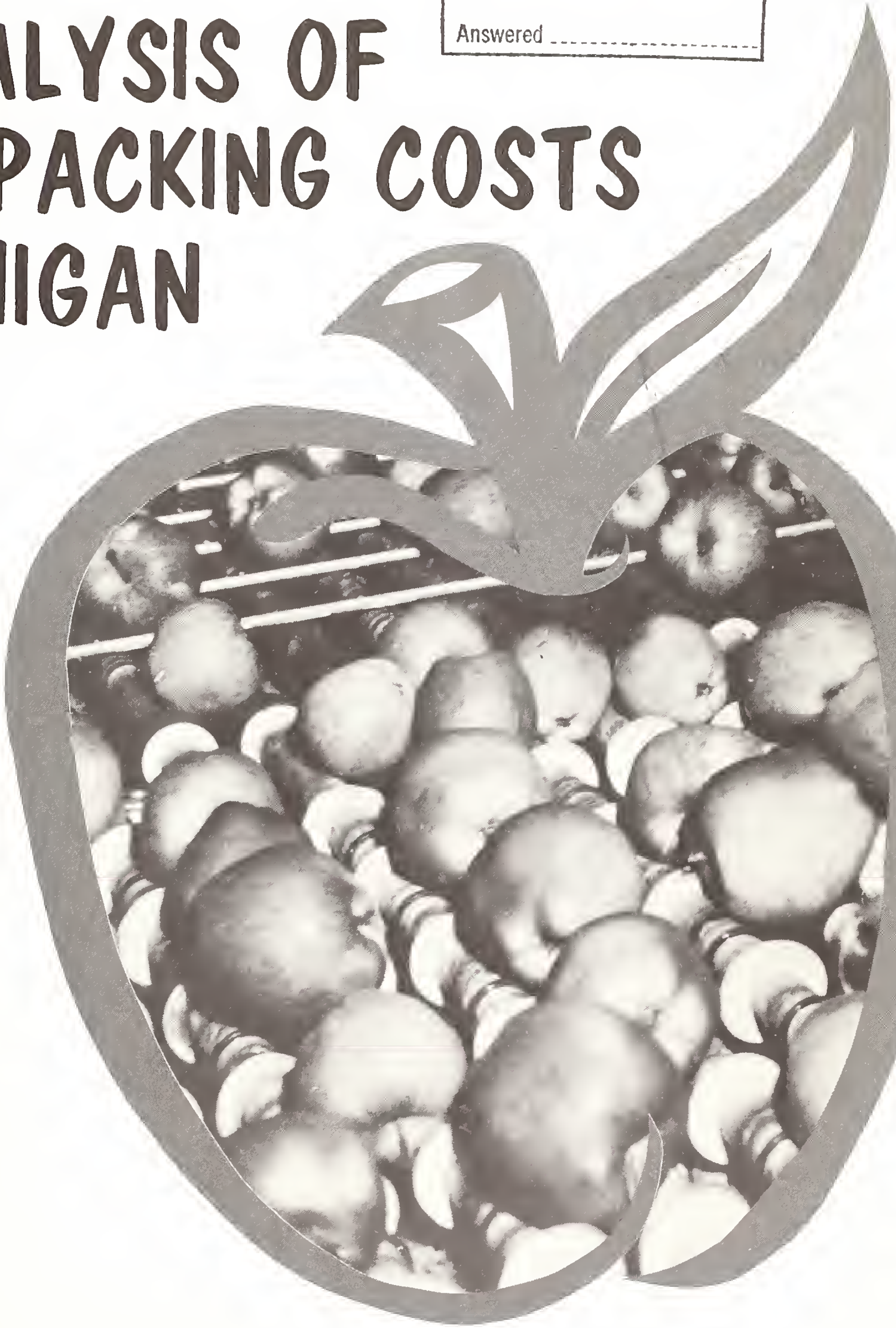
AN ANALYSIS OF APPLE-PACKING COSTS IN MICHIGAN



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in cooperation with
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SUMMARY

Conclusions

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

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

There are good economic reasons for a further reduction in the number of apple-packing plants in Michigan. Only with increases in the total season pack will packers be able to realize the potential cost savings available through increased plant capacity and a longer packing season. Almost 80 percent of the Michigan apple packers handled less than 60,000 bushels of apples in 1962-63. Assuming a 70-percent packout rate, this means that none of these plants packed as much as 50,000 cartons during the year. If five packers who presently pack 100 cartons per hour for a 500-hour season (a total of 50,000 cartons) were to combine, the optimum operation would be to pack 167 cartons per hour for a 1,495-hour season. This combination would result in an annual total cost saving of $41,467 ($220,007-$178,540) or $8,293.40 per packer. If they were to pack 200 cartons per hour for a 1,250-hour season the total cost saving would be $41,207 ($220,007-$178,800), or $8,241.40 per packer. Possible cost savings from combining operations are even greater for smaller volume packers. The net saving to the individual packer would be the total saving in packing costs minus any increase in assembly costs.

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

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

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

The Study

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

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

The economic-engineering method of cost analysis was used in this study. Labor utilization and equipment data for the analysis were obtained from observations taken in 14 Michigan apple-packing plants.

For convenience of analysis, labor and equipment requirements are given by plant stages for various rates of operation. Least-cost methods of operation for the various stages were determined. Then planning equations indicating estimated total season costs in relation to size of plant and length of operating season were developed for each operating stage and nonoperating stage component.

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

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

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

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

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

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

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

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

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

AN ANALYSIS OF APPLE-PACKING COSTS IN MICHIGAN

by Hoy F. Carman 1/

INTRODUCTION

Michigan's growing apple industry is becoming more important to the State's agricultural economy and is gaining increased national prominence. Approximately 10 percent of the annual U.S. apple output is produced in Michigan. The value of Michigan's apple crop increased from just over $20 million in 1959 to over $25 million in 1963 (18). 2/

Michigan's fresh-apple-packing industry is growing and dynamic. Apple packers have quickly adopted new handling methods, new consumer packages, and other technological advances. They have also been consolidating their packing operations (5). Until recently, apple packing in Michigan was viewed as a farm enterprise providing an opportunity to utilize family labor which had few alternative uses. Buyers' demands for rapid delivery of large orders of uniform quality apples and the apparent economies of large scale apple-packing operations have led to change. During the last 7 to 10 years, there has been a sharp decrease in the number of Michigan apple-packing firms and a corresponding increase in their average size. Many of the small apple packers of yesterday are now stockholders in large corporation packing operations.

The market power of large buyers of apples has placed increased pressure on that portion of the apple marketing margin allocated to packing. Many small apple packers (those packing less than 40,000 bushels per year) have been finding it increasingly difficult to profitably pack their fruit. Their concern led to requests for information on the relationships between costs per unit of packing apples and volume packed. Many small packers must decide on one of several alternative plans to follow during the next several years. These include continuing to pack their own fruit at their present scale, selling their fruit field-run to other packers, expanding the scale of their packing facilities either on their own or through combination with other packers, or becoming stockholders in established cooperatives or corporations which already pack on a large scale. The data presented in this study and the accompanying analysis will provide information for plant owners in Michigan and in other apple-producing areas to use in deciding among the above alternatives.

The objectives of this study were threefold:

1. To find least-cost methods for packing apples for different stages in the apple-packing operation. Costs for various methods and types of equipment were calculated and compared.

2. To develop labor requirements for the various jobs being done in Michigan apple-packing plants. These requirements were compared and supplemented with labor requirements which have been developed in other studies.

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2/ Underscored numbers in parentheses refer to Bibliography, p. 40.

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

Scope of the Study

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

The study was carried out during the 1963-64 packing season. The data are believed to be reasonably complete and accurate, and adequate for present planning needs. New technologies are constantly being devised and put into operation. Thus, important alternatives which might be relevant at some future time may not have been considered. In addition, estimates are subject to errors of omission and measurement. An error of omission may arise through failure to include the most efficient possible plant for some scales at which plant costs are measured. Errors in measurement may arise because of the period in which observations were taken in a particular plant or because of individual differences among workers in the sample. It is believed that error has been minimized through inclusion of the major variations in technologies and through dispersion of in-plant observations.

The Research Method

The economic-engineering method of cost analysis was used in the study. This method is generally termed the "synthetic" method because the researcher combines or synthesizes the many cost components of plant operations to obtain total plant costs. The synthetic procedure entails constructing a plant on paper just as architects and engineers do when bidding for contracts. Most of the basic labor utilization and equipment data employed in the analysis were obtained through observation of actual plant operations. A detailed description of the economic-engineering method of cost analysis is presented by French, Sammet, and Bressler (10).

Sources of Data

The economic-engineering method of cost analysis requires several types of data for constructing the plant stages. Required data include (1) labor requirements for the various apple-packing jobs, (2) wage rates, (3) material costs, (4) equipment costs, (5) building construction costs, and (6) overhead charges. Following is a discussion of the sources of these data.

Labor Data

Data on labor utilization and labor requirements were gathered through work sampling. 3/ Each of the jobs in a sample of 14 Michigan apple-packing plants

3/ See Barnes for a detailed presentation on the method of work sampling and its application (2).

was observed. The data obtained were then used to develop labor standards for each job. For most jobs, a uniform allowance of 15 percent of total worktime was made for nonproductive time such as waiting for supply, unavoidable delay, coffee breaks, and personal delay. For the heavy lifting jobs, such as manual dumping, a delay allowance of 20 percent was made. The actual working time plus the allowance gave the total time per unit from which output per hour was computed. For example, it was found that 1.99 minutes per 12 bag carton were required to fill a poly bag with apples and place the bag aside. 4/ With the allowance for nonproductive time, the total time per carton was 2.34 minutes. This figure, divided into 60 minutes, gave a work standard of 25 cartons per hour (appendix table 16).

The standards described above were used as a basis for determining labor requirements for the various plant operations. The computed labor standards are considered to be the continuous output rates which reasonably efficient workers should attain. They do not represent the best output achieved; rather, they represent an average of actual work-time plus a delay allowance. No attempt was made to rate individual workers. Rating requires the judgment of experienced analysts and none was available for this study. 5/

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

The number of workers required for each job when plants are operating at the various output rates was determined on the basis of one worker for each multiple and for any additional fraction of the applicable job standard. Labor requirements combined with wage rates paid by Michigan apple packers (appendix table 17) provided labor costs for the various apple-packing jobs.

Equipment Data

Equipment output capacities were obtained from estimates of plant managers, plant observations, and manufacturer specifications. Installed equipment replacement costs were based on manufacturer quotations. When there were price differences for a given piece of equipment, the lowest priced equipment capable of performing the operation with comparable efficiency was used. This is consistent with the objective of determining least-cost methods for packing apples for the different stages in the apple-packing operation. Data were compared with specifications and costs contained in recent publications.

Other Data

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

4/ "Polyethylene" is shortened to "poly" in this report.
5/ Briefly stated, rating is a process whereby the time study analyst compares the performance of the operator under observation with the analyst's own concept of normal performance. For a more complete discussion see Barnes (2).

Data from other studies, utility companies, equipment companies, and the sample plants form the basis for estimating the various overhead and operating charges.

The Sample Plants

The sample plants consisted of a group of 14 apple-packing firms located in the principal apple-packing areas of Michigan. To satisfy the objectives of the study, the sample plants were selected to cover a wide range in plant size, work methods, and equipment types. No attempt was made to make the sample statistically representative of average conditions throughout the industry. Several characteristics of the sample plants are summarized in table 1.

Table 1.--General characteristics of sample apple-packing plants

Plant	1962-63 fresh pack	Peak rate of output per hour	Average rate of output per hour	Packout as a percentage of apples dumped 1/	Percentage of pack in various containers			
					Poly bags	Tray pack	Jumble pack	Other 2/
	Bu.	Bu.	Bu.	Pct.	Pct.	Pct.	Pct.	Pct.
A.....	50,000	194	141	68	80	15	5	-
B.....	207,000	202	158	67	77	7	7	9
C.....	78,000	262	174	71	75	5	20	-
D.....	65,000	242	144	81	100	-	-	-
E.....	124,000	230	182	49	58	1	40	1
F.....	195,000	214	162	58	60	30	10	-
G.....	60,000	155	141	69	100	-	-	-
H.....	17,100	33	27	72	99	-	-	1
I.....	76,500	281	192	72	90	10	-	-
J.....	150,000	297	176	75	67	20	13	-
K.....	130,000	174	130	63	50	15	5	30
L.....	162,500	336	267	66	65	27	2	6
M.....	180,000	279	202	69	60	25	5	10
N.....	263,300	216	188	75	73	2	18	7

1/ The difference between the percentage figure in this column and 100 percent gives the combined percentage of cull and utility apples.
2/ Apples packed in bushel baskets, gift packs, and shrink film overwraps.

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

As noted, the sample plants included a majority of medium-sized and large plants. The sample plants packed approximately 23 percent of the 1962-63 fresh apple pack in Michigan. These plants also packed a higher proportion of their pack in poly bags than did the average Michigan plant. Totaling the figures in table 1 reveals that the sample plants packed 70 percent of their pack in poly bags, 14 percent in tray packs, 11 percent jumble pack, and 5 percent in other packages. Data for the 1963-64 pack would probably indicate an even higher percentage of the pack in poly bags.

Deriving the Cost-Volume Relationship

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

ANALYSIS OF COST COMPONENTS

Plant Organization

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

In the packing operation the apples can be placed in a variety of packages. The 3- and 4-pound poly bags placed 12 and 10 to a master container are currently the most popular package for Michigan. Depending on customers' requirements, the apples may also be jumble packed in bushel cartons, be tray packed, or placed in overwrapped trays. The package used in a particular plant at a given time will depend largely on the current day's orders. Because most Michigan packers pack strictly on order, the packed apples remain in temporary storage only a short time before being loaded out on trucks.

Activities included in the previously mentioned sequences of operations are, for ease of analysis, grouped into production stages. This allows independent cost analysis of each segment of the total plant. Analysis by stages reduces the total number of plant combinations which must be considered. Within many of the stages there are alternative methods or techniques which can be used to perform a given operation. This means that there can be a few or many ways to organize a plant. By choosing the least-cost technique in each stage, a least-cost organization can be constructed for each size of plant and length of season.

Assuming that the stages are independent (that is, the technology utilized in one stage does not affect the choice of technology for another stage), a least-cost plant organization is derived by simply adding least-cost techniques for each stage. If the stages were dependent, they would need to be redefined into a single stage for cost comparison purposes. Since the number of alternative technologies for a production stage is the product of the technologies of the individual operations, it is obvious that the number of calculations which must be made increases sharply

PROCESS FLOW DIAGRAM, REPRESENTATIVE APPLE-PACKING PLANT, MICHIGAN, 1964

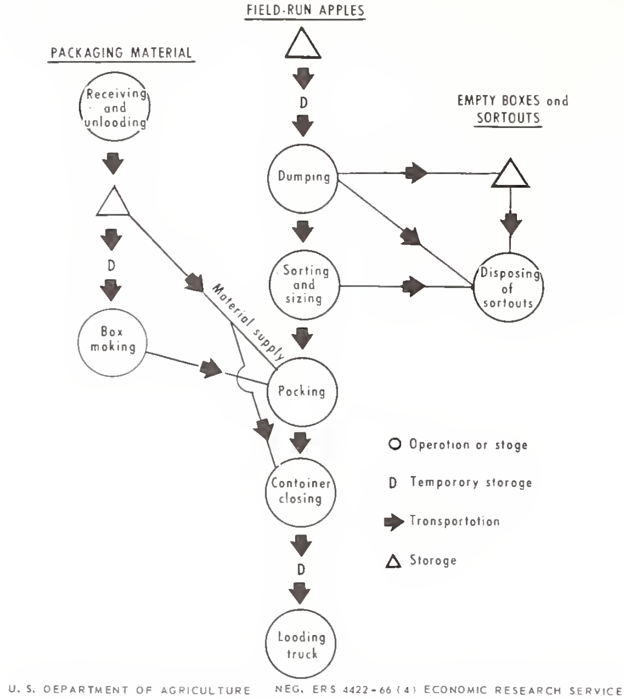

Figure 1

FLOOR PLAN, REPRESENTATIVE MEDIUM-SIZED APPLE-PACKING PLANT, MICHIGAN, 1964

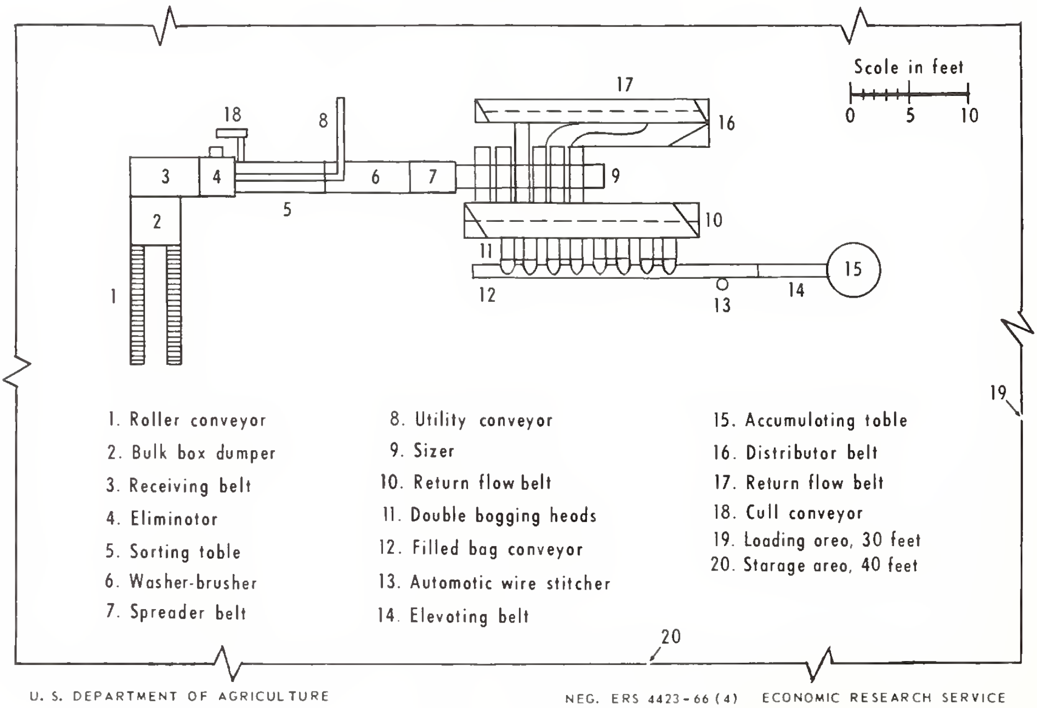

Figure 2

when the stages are dependent. An additional limitation to the simple combination of least-cost technologies for each stage is the problem of smoothly matching the capacities of each stage. This problem is commonly referred to as the problem of harmonious combinations of equipment. Neither of these limitations affected the analysis of the synthetically constructed plants in this study. The plant stages proved to be independent and stage capacities were such that they matched smoothly to provide plant capacities of 100 through 500 cartons per hour output.

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

Assumptions

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

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

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

3. Packers operate for 8 or 10 hours a day. No overtime wages are paid.

4. A bushel of apples weighs 48 pounds. Packed containers of apples average approximately 40 pounds.

Operating Stage Analysis

Stage 1: Dumping

Apples are handled in both bushel crates and bulk boxes. Different methods of dumping are used for the two types of containers. Dumping bushel crates is primarily a hand operation; bulk boxes, because of their weight, are dumped by machine.

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

Because of the cost advantages which can be realized through the use of bulk boxes, most Michigan apple packers now use them (11, 17). Capacities of bulk boxes range from 15 to 23 bushels of apples. This means that a filled bulk box may weigh as much as 1,300 pounds. Two types of bulk-box dumpers are commonly used in Michigan. They are the tilt-type hydraulic dumper and the water immersion dumper. With the tilt-type dumper the filled box is placed in a hydraulically controlled dumping frame. As the filled box swings up into dumping position, it comes in contact with a padded cover, one side of which is hinged to allow the operator to control the rate of flow of apples out of the box.

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

In the plants studied, the actual rate of dumping with the hand-dumping method varied from 107 to 210 bushels per hour. However, the rate of dumping is governed by other operations on the packing line. The dumper adjusts his pace so as to maintain the proper flow of fruit to other workers on the line. A standard for the manual dumping job was computed using an assumed pace of 142 bushels per hour. With the dumping aid, the standard is 152 bushels per hour.

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

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

Table 2 presents labor and equipment requirements and costs for dumping apples at five different input rates. Assuming a 70-percent packout, these are the input rates necessary to obtain outputs of 100, 200, 300, 400, and 500 cartons per hour. Costs are given for three dumping methods, manual, dry bulk, and water bulk. Note that costs for the manual dumping method are given for only three input rates. Because of the rapid adoption of bulk boxes, it is doubtful that a sufficient volume of apples in bushel crates would be available to satisfy the requirements of larger capacity plants.

Total season costs for a particular dumping method and plant size are computed by multiplying the total variable costs per hour by the number of hours the plant is operated and then adding the annual fixed charge. Variable costs per hour include charges for labor, power, and variable repairs and maintenance of equipment. The annual fixed charge includes allowance for fixed repairs, insurance, interest

Table 2.--Labor requirements, hourly variable costs, equipment replacement costs, and annual fixed charge for dumping apples, by method used and size of plant, Michigan, 1963-64

Input rate (bu. per hr.)	Workers required	Variable costs per hour: Labor 1/	Variable costs per hour: Power and repair 2/	Variable costs per hour: Total	Equipment replacement cost and annual fixed charge 3/: Dumper	Receiving belt	Leaf eliminator	2¼ in. eliminator	Roller conveyor	Total replacement cost	Annual fixed charge
					MANUAL DUMPING						
	Number	Dollars									
120	1	1.38	.06	1.44		332.80		366.29		699.09	136.32
240	2	2.76	.07	2.83		402.58		474.03		876.61	170.94
360	3	4.14	.08	4.22		441.48		474.03		915.51	178.52
					DRY BULK DUMPING						
120	1	1.38	.21	1.59	964.08	441.48		474.03	312.00	2,191.59	427.36
240	1	1.38	.21	1.59	964.08	441.48		474.03	312.00	2,191.59	427.36
360	2	2.76	.37	3.13	1,928.16	546.52		605.07	624.00	3,703.75	722.23
480	2	2.76	.37	3.13	1,928.16	546.52		605.07	624.00	3,703.75	722.23
600	2	2.76	.37	3.13	1,928.16	546.52		605.07	624.00	3,703.75	722.23
					WATER BULK DUMPING						
120	1	1.38	.39	1.77	4,160.00		280.80	366.29		4,807.09	937.38
240	1	1.38	.40	1.78	4,160.00		280.80	474.03		4,914.83	958.39
360	1	1.38	.53	1.91	5,200.00		452.40	474.03		6,126.43	1,194.65
480	1	1.38	.55	1.93	5,200.00		452.40	605.07		6,257.47	1,220.21
600	1	1.38	.55	1.93	5,200.00		452.40	605.07		6,257.47	1,220.21

1/ Hourly wage $1.25 plus 10 percent to cover social security and workmen's compensation.
2/ Electric power estimated at 3.5 cents per hour per motor horsepower. Variable repairs and maintenance calculated at 0.5 percent of replacement cost per 100 operating hours.
3/ See appendix table 18 for list of equipment replacement costs and annual fixed charges.

on investment, property tax, and depreciation. Total season costs for a given volume and length of season vary by the method of dumping used. For a plant input capacity of 120 bushels per hour, manual dumping is the least-cost method for seasons up to 1,600 hours. Dry bulk dumping is the least-cost method for plants dumping 240 bushels per hour and operating up to 1,600 hours. It is also the least-cost method for plants dumping 360 bushels per hour and operating up to 400 hours per season. For plants this size operating more than 400 hours per season, water bulk dumping offers lowest total season costs. Water bulk dumping is also the least-cost method for plants with capacities of 480 and 600 bushels per hour.

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

Figure 3 presents stage planning costs for seasons of 400, 800, 1,200, and 1,600 hours. The lines illustrate the relation of total season costs to input capacity when plants are equipped with the least-cost dumping method. It is obtained by fitting a least-squares regression line through the least-cost points at selected output rates for the alternative methods considered. Costs in relation to dumping rate as represented by this line are referred to as "planning costs" since they represent attainable levels of cost with respect to plant size. 6/

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

$$TSC = 131.78(H)+272.93(C)+15.32(H)(C) \qquad (1)$$

where

TSC = Total season costs of dumping in dollars.
(H) = Hundred hours of plant operation per season.
(C) = Capacity output of plant per hour in hundreds of cartons.
(H)(C) = Total season pack in 10,000-carton units.

Equation (1) can be used to estimate total season costs of dumping apples for a given plant size and length of season. For example, if a plant with a capacity of 300 cartons per hour were to operate 800 hours, the estimated cost of the dumping stage would be:

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

Equation (1) shows an average relationship between costs and rate of output for a given length season. Planning equations are developed below for all stages and cost components, and are combined to form planning cost equations for an entire plant. This procedure permits the derivation of average costs for plants of different capacity.

Stage 2: Sorting and Sizing

Apples are deposited on the sorting table after leaving the dumping stage. Workers stationed along each side of the sorting table remove the cull and utility

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6/ This method of fitting curves to stage cost data was used by Carleton C. Dennis (6).

COSTS FOR DUMPING, REPRESENTATIVE APPLE-PACKING PLANTS, MICHIGAN, 1963-64 SEASON

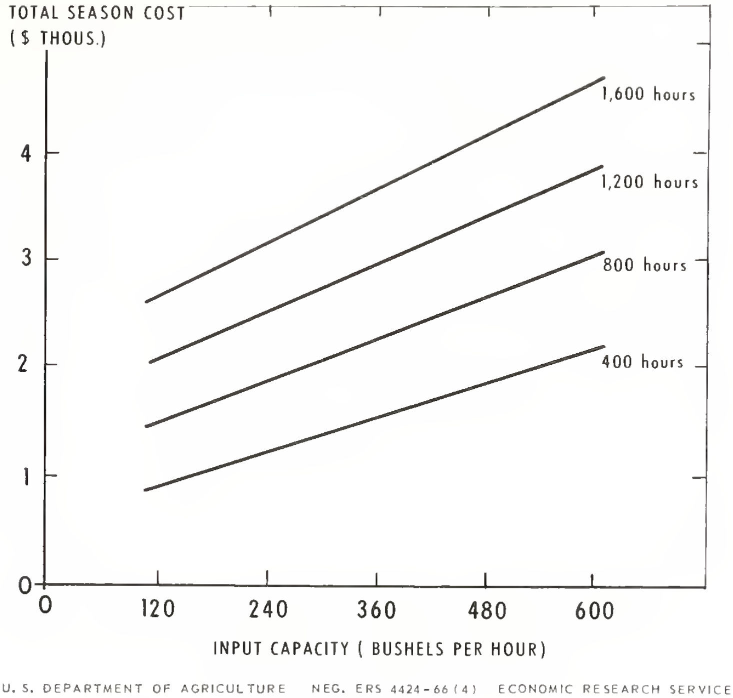


Figure 3

grade apples. The cull apples are placed in chutes at the side of the table and are conveyed to a bulk box beside the packing line. Most cull grade apples are processed for juice, cider, or vinegar. Utility grade apples are placed on a conveyor belt which runs over the center of the sorting table and then to a bulk box beside the packing line. The utility grade apples are sold to processors for processing into sauce, slices, and other products.

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

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

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

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

The float roll sorting table, a table similar to the roller sorting table was developed and tested in Washington State (15), where it was found to be more efficient than any of the other tables observed. Speed of sorting, however, was not as high as observed in Michigan when the roller sorting table was used. Probable reasons for these differences include size of fruit, variety and type of pack, and differences between workers. Two sorting table modifications tested in the Washington study were the installation of sorting lanes and cull disposal chutes (15). These modifications, as yet largely untried by Michigan apple packers, should increase the efficiency of the sorting operation.

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

The majority of Michigan apple packers use one of two types of dimension sizers--the chain-type sizer or the variable-speed cup-type sizer. The chain sizer was generally used in the smaller packinghouses while larger volume operations tended to use the variable-speed cup sizer. Other types of dimension sizers are in use but only by a limited number of packers.

Costs are computed only for the variable-speed cup sizer. Even though chain sizers are used by many of the smaller packers, their disadvantages precluded their consideration in the study. The major disadvantages include space requirements, bruising of apples, and lack of accuracy of sizing. 7/ The variable-speed cup sizer consists of sets of plastic cups made up of two parts. These cups separate as they move forward. When the diameter of the cup equals the diameter of the apple, the apple falls through the cup onto a takeaway belt. The takeaway belts deliver apples to the return flow belts.

No labor is required for operating the washer-brushers and sizers. The amount of labor required for sorting varies with the percentage of cull and utility grade apples. Since the percentage of culls and utilities may vary from lot to lot of apples, it may be necessary to adjust the number of sorters one or more times during a working day. Because the sorting operation is an important determinant of the quality of the pack, supervision of the operation is an important and continuing job.

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

7/ Evans and Marsh (7) found that damage to apples averaged 6 percent with properly used chain sizers and 3.5 percent with variable-speed cup sizers. Burt (4) found that bruising with the chain sizer averaged 15.8 percent and with the variable-speed cup sizer only 1.4 percent. Burt also concluded that if no more than 1/8-inch variation from the standard diameter (giving a range of 1/4 inch) is acceptable, then chain sizing is not adequate since only 49 to 87 percent of the sized apples fell within this range. With the variable-speed cup sizer 60 to 89 percent were within 1/8 inch of the standard diameter.

The predominant factor affecting the number of sorters required is the percentage of cull and utility grade apples which must be removed. Table 3 gives the number of workers required for different rates of operation and for removing various percentages of cull and utility grade apples. The cost advantage of packing high quality fruit is pointed out by data in this table. For instance, when apples are dumped at a rate of 360 bushels per hour, labor costs increase 50 percent per hour when the percentage of culls and utilities increases from 10 to 40 percent.

In table 3, any time a fraction of a worker is required a worker is added to the labor requirements. For example, row one shows that 2.04 workers are required to sort 114 bushels of apples per hour when there are 15 percent cull and utility grades present. This results in a labor requirement of 3 workers.

Table 4 shows the costs per hour of sorting apples with different percentages of cull and utility grades and at various rates of operation. This information, combined with the information on annual fixed charge and power and repair costs per hour given in table 5, was used to derive estimated total season costs for the sorting and sizing stage.

Table 3.--Number of sorters required for various rates of operation and percentage of cull and utility grade apples, Michigan, 1963-64

Rate of operation 1/ (bu. dumped per hr.)	Percent cull and utility grade apples: 10	15	20	25	30	35	40
	Number of workers 2/						
120	2	3	3	3	3	3	3
240	4	5	5	5	5	5	6
360	6	7	7	7	7	8	9
480	8	9	9	9	10	10	11
600	10	11	11	11	12	13	14

1/ It is assumed that 5 percent of the apples dumped are removed at the 2¼-inch eliminator.

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

Table 4.--Per hour sorting labor costs for various rates of operation and different percentages of cull and utility grade apples, Michigan, 1963-64 1/

Rate of operation (bu. dumped per hr.)	Percent cull and utility grade apples: 10	15	20	25	30	35	40
	Dollars per hour 2/						
120	2.76	4.14	4.14	4.14	4.14	4.14	4.14
240	5.52	6.90	6.90	6.90	6.90	6.90	8.28
360	8.28	9.66	9.66	9.66	9.66	11.04	12.42
480	11.04	12.42	12.42	12.42	13.80	13.80	15.18
600	13.80	15.18	15.18	15.18	16.56	17.94	19.32

1/ Based on labor requirements listed in table 3.

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

Table 5.--Hourly variable equipment costs, equipment replacement costs, and annual fixed charge, for the sorting and sizing stage, by size of plant, Michigan, 1963-64

Output capacity (cartons per hr.)	Variable costs per hour (power and repair) 1/	Equipment replacement costs and annual fixed charge 2/							
		Sorting table	Cull and utility conveyors	Washer-brusher	Spreader belt	Sizing unit	Automatic box filler	Total replacement cost	Annual fixed charge
	Dollars								
100	.79	768	840	1,855	291	8,320		12,074	2,354.43
200	.85	1,048	882	2,057	333	8,320		12,640	2,464.80
300	1.33	1,265	1,205	2,256	364	13,104	1,448	19,642	3,830.19
400	1.42	1,464	1,219	2,808	484	13,104	1,448	20,527	4,002.77
500	1.52	1,800	1,327	3,874	582	13,104	1,448	22,135	4,316.33

1/ Electric power estimated at 3.5 cents per hour per motor horsepower. Variable repairs and maintenance calculated at 0.5 percent of replacement cost per 100 operating hours.
2/ See appendix table 18 for list of equipment replacement costs and annual fixed charges.

The lines in figure 4 illustrate estimated total season planning costs for the sorting and sizing stage. The planning costs are for specified lengths of season when 25 percent of the apples are sorted out as utilities and culls. Less than 25 percent cull and utility grade apples would result in lower total season costs, and more than 25 percent would result in higher total season costs. Each of the planning cost lines shows, for specified hours of operation per season, estimated total season costs for sorting and sizing in relation to rate of output. Again the planning costs can be expressed in a stage planning equation as follows:

$$TSC = 1740.76+143.33(H)+549.73(C)+244.45(H)(C)+3.24(H)(C)(P) \qquad (2)$$

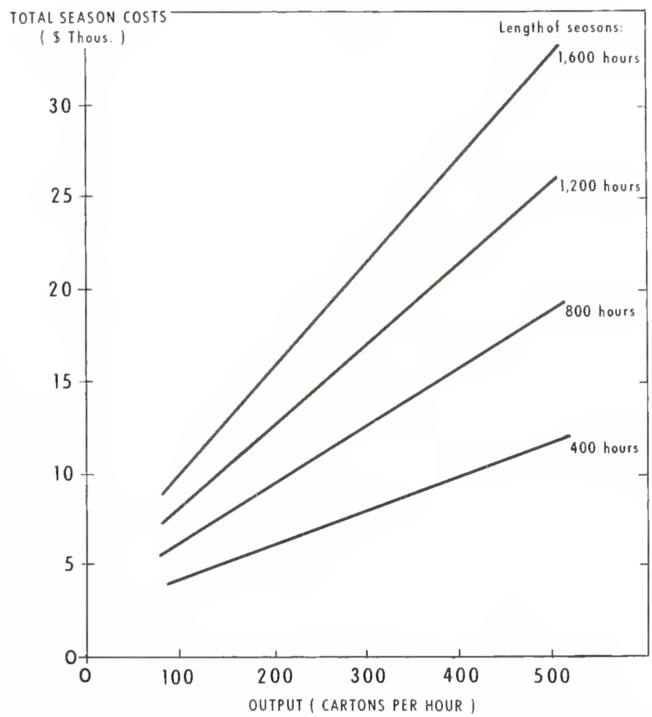
where

TSC = Total season cost of sorting and sizing in dollars.
(H) = Hundred hours of plant operation per season.
(C) = Capacity output of plant per hour in hundreds of cartons.
(P) = Percentage of apples sorted out as culls and utilities.
(H)(C) = Total season pack in 10,000-carton units.
(H)(C)(P) = A relative measure of total season sortout.

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

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

COSTS OF SORTING AND SIZING (25 PERCENT SORTOUT), REPRESENTATIVE APPLE-PACKING PLANTS, MICHIGAN, 1963-64 SEASON



U. S. DEPARTMENT OF AGRICULTURE NEG. ERS 4425-66 (4) ECONOMIC RESEARCH SERVICE

Figure 4

Stage 3: Packing

The packing stage is the focus of activities in apple-packing operations. It is here that apples are placed in containers as specified by buyers for shipment to markets. The majority of apples (over 65 percent of the 1962-63 Michigan pack and probably over 70 percent of the 1963-64 pack) are placed in consumer packages. These consumer packages, mainly 3- and 4-pound poly bags, are shipped in master containers which hold 36 to 40 pounds of bagged apples. Some apples are also placed in tray packs and in jumble-type packs. Other packs may be put up at the request of a buyer. These include gift packs, shrinkfilm overwrapped trays, bushel baskets, and small jumble packs.

Regardless of the package used, apples proceed through a fairly standard sequence of operations in the packing stage. The apples are delivered to the return flow belt from the sizer, removed from the belt and placed in packages, and the packages are closed.

Almost all Michigan plants have equipment for bagging, for tray packing, and for jumble packing. Bagging requires return flow belts, baggers, a filled-bag conveyor, a bag closing device, and an accumulating table for bags. Packing trays or jumble packs require distributor belts, return flow belts, packing stands, and a roller conveyor to transfer filled cartons to the closing station. Use of shrinkfilm overwrapped trays requires additional investment in wrapping stands, heat tunnel, roller conveyor, and accumulating table.

Michigan apple packers, because of their specialization in bagging, have labor costs for bagging as low or lower than packers in other regions. Labor costs for tray packing and jumble packing are, however, higher than for other regions, where packers have tended to specialize in these types of packs. 8/

The analytical procedure for the packing stage is to construct synthetic plants with sufficient capacity to bag all of their output in 3- and 4-pound poly bags. Additional equipment is added to this basic line so that 15 to 20 percent of the pack can be placed in tray packs and in jumble packs. Thus, total season costs can be computed for a plant bagging 65 percent of its output, tray packing 20 percent of its output, and jumble packing 15 percent.

Bagging.--In Michigan 4-pound bags are placed upright 10 to a master container. These packs are called 10-4's by persons in the industry. Three-pound bags are placed on their sides, six bags to a layer, and two layers to a master container. These packs are called 12-3's. Since most packers place from 2 to 3 ounces extra in each bag to allow for shrinkage, the net weight of the containers is about 42 and 38 pounds respectively. While in-plant observations were being taken, half of the cartons bagged were 10-4's and half were 12-3's.

The type of equipment used, the equipment layout, and the sequence of operations are all important determinants of output in bagging apples. Plant observations and equipment prices revealed that for plants in the output ranges considered in this study, semiautomatic baggers and semiautomatic bag stitchers should be used. The use of these two pieces of equipment influences the layout and sequence of operation. The semiautomatic baggers require more space than bagging aids for hand bagging and move the worker away from the return flow belt. With the semi-

8/ Comparative labor requirements are presented in several other studies (3, 4, 13, 16, 20, 21).

automatic bag stitcher, a worker fills the bag and places it on a filled-bag conveyor. It is closed by another worker. Without the semiautomatic bag stitcher the worker fills the bag, tapes it closed, and places it on a conveyor. Labor standards in the appendix show that four workers bagging and one worker tying have a higher output per hour than five workers bagging and taping their own bags. The placement of the filled-bag conveyor belt is important. To increase output, the belt should be placed directly under the bagging heads rather than behind the workers. This eliminates the time and effort necessary to turn around in order to dispose of a filled bag.

The equipment requirements for packing 3- and 4-pound bags are identical. The cost per carton for packing 3-pound bags is higher, however, because of higher labor requirements (table 6). The extra worker is required to place the filled bags in master containers. For the plants with larger output capacity (300, 400, and 500 cartons per hour), two bagging areas are necessary. This means that two each of the return flow belts, filled-bag conveyors, semiautomatic bag closers, elevating belts, and accumulator tables are required. There will be some waiting to place filled bags on the conveyor when 10 workers using semiautomatic baggers are using 1 conveyor, but the standard rate of bagging can be maintained.

The sequence of operations for packing in poly bags is as follows: Apples moving down the return flow belt are diverted into the bagger by a diverter rod. A short belt automatically dumps apples into the bagging head until the required weight is reached. The worker checks the weight and adds or subtracts apples as necessary. The worker then places a poly bag over the bagger head, dumps the apples into the bag, and places it upright on the filled-bag conveyor. The conveyor carries the bag toward a semiautomatic wire stitcher where a worker guides the top of the bag into the stitcher intake. The stitcher gathers and closes the neck of the bag and deposits it back on the conveyor. The closed bag then travels to an accumulating table from which it is placed in a master container.

Labor requirements, equipment replacement costs, annual fixed charges, and variable costs for packing in 3- and 4-pound poly bags are given in table 6. Total season planning costs which show the relationship between total season costs and plant size are given by the following equations:

$$TSC_4 = 417.0+109.80(H)+928.0(C)+757.20(H)(C) \quad (3)$$

$$TSC_3 = 417.0+247.80(H)+928.0(C)+757.20(H)(C) \quad (4)$$

where

TSC_4 = Total season cost for packing 4-pound poly bags.

TSC_3 = Total season cost for packing 3-pound poly bags.

(H) = Hundred hours of plant operation per season.

(C) = Capacity output of plant per hour in hundreds of cartons.

(H)(C) = Total season pack in 10,000-carton units.

If a plant with a capacity of 300 cartons per hour were to operate 800 hours, the estimated cost for packing 4-pound poly bags would be

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

and for packing 3-pound poly bags it would be

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

Table 6.--Labor requirements, hourly variable costs, equipment replacement costs, and annual fixed charge for packing apples, by size of bag and size of plant, Michigan, 1963-64

Output capacity (cartons per hour)	Workers required	Variable costs per hour			Equipment replacement cost and annual fixed charge 3/						
		Labor 1/	Power and Repair 2/	Total	Return-flow belt	Baggers	Angle bag conveyor	Semi-automatic bag closer	Elevating belt and accumulator table	Total replacement cost	Annual fixed charge
					FOUR-POUND BAGS						
	Number	Dollars									
100	6	8.28	.41	8.69	1,333.28	2,277.60	609.44	1,432.00	618.80	6,271.12	1,393.69
200	11	15.18	.58	15.76	1,433.12	4,555.20	803.92	1,432.00	618.80	8,843.04	2,066.03
300	17	23.46	.97	24.43	2,516.80	6,832.80	1,418.56	2,864.00	1,237.60	14,869.76	3,412.07
400	22	30.36	1.16	31.52	2,866.24	9,110.40	1,607.84	2,864.00	1,237.60	17,686.08	4,132.07
500	27	37.26	1.41	38.67	3,592.16	11,388.00	2,184.00	2,864.00	1,237.60	21,265.76	5,000.92
					THREE-POUND BAGS						
100	7	9.66	.41	10.07	1,333.28	2,277.60	609.44	1,432.00	618.80	6,271.12	1,393.69
200	12	16.56	.58	17.14	1,433.12	4,555.20	803.92	1,432.00	618.80	8,843.04	2,066.03
300	18	24.84	.97	25.81	2,516.80	6,832.80	1,418.56	2,864.00	1,237.60	14,869.76	3,412.07
400	23	31.74	1.16	32.90	2,866.24	9,110.40	1,607.84	2,864.00	1,237.60	17,686.08	4,132.07
500	28	38.64	1.41	40.05	3,592.16	11,388.00	2,184.00	2,864.00	1,237.60	21,265.76	5,000.92

1/ Hourly wage, $1.25 plus 10 percent to cover social security and workmen's compensation.
2/ Electric power estimated at 3.5 cents per hour per motor horsepower. Variable repairs and maintenance calculated at 0.5 percent of replacement cost per 100 operating hours.
3/ See appendix table 18 for list of equipment replacement costs and annual fixed charges.

Tray and Jumble Packing.--Tray and jumble packs have become popular and now take the place formerly occupied by bushel baskets. The tray pack consists of a tray master measuring 20 by 12 by 12 inches and four or five molded pulp trays. The number of trays needed depends on the size of the apples being packed. Three and one-fourth inch apples and larger require four trays while smaller apples require five trays. The jumble pack is placed in a 17- by 13- by 11-inch carton.

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

Distributor belts, a return flow belt or additional length on the return flow belt used for bagging, packing stands for each packer, and a roller conveyor must be added to the basic bagging equipment.

Labor requirements, equipment replacement costs, annual fixed charges, and variable costs for tray and jumble packing are presented in table 7. Total season costs for each of the packages can be estimated through application of the following equations:

$$TSC_t = 315.00+65.70(H)+431.82(C)+1141.36(H)(C) \quad (5)$$

$$TSC_j = 296.26+9.73(H)+352.77(C)+822.02(H)(C) \quad (6)$$

where

TSC_t = Total season costs of packing tray packs.

TSC_j = Total season costs of packing jumble packs.

(H) = Hundred hours of plant operation per season.

(C) = Capacity output of package per hour in hundreds of cartons.

(H)(C) = Total season pack in 10,000-carton units.

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

The other containers used by Michigan apple packers individually account for a small percentage of annual packed volume. Use of these containers was observed infrequently during in-plant observations. Since no labor standards were developed, no costs are calculated for packing in these containers. For those interested, some cost data are available in other studies. 9/

9/ Labor costs for gift packs can be approximated from those for similar tray and jumble packs. For costs of packing bushel baskets see French and Gillette (9). Costs of overwrapping were calculated by James B. Fountain (8).

Table 7.--Labor requirements, hourly variable costs, equipment replacement costs, and annual fixed charge for tray and jumble packing apples by size of plant, Michigan, 1963-64

Output capacity (cartons per hour)	Workers required	Variable costs per hour			Equipment replacement cost and annual fixed charge 3/						
		Labor 1/	Power and repair 2/	Total	Distributor belt	Return-flow belt	Packing stands	Conveyor	Conveyor stands	Total replacement cost	Annual fixed charge
TRAY PACK											
	Number	Dollars									
22	2	2.76	.13	2.89	726.96	1,137.76	93.60	70.72	18.72	2,047.76	394.73
44	4	5.52	.15	5.67	933.92	1,333.28	187.20	70.72	18.72	2,543.84	489.13
66	6	8.28	.20	8.48	1,368.64	1,606.80	280.80	106.08	24.96	3,387.28	650.22
88	8	11.04	.22	11.26	1,368.64	1,796.08	374.40	106.08	24.96	3,670.16	703.04
110	10	12.42	.23	12.65	1,368.64	1,985.36	468.00	141.44	31.20	3,994.64	762.93
JUMBLE PACK											
17	1	1.38	.12	1.50	726.96	1,137.76	46.80	35.36	12.48	1,959.36	379.71
34	2	2.76	.13	2.89	726.96	1,137.76	93.60	70.72	18.72	2,047.76	394.73
51	3	4.14	.15	4.29	933.92	1,333.28	140.40	70.72	18.72	2,497.04	481.17
68	4	5.52	.15	5.67	933.92	1,333.28	187.20	70.72	18.72	2,543.84	489.13
85	5	6.90	.20	7.10	1,368.64	1,606.80	234.00	106.08	24.96	3,340.48	642.27
102	6	8.28	.20	8.48	1,368.64	1,606.80	280.80	106.08	24.96	3,387.28	650.22

1/ Hourly wage, $1.25 plus 10 percent to cover social security and workmen's compensation.
2/ Electric power estimated at 3.5 cents per hour per motor horsepower. Variable repairs and maintenance calculated at 0.5 percent of replacement cost per 100 operating hours.
3/ See appendix table 18 for list of equipment replacement costs and annual fixed charges.

Stage 4: Container Closing

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

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

The organization of workers and work assignments is an important aspect of this stage. The nature of the jobs to be performed is such that one man can perform one or all of the operations. Following are the crew organizations used in the five model plants: plant packing 100 cartons per hour--one man closes, stamps, and palletizes the cartons; 200 cartons per hour--one man closes the cartons while another man stamps and palletizes them; 300 cartons per hour--two men close cartons and palletize them while another man stamps the cartons; 400 cartons per hour--two men close cartons and two men stamp and palletize cartons; 500 cartons per hour--two men close cartons, two men palletize cartons, while another man stamps the cartons.

Crew requirements, variable costs, equipment replacement costs, and annual fixed charges for output rates of 100 to 500 cartons per hour are given in table 8. The following stage planning equation was derived from calculated total season costs:

$$TSC = 52.59 + 139.19(H)(C) \qquad (7)$$

where

TSC = Total season costs of container closing.
(H) = Hundred hours of plant operations per season.
(C) = Capacity output of plant per hour in hundreds of cartons.
(H)(C) = Total season pack in 10,000-carton units.

Total season costs of a plant with a capacity of 300 cartons per hour operating 800 hours per season would be

$$TSC = 52.59 + 139.19(24) = \$3393.15.$$

Stage 5: In-Plant Handling of Products and Materials

This stage is concerned with the handling and movement of apples and packing materials within the packing plant. Activities and operations in this stage include receiving and storing packing materials, bringing unpacked apples out of storage and positioning them at the dumper, removing empty boxes to the storage areas, removing filled boxes of cull and utility apples, returning empty boxes into position at cull and utility conveyors, moving pallets of packed fruit to temporary storage, and loading out packed fruit.

Transportation is very important in this stage since all of the previously mentioned activities involve the movement of apples or materials. Fork-lift trucks are used extensively in this stage. Charges for lift trucks are made on the basis of the time

Table 8.--Labor requirements, hourly variable costs, equipment replacement costs, and annual fixed charges for closing containers, by size of plant, Michigan, 1963-64

Output capacity (cartons per hr.)	Workers required	Variable costs per hour			Equipment replacement cost and annual fixed charge 3/					
		Labor 1/	Power and repair 2/	Total	Staplers	Roller conveyor	Conveyor stands	Stamps and pads	Total replacement cost	Annual fixed charge
	Number	Dollars								
100	1	1.38	.01	1.39	130.00	70.72	18.72	10.40	229.84	42.58
200	2	2.76	.01	2.77	130.00	70.72	18.72	10.40	229.84	42.58
300	3	4.14	.02	4.16	195.00	140.72	37.44	20.80	393.96	72.37
400	4	5.52	.02	5.54	260.00	140.72	37.44	20.80	458.96	85.05
500	5	6.90	.03	6.93	260.00	212.16	49.92	20.80	542.88	99.31

1/ Hourly wage, $1.25 plus 10 percent to cover social security and workmen's compensation.
2/ Variable repairs and maintenance calculated at 0.5 percent of replacement cost per 100 operating hours.
3/ See appendix table 18 for list of equipment replacement costs and annual fixed charges.

actually used. A total charge of $0.48 per hour of lift truck operation includes $0.23 for variable repairs and maintenance and $0.25 for fuel and oil. Lift truck drivers must be present whenever the plant is operating even though they may not be driving a lift truck at all times. Therefore labor costs for this stage, as shown in table 9, are computed for the total number of hours the plant is operated. Because the charge for lift trucks is made on the basis of time used, the analysis for this stage is mainly concerned with lift truck time requirements for different operations and activities.

Table 9.--Labor requirements, hourly variable costs, equipment replacement costs, and annual fixed charges for handling products and materials, by size of plant, Michigan, 1963-64

Output capacity (cartons per hr.)	Workers required	Variable costs per hour			Equipment replacement cost and annual fixed charge 3/				
		Labor 1/	Power and repair 2/	Total	Lift truck	Pallets	Bulk boxes	Total replacement cost	Annual fixed charge
	Number	Dollars							
100	1	1.76	.05	1.81	5,993	400	675	7,068	1,201.56
200	2	3.52	.11	3.63	11,986	800	1,350	14,136	2,403.12
300	3	5.28	.16	5.44	17,979	1,200	2,025	21,204	3,604.68
400	4	7.04	.22	7.26	23,972	1,600	2,700	28,272	4,806.24
500	5	8.80	.27	9.07	29,965	2,000	3,375	35,340	6,007.80

1/ Hourly wage, $1.60 plus 10 percent to cover social security and workmen's compensation.
2/ Variable repairs and maintenance calculated at 1.0 percent of replacement cost per 100 operating hours for pallets and bulk boxes. The table includes no charge for the fork-lift trucks. Charges for the fork-lift trucks are 23 cents for variable repairs and maintenance and 25 cents for fuel and oil per hour of lift truck operations.
3/ See appendix table 18 for list of equipment replacement costs and annual fixed charges.

For receiving and storing packing materials with a lift truck, a time requirement of 0.03 man-minutes per carton was used. 10/ This allowance includes time for unloading the truck and stacking cartons, bags, and other materials in storage. A plant packing 100 cartons per hour and operating for 500 hours during the packing season would thus require 25 hours of lift truck time for receiving and storing packing materials.

Several simplifying assumptions are necessary in order to compute time requirements for bringing unpacked apples out of storage and positioning them at the dumper. As the season pack increases, storage capacity must increase, and, consequently, travel distances will also increase. It is assumed that the packer has storage capacity for 90 percent of his annual pack and that storage capacity is added in units of 25,000 bushels. It is also assumed that for a 25,000-bushel storage unit the one-way travel distance from storage to dumper is 100 feet. 11/

10/ This time requirement, developed in an earlier study by French and Gillette (9), includes an allowance for delay.
11/ Packinghouse and storage layout is similar to that found in Robert E. Heffernan's report (14).

For each additional unit of storage, one-way travel distance is increased 20 feet. A gross travel time of 0.0055D (where D = one-way distance in feet) plus 0.764 minutes per trip for turn-around time is required for bringing apples from storage to the dumper. 12/ Assuming that 70 percent of the apples are packed and that 20-bushel bulk boxes are used, six trips per 100 cartons packed are required. From travel distances, number of trips, and time requirements, total lift truck time requirements for bringing apples out of storage were computed by length of season and size of plant.

A time requirement of 0.0055D plus 0.764 minutes turn-around time per trip is assumed for moving packed fruit to temporary storage and to trucks. The one-way travel distance is assumed to be 100 feet. With 20 cartons of packed fruit per pallet, the lift truck time requirement is 6.57 minutes per 100 cartons.

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

The time requirements just outlined were used to compute lift truck costs which were then combined with data in table 9. From the combined data, the following stage planning equation was developed:

$$TSC = 229.96 - 62.71(H) + 1038.28(C) + 251.01(H)(C) \quad \text{13/} \qquad (8)$$

where

TSC = Total season cost of in-plant handling of products and materials.
(H) = Hundred hours of plant operations per season.
(C) = Capacity output of plant per hour in hundreds of cartons.
(H)(C) = Total season pack in 10,000-carton units.

Because of the large number of figures, the lift truck time requirements used in computing total season costs are omitted. The planning equation, with a correlation coefficient of 0.9983, provides reasonable estimates of total season costs by length of season and size of plant.

Since the lift truck may be used for handling other fruits and for receiving apples into storage, the fixed cost allocation to this stage in table 9 may be overstated. If the lift truck is used for these other activities, the effect is to lengthen the season and thus decrease per unit costs.

Indirect Cost Analysis

Component 1: Office and Administrative Expense

Office and administrative costs include the salaries of office employees--bookkeeper, secretaries, and manager--as well as office supplies. The costs of

12/ This time requirement, developed by French and Gillette (9), includes a delay allowance of 10 percent.

13/ Although the coefficient for hours is negative, an expansion in hours will not reduce total season costs. The variable for total season pack, (H)(C), more than offsets the effect of hours alone. Taking the derivative of total season costs with respect to hours:

$$\frac{\partial TSC}{\partial H} = -62.71 + 251.01(C)$$

it is evident that for the range of plant sizes considered (100 to 500 cartons per hour), an increase in hours operated will increase total season costs.

office help and management are considered jointly because of some overlap in duties. The manager may perform some of the bookkeeping or secretarial duties while the bookkeeper or secretaries may perform some of the management duties.

Accurate information on costs of management are difficult, if not impossible, to obtain. Most managers perform selling as well as management functions, but there is no way to determine precisely the amount of time spent in each activity. Many owners perform the management function without making a specific allowance for it. The manager-owner's returns include profits as well as returns to management. The clerical component is also difficult to estimate. The office workers are involved in selling and in many cases perform administrative work as well.

French, Sammet, and Bressler (10), and Dennis (6) have alluded to the difficulties of obtaining accurate information on costs of management. They encountered difficulties in obtaining plant management costs because managers were often involved in other management-type activities not related to the operation being analyzed. Salaries based on performance over several years and the highly imperfect market for managerial talent complicated the deviation of management cost estimating equations. French, Sammet, and Bressler found management costs to be a function of plant size while Dennis found costs to be a function of the total season pack.

Information from cooperating apple-packing plants suggests that office and administrative costs are a function of total season pack. While the planning equation for this component lacks precision, it does offer a reasonable approximation of costs for the range of plant sizes and season lengths considered. The planning equation is:

$$TSC = 1041.51 + 301.88\,(H)(C) \qquad (9)$$

where

TSC = Total season cost for office and administration.
(H) = Hundred hours of plant operation per season.
(C) = Capacity output of plant per hour in hundreds of cartons.
(H)(C) = Total season pack in 10,000-carton units.

For example, the total season office and administrative costs in a plant packing 300 cartons per hour and operating 800 hours per season would be:

$$TSC = 1041.51 + 301.88(24) = \$8,286.63$$

Component 2: Packaging Materials

Packaging materials account for a significant portion of total apple-packing costs. This cost component includes charges for packaging materials, wire stitching, and staples as well as labor and equipment charges for making boxes and supplying materials to packers.

Table 10 presents average packing material prices as quoted in Michigan during the 1963-64 packing season. Included are all material items necessary for packing 3- and 4-pound poly bags, tray packs, and jumble packs. The charge for poly bags includes an allowance for printed bags. This is not regarded as a selling expense since Michigan packers are required to identify their product with their name and address. Art work and printing plate charges for printed bags vary considerably. A fair approximation is $125 as a one-time expense. This charge is allocated over a period of 5 years and is included as a fixed charge in table 11.

Table 10.--Packing material costs for poly bags, tray packs, and jumble packs, Michigan, 1963-64

Type of pack	Material item						
	Master container	Wire for stitiching master 1/	Bags 2/	Wire closure for bags	Trays	Staples for closing filled cartons 3/	Total
	Dollars per 100 cartons						
10-4's	31.40	.14	10.25	.11	--	.03	41.93
12-3's	32.30	.14	11.10	.14	--	.03	43.71
Tray pack	29.15	.14	--	--	20.50	.03	49.82
Bushel carton	18.58	.14	--	--	--	.03	18.75

1/ Worker places 8 stitches in the bottom of each carton. 2/ Includes charge for printed bags. 3/ Worker uses 2 staples to close top of carton.

Table 11.--Labor requirements, hourly variable costs, equipment replacement costs, and annual fixed charges for packing materials, by size of plant and type of package, Michigan, 1963-64

Output capacity (cartons per hr.)	Workers required	Variable costs per hour				Equipment replacement cost			Annual fixed charge	
		Labor 1/	Power and repair 2/	Material 3/ cost	Total	Wire stitcher	Table	Total replacement cost 4/	Equipment	Material
FOUR-POUND BAG MASTER										
	Number	Dollars								
100	1	1.43	.04	41.93	43.40	640.64	20.00	660.64	112.31	25.00
200	2	2.81	.04	83.86	86.71	640.64	20.00	660.64	112.31	25.00
300	3	4.19	.04	125.79	130.02	640.64	20.00	660.64	112.31	25.00
400	3	4.24	.08	167.72	172.04	1,281.28	40.00	1,321.28	224.62	25.00
500	4	5.62	.08	209.65	215.35	1,281.28	40.00	1,321.28	224.62	25.00
THREE-POUND BAG MASTER										
100	1	1.43	.04	43.71	45.18	640.64	20.00	660.64	112.31	25.00
200	2	2.81	.04	87.42	90.27	640.64	20.00	660.64	112.31	25.00
300	3	4.19	.04	131.13	135.36	640.64	20.00	660.64	112.31	25.00
400	3	4.24	.08	174.84	179.16	1,281.28	40.00	1,321.28	224.62	25.00
500	4	5.62	.08	218.55	224.25	1,281.28	40.00	1,321.28	224.62	25.00
TRAY PACK										
200	1	1.43	.04	99.64	101.11	640.64	20.00	660.64	112.31	--
JUMBLE PACK										
200	1	1.43	.04	37.50	38.97	640.64	20.00	660.64	112.31	--

1/ Hourly wage, carton maker $1.30, utility worker $1.25 plus 10 percent to cover social security and workmen's compensation.
2/ Electric power estimated at 3.5 cents per hour per motor horsepower. Variable repairs and maintenance calculated at 0.5 percent of replacement cost per 100 operating hours. 3/ See table 10 for list of material costs. 4/ See appendix table 18 for list of equipment replacement costs and annual fixed charges.

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

The only equipment required for this stage is a wire stitcher and table for the box-making operation. Table 11 presents labor requirements, equipment replacement costs, annual fixed charges, and variable costs for the packaging material stage. The addition of material costs as developed in table 10 permits the derivation of planning equations for each of the containers. They are:

$$TSC_4 = 182.20 + 64.25(H) + 4295.38(H)(C) \quad (10)$$

$$TSC_3 = 180.20 + 63.71(H) + 4473.56(H)(C) \quad (11)$$

$$TSC_t = 5062.00(H)(C) \quad (12)$$

$$TSC_j = 1955.00(H)(C) \quad (13)$$

where

TSC_4 = Total season cost of materials for packing 4-pound poly bags.

TSC_3 = Total season cost of materials for packing 3-pound poly bags.

TSC_t = Total season cost of materials for packing tray packs.

TSC_j = Total season cost of materials for packing jumble packs.

(H) = Hundred hours of plant operation per season.

(C) = Capacity output of plant per hour in hundreds of cartons.

(H)(C) = Total season pack in 10,000-carton units.

Component 3: Building Costs

Floor space requirements for well-organized plants of various capacities, based on observations in the sample plants and on published recommendations (12), are given in table 12. These total space requirements include allowances for packing, temporary storage of packed fruit, packing materials storage, rest rooms, and office.

Many factors can influence building costs. The building materials selected, the building site, and local conditions can cause large variations in costs. The amount of fill or the size of footings required can affect costs significantly, as can the availability of building materials, contractors, and labor. Despite these difficulties, building costs for Michigan are estimated in table 12. These costs are based on specifications and prices as reported by French and Gillette (9) and Pflug and Brandt (19). Prices and wages, which were for the third and fourth quarter of 1957, were adjusted to August 1964 levels through use of the Engineering News Record Building and Construction Cost Indexes (1).

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

Table 12.--Building space requirements, dimensions, replacement costs, and annual fixed charges, by plant output capacity, apple-packing plants, Michigan, 1964

Output capacity (cartons per hr.)	Space requirement	Dimensions	Building replacement cost	Annual fixed charge 1/
	Square feet	Feet	Dollars	Dollars
100	4,800	60 x 80	28,891	2,571.30
200	9,600	80 x 120	48,358	4,303.86
300	14,400	80 x 180	68,220	6,071.58
400	19,200	80 x 240	88,180	7,848.02
500	24,000	100 x 240	104,443	9,295.43

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

The planning equation for the annual fixed building charge is:

$$TSC = 920.40 + 1699.20(C) \qquad (14)$$

where

TSC = Total season cost of building.
(C) = Capacity output of plant per hour in hundreds of cartons.

Component 4: Supervision and Miscellaneous Labor, Equipment, and Materials

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

Following are the number of workers required for each of the plant sizes considered. For the plant with a capacity of 100 cartons per hour, one man is needed to take care of cull and utility apples and to perform the miscellaneous jobs. This man, with the lift truck driver, can load out packed apples. In the plant with a capacity of 200 cartons per hour, one man is needed to take care of cull and utility apples and another man is needed to load trucks and take care of miscellaneous jobs. In this plant, as in the 100- and 300-carton per hour plants, supervision is performed by management or by a lift truck driver at no additional salary. In the plant with a capacity of 300 cartons per hour, one man is required to care for cull and utility apples and two men are needed to load out packed apples and perform miscellaneous jobs. For the 400- and 500-carton per hour plants, a supervisor is required, one man is required to care for cull and utility apples, and two men are needed to load out packed fruit and take care of miscellaneous jobs.

Table 13 presents labor requirements, equipment replacement costs, annual fixed charges, and variable costs for this component. The miscellaneous equipment required consists of radiant heaters, a scale, extra conveyor, and other equipment. The replacement cost of the other equipment is based on records of the sample firms. Because of the large variety involved, no attempt was made to list individual items.

Using the data presented in table 13, a planning equation for this cost component was derived. It is:

$$TSC = 608.90 + 64.40(H) + 159.50(C) + 138.20(H)(C) \quad (15)$$

where

TSC = Total season costs of supervision and miscellaneous labor, equipment, and materials.
(H) = Hundred hours of plant operation per season.
(C) = Capacity output of plant per hour in hundreds of cartons.
(H)(C) = Total season pack in 10,000-carton units.

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

$$TSC = 608.90 + 64.40(8) + 159.50(3) + 138.20(24) = \$4919.40$$

PLANT COSTS

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

Simplifications and Specifications

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

1. The cost analysis is for five selected plant sizes ranging in output from 100 to 500 cartons per hour.

2. The average net weight of a packed carton of apples is assumed to be 40 pounds.

3. All packed apples are loaded on trucks for shipment to market.

4. Wage rates utilized in the analysis are given in appendix table 17.

5. Costs of assembly, receiving into storage, storage, and selling are omitted. Also omitted are costs of land for building sites as well as the cost of any outside paved area.

Table 13.--Labor requirements, hourly variable costs, equipment replacement costs, and annual fixed charges for supervision and miscellaneous labor, equipment, and materials by size of plant, Michigan, 1963-64

Output capacity (cartons per hr.)	Workers required	Variable costs per hour			Equipment replacement cost and annual fixed charge 3/					
		Labor 1/	Fuel and repair 2/	Total	Heaters	Scale	Conveyor and stands	Other equipment	Total replacement cost	Annual fixed charge
	Number	Dollars								
100	1	1.38	.32	1.70	1,835	210	303.68	1,600	3,948.68	671.28
200	2	2.76	.50	3.26	2,936	210	303.68	2,500	5,949.68	1,011.45
300	3	4.80	.57	5.37	3,303	210	303.68	3,100	6,916.68	1,175.84
400	4	6.18	.58	6.76	3,303	210	303.68	3,300	7,116.68	1,209.84
500	4	6.18	.68	6.86	4,037	210	303.68	3,500	8,050.68	1,368.62

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

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

3/ See appendix table 18 for list of equipment replacement costs and annual fixed charges.

6. Five percent of the apples dumped are eliminated as less than 2-1/4 inches in diameter. Thus, a plant with a sortout of 25 percent culls and utilities would pack out 70 percent of the apples dumped.

Total Cost Calculations

The combination of stage planning costs and indirect cost components to obtain total plant costs is primarily a case of addition. This combination is accomplished by adding the coefficients of the stage cost equations and of the indirect cost equations. In the case of the synthesized apple-packing plants the addition is simple since the stages are independent, that is, the technology in one stage does not affect the cost of a technology in another stage. 14/

The stage cost equations are summarized in table 14. Cost categories are separated into common costs and costs based on the package used. This helps to simplify further computations since common costs are the same regardless of the package used. The total plant cost equation is obtained by adding the costs of the relevant package to total common costs.

An individual equation is read from table 14 by combining the coefficients in the table with the proper variables in the subheading. For example, the cost equation for the sorting and sizing stage is read:

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

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

The total common costs equation from table 14 is:

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

where the variables are the same as previously defined.

The equation for total plant costs for packing 4-pound poly bags is obtained by adding the coefficients for packing costs for 4-pound bags and package material costs for 4-pound bags to total common costs. This procedure yields the cost equation for packing apples in 4-pound poly bags which is:

$$TSC_4 = 5193.32+450.85(H)+4647.64(C)+6142.63(H)(C)+3.24(H)(C)(P) \quad (16)$$

Likewise, the cost of packing 3-pound poly bags is:

$$TSC_3 = 5191.32+588.31(H)+4647.64(C)+6320.81(H)(C)+3.24(H)(C)(P) \quad (17)$$

Since the usual proportion of poly bags is one-half 3-pound bags and one-half 4-pound bags, a simple average of equations (1) and (2) yields the cost equation for a Michigan packing plant which bags all of its output. It is:

$$TSC = 5192.32+519.58(H)+4647.64(C)+6231.72(H)(C)+3.24(H)(C)(P) \quad (18)$$

By specifying the variables in equation (18), the total season costs of a plant operating at capacity and bagging all of its output can easily be computed. Take, for example, a plant with a capacity of 200 cartons per hour which operates for an

14/ For a discussion of the difficulties encountered when stages are dependent see French, Sammet, and Bressler (10).

Table 14.--Summary of planning cost equations for operating stages and indirect cost components for apple-packing plants, Michigan, 1963-64

Cost category	Variables 1/ a	H	C	HC	HCP
	Coefficients				
Common Costs:					
Dumping	--	131.78	272.93	15.32	--
Sorting and sizing	1,740.76	143.33	549.73	244.45	3.24
Container closing	52.59	--	--	139.19	--
Handling	229.96	-62.71	1,038.28	251.01	--
Office and administration	1,041.51	--	--	301.88	--
Building costs	920.40	--	1,699.20	--	--
Supervision and miscellaneous	608.90	64.40	159.50	138.20	--
Total	4,594.12	276.80	3,719.64	1,090.05	3.24
Costs based on package:					
Packing costs:					
4-pound bags	417.00	109.80	928.00	757.20	--
3-pound bags	417.00	247.80	928.00	757.20	--
Tray pack	315.00	65.70	431.82	1,141.36	--
Jumble pack	296.26	9.73	352.77	822.02	--
Package material costs:					
4-pound bags	182.20	64.25	--	4,295.38	--
3-pound bags	180.20	63.71	--	4,473.56	--
Tray pack	--	--	--	5,062.00	--
Jumble pack	--	--	--	1,955.00	--

1/ The cost equation variables are as described previously:
a=A constant cost that is incurred regardless of length of season or size of plant.
H=Hundred hours of plant operation per season.
C=Capacity output of plant per hour in hundreds of cartons.
P=Percent of apples sorted out as culls and utilities.
HC=Total season pack in 10,000-carton units.
HCP=A relative measure of total season sortout.

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

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

A similar procedure is used for estimating costs in a packing plant which packs trays and jumble packs in addition to bagging. The following equation is derived by combining the coefficients for common costs, bagging, tray packing, jumble packing, and material costs:

$$TSC = 5803.58+595.01(H)+3719.64(C)+1090.05(HC)+3.24(HCP)+928.00(P_1C)+ 5141.67(HP_1C)+431.82(P_2C)+6203.36(HP_2C)+352.77(P_3C)+2777.02(HP_3C) \quad (19)$$

where H, C, and P are as previously defined
and P_1 = proportion of pack in poly bags

P_2 = proportion of pack in trays not to exceed 0.20

P_3 = proportion of pack in jumble pack not to exceed 0.20

where $P_1+P_2+P_3 = 1.0$

To find the estimated total season costs for a plant with a capacity of 200 cartons per hour operating 800 hours and packing 70 percent bags, 20 percent trays, and 10 percent jumble packs, the appropriate substitution is made in equation (19). Estimated total season costs are:

$$TSC = 5803.58+595.01(8)+3719.64(2)+1090.05(8)(2)+3.24(8)(2)(25)+928.00(.7)(2)+5141.67(8)(.7)(2)+431.82(.2)(2)+6203.36(8)(.2)(2)+352.77(.1)(2)+2777.02(8)(.1)(2)=\$120,162.91$$

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

Average costs are calculated by dividing total season costs by the number of cartons packed. In the cost example just calculated for the plant with a capacity of 200 cartons per hour operating 800 hours, total season costs were $120,162.91 and total output was 160,000 cartons. Dividing total season cost by total output results in an average cost of $0.751 per carton packed. Estimated average costs for other packs, lengths of season, and plant size are derived in the same manner. The following sections examine the effects of size of plant and length of season on average costs.

The Effect of Plant Size on Costs

Given the total cost equations just developed, planning curves can be derived for apple-packing plants. To derive a planning curve requires that several variables be specified. These include length of season, type of pack, and percent sortout. As an illustration, suppose that the season length is 400 hours, that the proportion of bags packed is one-half 4-pound and one-half 3-pound, and that 25 percent of the apples are removed as culls and utilities. These specifications and the technology specified in deriving the stage planning equations result in the planning curve shown in figure 5. This figure shows that average costs decrease rapidly in the range of 100 to 300 cartons per hour and then gradually taper off up to 500 cartons per hour. Major economies of size, however, are realized by the time plant output capacity reaches 300 cartons per hour. The characteristic shape of the planning curve results from the spreading of the fixed costs of buildings, equipment, and management over more units of output and the substitution of various cost-reducing techniques in the larger plants. Planning curves for other lengths of season, types of pack, and percents of sortout will exhibit a shape similiar to figure 5, but will be above or below the curve illustrated.

The Effect of Type of Pack on Costs

Cost equations are derived for four types of packages--10-4's, 12-3's, tray packs, and jumble packs. Per unit costs of these packs vary with capacity of plant and hours of operation per season (table 14). Costs between different packages differ because of labor and machine requirements as well as container costs. In general, it costs less to pack in a jumble pack than in the other containers. Following in order of increasing per unit costs are 10-4's, 12-3's, and tray packs. Data are presented in a manner such that once length of season, size of plant, and percent of sortout are specified, the average costs of various packs can be computed.

The Effect of Length of Season on Costs

There are fixed and partially fixed costs which do not vary or do not vary proportionately with the number of hours operated. A longer packing season spreads

AVERAGE COSTS OF PACKING APPLES IN POLY BAGS
MICHIGAN, 1963-64 SEASON

Half in 3-pound, Half in 4-pound Bags; 400-hour Operating Season; 25 Percent Sortout

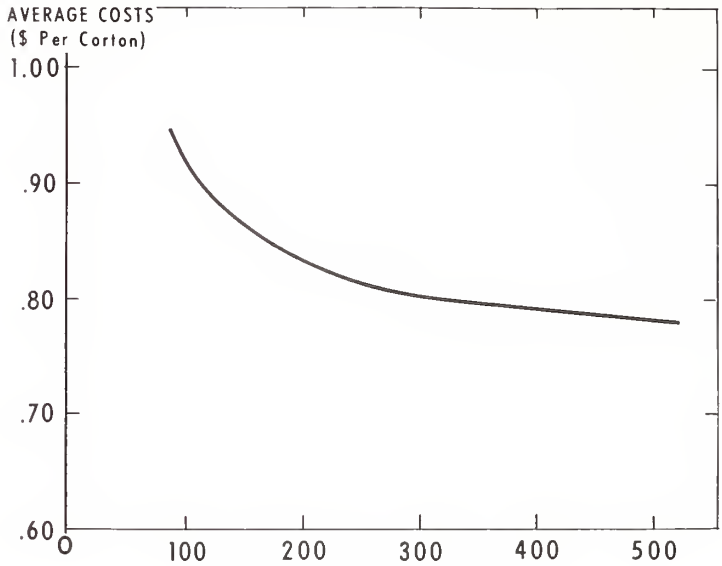


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Figure 5

these costs over a greater number of units and results in a lower per unit cost. Controlled atmosphere storage permits the storage of apples over long periods of time, and some packers now pack over a 9-or 10-month period. Costs of controlled atmosphere storage are higher than costs of conventional refrigerated storage and there is also a seasonal increase in apple prices during the packing season. These factors are not considered in this analysis.

Figure 6 shows the effect of length of season on average costs for plants bagging apples and having a sortout of 25 percent. Note that the curve for a 400-hour season is identical to the curve in figure 5. While there is a significant decrease in per unit costs as length of season increases, the majority of the decrease is in the range between 400 and 800 hours. Beyond this range, the decrease in average costs is less for each additional increment of 400 hours.

The Effect of Underutilization of Plant Capacity on Costs

All of the cost relationships developed in previous sections are based upon plant operation at planned capacity. In established plants there are cost items such as labor and materials which vary with output, and there are other cost items such as building, equipment, and management which are fixed. The fixed costs continue to be incurred regardless of the rate of plant operation. Thus, for rates of operation at less than capacity, per unit costs of packing will increase. Table 15 lists the fixed and variable costs for a 300-carton-per-hour plant bagging 4-pound bags of apples at selected rates of operation. Similar tables can be computed for other plant sizes and types of pack. From these tables, shortrun average cost curves can be calculated for the five plant sizes considered.

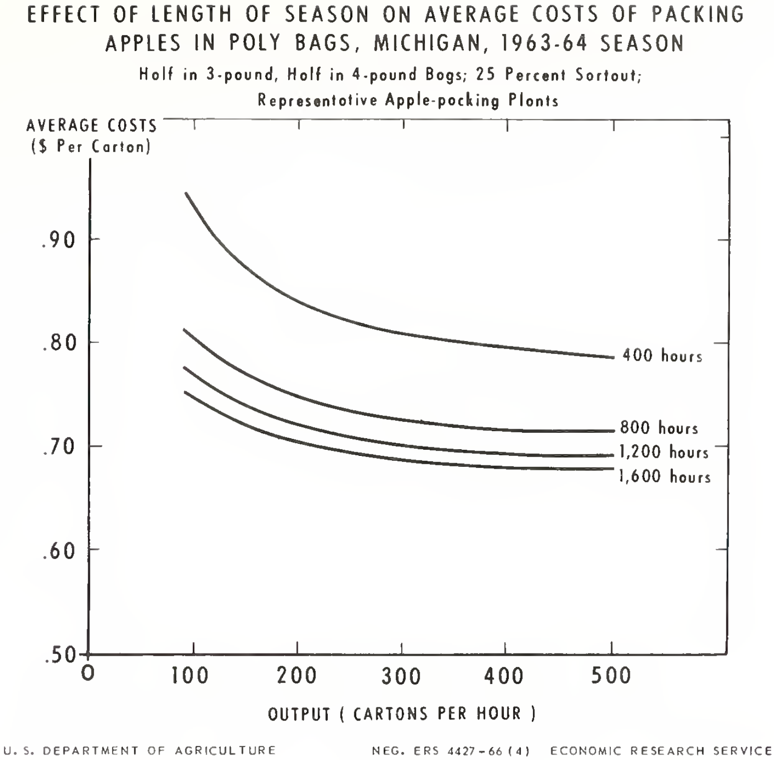

Figure 6

Table 15.--Total fixed and variable costs for bagging apples in a plant with a capacity of 300 cartons per hour and a sortout rate of 25 percent, Michigan, 1963-64

Stage or cost component	Fixed cost	Variable cost per hour by rate of output (cartons)			
		100	150	200	250
	Dollars				
Dumping	1194.65	1.91	1.91	1.91	1.91
Sorting and sizing	3830.19	5.47	6.85	8.23	9.61
Packing 4-pound bags	3412.07	9.25	13.39	20.29	21.67
Container closing	72.37	1.40	2.78	2.78	4.16
Handling products and materials 1/	3604.68	1.92	1.92	3.68	3.68
Office and administration	8286.63	--	--	--	--
Packaging materials	137.31	43.40	65.10	86.71	107.68
Building costs	6071.58	--	--	--	--
Supervision and miscellaneous	1175.84	1.95	3.33	3.33	5.37
Total	27785.32	65.30	95.28	126.93	154.08

1/ This does not include the variable costs of fork-lift trucks. For this plant operating 800 hours, the following total variable costs for fork-lift trucks must be added: 100 cartons per hour, $249.60; 150 cartons, $374.40; 200 cartons, $499.20 250 cartons, $624.00.

Figure 7 illustrates the shortrun average cost curves in relation to the previously derived planning curve. The cost curves are for plants bagging 4-pound bags of apples, operating 800 hours per season, and with a sortout rate of 25 percent. For all plant sizes, operation at less than capacity results in higher per unit costs than those shown by the planning curve. As rate of output nears capacity, shortrun costs move toward planning costs until the two become equal at plant capacity. No attempt was made to calculate costs in excess of the capacity rate of operation, that is, in excess of rated machine capacity. No plants were observed operating in this range and thus no observations on labor requirements are available. Operating at more than rated capacity would, however, undoubtedly result in a sharp increase in average costs due to increased hand labor, crowding of workers, and overloading of equipment.

Figure 7 demonstrates the costs of operating at less than planned capacity. For instance, a 300-carton-per-hour plant which is operating at an average rate of 100 cartons per hour incurs a 43-percent increase in per unit costs over per unit costs when it is operating at capacity. Average costs are 24 percent higher than for a 100-carton-per-hour plant operating at capacity. While it is sometimes desirable to have the capacity to pack extra-large orders it must be remembered that this type of flexibility is costly.

Optimum Combination of Hours and Capacity

In preceding sections, the effects of length of season and size of plant on per unit costs of packing apples have been discussed. Figure 6 shows that per unit costs decrease with increases in plant size and with longer packing seasons. It

RELATION OF SHORT-RUN TO LONG-RUN AVERAGE COSTS IN APPLE-PACKING PLANTS, MICHIGAN, 1963-64 SEASON

800-hour Season, Bagging in 4-pound Poly Bags, 25 Percent Sortout, Representative Apple-packing Plants

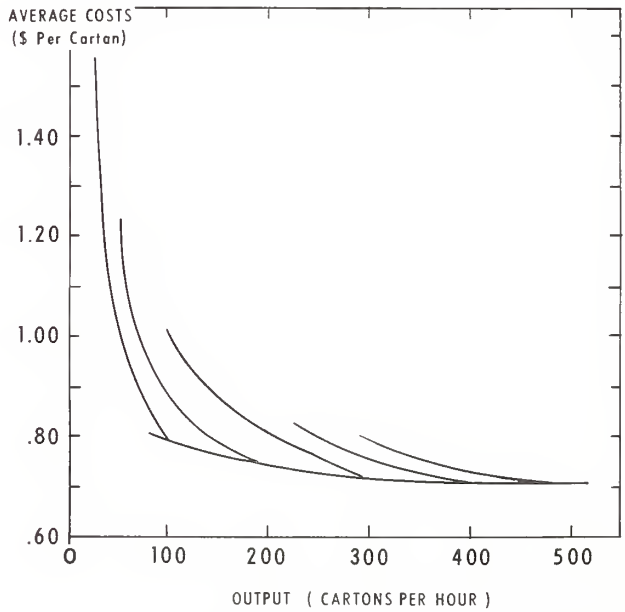

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Figure 7

is obvious that a given season output can be handled by many different combinations of hours of operation and capacity and that the particular combination used will influence costs. While the length of the working day and the storage period place limitations on hours of operation there is still considerable latitude for combining hours and capacity. How then should they be combined? The particular combinations will vary with the type of pack, but the general relationships will be the same. Following are the computations for plants packing poly bags (one-half 4-pound and one-half 3-pound) and removing 25 percent of the apples as utilities and culls. The longrun cost function given these conditions is:

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

where the variables are as previously specified.

Season volume may be expressed as:

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

Substituting S = (H)(C) the longrun cost function becomes

$$TSC = 5192.32+519.58(H)+4647.64\frac{S}{H}+6312.72(S) \quad (20)$$

To minimize this function in terms of hours:

$$\frac{\partial TSC}{\partial H} = 519.58-4647.64\frac{S}{H^2} = 0$$

Thus:

$$H^2 = 8.9449S$$
$$H = 2.99\sqrt{S} \quad (21)$$

Since S = (H)(C)

$$C = \frac{\sqrt{S}}{2.99} \quad (22)$$

Thus, if the total season volume is specified, the minimum cost combination of hours and capacity is given by equations (21) and (22). Substituting S = (H)(C) in equation (21) above it can be seen that hours and capacity should be expanded in the ratio of H = 8.94(C). The optimum combination of hours and capacity for a packer planning to bag 250,000 cartons per season would be:

$$H = 2.99\sqrt{250{,}000}$$
$$= 2.99(500) = 1495$$

and

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

Thus, to bag 250,000 cartons per year the packer would operate a plant with a capacity of 167 carton per hour for 1,495 hours.

It is obvious that the application of equations (21) and (22) is limited. Because of custom, sales, and wage rates, Michigan packers typically pack 8 to 10 hours per day. The storage life of apples is limited even though controlled atmosphere storage lengthens it. Suppose that because of these factors the total packing season is limited to 3,000 hours. Thus, for season packs up to 1,005,000 cartons, capacity and hours can be expanded in the ratio of H= 8.94(C). Once the limit of 3,000 hours is reached the size of total season pack can be expanded only through larger capacity plants. Even with a season pack of 1,005,000 cartons, the optimum sized plant packs only 335 cartons per hour. This is well below the 500 cartons per hour packed by the largest plant included in the calculations.

Since most Michigan apple packers pack a combination of packs, a more useful minimum cost combination of hours and capacity can be obtained from equation (19). Making the substitution of S = (H)(C) as in equation (20), treating P_1, P_2, and P_3 as constants, and minimizing with respect to hours gives:

$$\frac{\partial TSC}{\partial H} = 595.01 - 3719.64\frac{S}{H^2} - 928.00\,P_1\frac{S}{H^2} - 431.82\,P_2\frac{S}{H^2} - 352.77\,P_3\frac{S}{H^2} = 0$$

The minimum cost combination of hours and capacity can be derived from the following equation by specifying P_1, P_2, and P_3.

$$595.01H^2 = S(3719.64 + 928.00P_1 + 431.82P_2 + 352.77P_3) \qquad (23)$$

The optimum combination of hours and capacity for a packer planning to pack 250,000 cartons per season with 70 percent in poly bags, 20 percent in trays, and 10 percent jumble pack would be:

$$595.01H^2 = 4490.88S$$

or

$$H^2 = 7.547S \qquad H = 2.75\sqrt{S}$$

Thus, for a season pack of 250,000 cartons the optimum combination of hours and capacity is:

$$H = 2.75(500) = 1375 \text{ hours}$$

and

$$C = \frac{500}{2.75} = 182$$

Note that the optimum sized plant for a season pack of 250,000 cartons is larger for a mixed pack than for bags. Examiniation of equation (23) reveals that the optimum size of plant increases for a given season pack with increases in the percentage of pack in trays and jumble pack.

INTERPRETATION AND APPLICATION

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

Within the range of plant sizes considered inthis study, average costs for packing continue to decrease. However, the assembly cost relationship is one of increasing costs since a larger and larger supply area is necessary to increase season volume. Thus, the combination of assembly costs and packing costs would probably result in an average cost curve which would reach a minimum and turn up at very large season volumes. In an earlier study, French and Gillette (9) estimated that with high density production, costs of assembly and packing would not begin to increase until a volume of nearly 1 million bushels was reached--and even at this volume the increase would be very slight.

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

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

There is no way to predict the development and adoption of new technology in apple packing. While companies and other agencies are working on the development of completely automatic baggers, electronic sorters, hydro-handling equipment, and other innovations, the development period is highly uncertain. In general, an innovation will be adopted only if it is cost saving. Thus, the effect of an innovation on the planning curve will be to lower it. An innovation could also alter the slope of the curve if it is suitable only for large or only for small packing plants.

The packing operations described in the study are flexible enough to allow for innovation. The building sizes will permit expansion of equipment, and a short write-off period is used in depreciating the equipment.

POTENTIAL AREAS FOR RESEARCH

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

A study of costs of storage as related to the seasonal movement in apple prices is needed. Particularly useful would be a comparison of costs of conventional controlled atmosphere storage and costs of new developments, such as an externally generated controlled atmosphere. A study of this type would aid storage operators in their decisions to store apples and acquire additional storage. Information on the costs of assembling apples would be particularly useful for packers considering the acquisition of large packing facilities. Time and labor requirements for the assembly of apples in bulk boxes would be needed for a study of assembly costs. Also needed would be information on number of trees, age of trees, and yield by area. The assembly cost function derived from these data could be combined with the planning curve for packing to yield a better estimate of cost relationships by size of total season pack. These data could also be used as inputs for a linear programming study of the optimum adjustment of numbers and sizes of apple-packing plants in Michigan.

Estimates of costs of selling by size of selling agency and by type of channel, while difficult to obtain, would be of general interest to the industry. If these estimates demonstrated economies of size, as hypothesized, there would be increased interest in concentrating the selling function in a few agencies. This raises the question of whether such agencies should pack in a number of plants located throughout the producing areas or in large centralized plants.

Finally, data obtained in the research projects proposed above could be combined with the data developed in this report to yield an overall cost picture.

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APPENDIX

Table 16.--Labor production standards for jobs performed in Michigan apple-packing plants, 1963-64

Job classification and description	Production standard
	Units per hour
1. Manual dumping The worker gets a full crate from pallet, moves it to the receiving belt, and dumps. He groups and places empty crates aside on a pallet.	142 bushels
2. Manual dumping (mechanical aid) Same as number 1 except a mechanical aid is used to assist the worker in turning and dumping the crate.	152 bushels
3. Mechanical dumping bulk boxes The worker rolls a full box into the hydraulically controlled frame. The box is lifted and filled hydraulically. The worker controls the flow of apples onto the receiving belt with a hinged gate on the dumper lid. The empty box is lowered and the worker moves it aside on the roller conveyor.	300 bushels
4. Mechanical dumping bulk boxes--water immersion The worker rolls a full box into position over the dumping tank. He hydraulically lowers the box into the water. After the apples have floated clear of the empty box he raises the box, allows it to drain, and then moves it aside on roller conveyor.	600 bushels
5. Packing of trays The worker places an empty carton on the packing stand; using both hands he removes apples from a two-way belt and places them on trays. The worker positions trays in the carton as needed. He places filled cartons aside on a roller conveyor.	11 cartons
6. Jumble packing	
a. The worker positions an empty carton on the packing stand. Using both hands, he moves apples from the 2-way belt to the carton. He places filled cartons aside on a roller conveyor.	17 cartons
b. Same as above, but the worker uses a scoop in one hand.	25 cartons
7. Filling 3-pound poly bags The worker obtains a bag from the bag holder, checks and adjusts the weight of the apples, places the bag over the dumping head, and dumps the apples into the bag. He then places the filled bag upright below the bagging head on an L-shaped conveyor.	308 bags (25 cartons)
8. Filling 3-pound poly bags (operator ties) Same as number 7 except the worker tapes the bag closed before placing it on the conveyor.	207 bags (17 cartons)

Table 16.--Labor production standards for jobs performed in Michigan apple-packing plants, 1963-64--Continued

Job classification and description	Production standard
	Units per hour
9. Filling 4-pound poly bags Same as number 7.	250 bags (25 cartons)
10. Filling 4-pound poly bags (operator ties) Same as number 8.	180 bags (18 cartons)
11. Bag closing (automatic) The worker gathers the top of each bag and feeds it into the automatic closer as the bag moves by on the conveyor.	3,100 bags
12. Boxing 4-pound poly bags The worker gets a master container and fills it with 10 bags of apples from a circular table. He pushes the filled master container aside on roller conveyor to the box closer.	107 cartons
13. Boxing 3-pound poly bags Same as number 12 except that the worker must add a partition to the master container so that it will hold 12 bags.	84 cartons
14. Carton closing Filled cartons move to the worker on roller conveyor. The worker closes and staples the carton and then pushes it aside on roller conveyor.	254 cartons
15. Stamping cartons The worker gets a rubber stamp, inks it, and stamps each end of the carton.	612 cartons
16. Stacking cartons The worker lifts filled cartons from the roller conveyor and stacks them on an adjacent pallet.	390 cartons
17. Carton making The worker gets forms, and moves the carton to a wire stitching machine, stitches the bottom, and stacks the carton aside.	228 cartons 310 cartons with 2 workers
18. Placing dividers and moving cartons aside The worker gets a stapled carton, gets and places dividers, and either stacks the carton in a holding area or places it in a chute leading to the packing area.	666 cartons

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

Table 17.--Wage rates used in computing apple-packing costs, 1964 wage levels 1/

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

1/ Social security and workmen's compensation payments are omitted. When these are included the plant wage rates must be increased by approximately 10 percent.

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

Table 18.--Dimensions, installed cost, expected life, and annual fixed charge for equipment items used in Michigan apple-packing plants, 1963-64

Item dimensions or capacity	Installed cost 1/	Expected life	Annual fixed charge 2/
	Dollars	Years	Dollars
Receiving belt:			
24 inches by 5 feet	332.80	8	64.90
30 inches by 5 feet	402.58	8	78.50
36 inches by 6 feet	441.48	8	86.09
48 inches by 7 feet	546.52	8	106.57
2¼ inch eliminator:			
24 inches by 3 feet	366.29	8	71.43
36 inches by 3 feet	474.03	8	92.44
48 inches by 3 feet	605.07	8	117.99
Tilt-type bulk box dumper, 67 inches by 84 inches:	964.08	8	188.00
Hydro bulk box dumper:			
300 bushels per hour	4,160.00	8	811.20
800 bushels per hour	5,200.00	8	1,014.00
Leaf eliminator:			
300 bushels per hour	280.80	8	54.76
800 bushels per hour	452.40	8	88.22
Sorting table:			
24 inches by 6 feet	768.00	8	149.76
30 inches by 8 feet	1,048.00	8	204.36
36 inches by 10 feet	1,265.00	8	246.68
48 inches by 10 feet	1,464.00	8	285.48
48 inches by 14 feet	1,800.00	8	351.00

Table 18.--Dimensions, installed cost, expected life, and annual fixed charge for equipment items used in Michigan apple-packing plants, 1963-64--Continued

Item dimensions or capacity	Installed cost 1/	Expected life	Annual fixed charge 2/
	Dollars	Years	Dollars
Washer-brusher:			
24 inches by 7 feet	1,855.00	8	361.73
30 inches by 7 feet	2,057.00	8	401.12
36 inches by 7 feet	2,256.00	8	439.92
48 inches by 10 feet	2,808.00	8	547.56
48 inches by 14 feet	3,874.00	8	755.43
Spreader belt:			
24 inches by 4 feet	291.00	8	56.75
30 inches by 4 feet	333.00	8	64.94
36 inches by 4 feet	364.00	8	70.98
48 inches by 4 feet	484.00	8	94.38
48 inches by 6 feet	582.00	8	113.49
Sizing unit:			
24 inches by 13 feet	8,320.00	8	1,622.40
48 inches by 13 feet	13,104.00	8	2,555.28
Automatic box filler	1,448.00	8	282.36
Distributor belt:			
24 inches by 10 feet	726.96	8	141.76
24 inches by 15 feet	933.92	8	182.11
36 inches by 20 feet	1,368.64	8	266.88
36 inches by 25 feet	1,638.00	8	319.41
36 inches by 35 feet	2,125.00	8	414.38
Return flow belt:			
24 inches by 15 feet	1,137.76	8	221.86
24 inches by 20 feet	1,333.28	8	259.99
36 inches by 16 feet	1,258.40	8	245.39
36 inches by 20 feet	1,433.12	8	279.46
36 inches by 25 feet	1,606.80	8	313.33
36 inches by 30 feet	1,796.08	8	350.24
36 inches by 35 feet	1,985.36	8	387.15
Semiautomatic bagger	1,138.80	5	307.48
Semiautomatic bag closer	1,432.00	8	279.24
Packing stands	46.80	10	7.96
Stapler	65.00	8	12.68
Stamps and pad	10.40	8	1.77
Wire stitcher	640.64	10	108.91
Table	20.00	10	3.40

Table 18.--Dimensions, installed cost, expected life, and annual fixed charge for equipment items used in Michigan apple-packing plants, 1963-64--Continued

Item dimensions or capacity	Installed cost 1/	Expected life	Annual fixed charge 2/
	Dollars	Years	Dollars
Fork-lift truck:			
2,000-pound	5,993.00	10	1,018.81
Pallets	2.50	10	.43
Bulk boxes:			
20 bushel	9.00	10	1.53
Space heaters	367.00	10	62.39
Table scale	303.68	10	51.63
Cull and utility conveyor (6 inches by 4 feet)	195.52	8	38.13
Each additional foot (6 inches by 1 foot)	8.32	8	1.62
Filled bag conveyor:			
15 feet	609.44	8	118.84
20 feet	709.28	8	138.31
25 feet	803.92	8	156.76
30 feet	1,092.00	8	212.04
Elevating belt and accumulator table	618.80	8	120.67
Skate conveyor:			
12 inches by 10 feet	35.36	8	6.90
Roller conveyor:			
12 inches by 10 feet	104.00	8	20.28
Conveyor stands	6.24	10	1.06

1/ Includes f.o.b. price, transportation and installation costs, and sales tax.
2/ Estimated on the basis of installed cost. Includes fixed repair, 2.0 percent; insurance, 1.0 percent; interest on investment, 3.0 percent; property tax, 1.0 percent; and depreciation calculated according to expected life (5 years, 20 percent; 8 years, 12.5 percent; and 10 years, 10 percent).

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

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