SOME ECONOMIC CONSIDERATIONS OF SORTING AND SIZING APPLES FOR BULK STORAGE

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ABSTRACT

SOME ECONOMIC CONSIDERATIONS OF
SORTING AND SIZING APPLES FOR
BULK STORAGE

By
John Powell Nichols

The economic feasibility of a system for the presorting and presizing of apples for storage in bulk was examined. A determination of the system's possible economic value to a modern and progressive packing, storing and marketing operation was made in order to establish a pattern of evaluation for analyzing each individual situation and set of operating circumstances.

Data were obtained from a selected storage and packing operation for the three crop seasons of 1961, 1962 and 1963 concerning relative volumes of apples in CA storage for the three major varieties of McIntosh, Jonathan and Red Delicious, and their classifications for quality according to U.S. No. 1 and better grades, utility grade, and culls. The average price gains between harvest and removal from storage were calculated for the utility and cull apples of the same three varieties, and similar price differentials were determined from published market reports for the U.S. No. 1 and better grades of apples in Western Michigan.

These values were related with other variable factors such as storage capacity, the possible efficiency rate at which the presizing and presorting system could improve the grade of stored apples and projected

operating costs, in order to estimate the monetary return from employing the system. It was found that some gains are attained by minimizing losses due to the failure of utility and cull fruits to cover their storage cost; other gains result from the opportunity to earn a profit on the U.S. No. 1 and better fruit that can be stored in place of the removed utilities and culls.

The net gain over variable cost that is possible by the adoption of a presizing and presorting system increased as the price gain during storage for utility and cull apples decreased, as this price gain for U.S. No. 1 and better fruit increased, and as the field-run percentage of utility and cull grade fruit increased.

The representative storage and packing operation examined in this study would have gained $14,234 per year during the three years of record if 80 percent of the utilities and culls had been removed by a pregrading system operated at a variable cost of $ .08 per bushel of apples handled.

The many variable factors which must be considered in an analysis of this nature require that each storage and packing operation must be examined individually. Also, any economic evaluation should be supplemented by consideration of other benefits such as increased efficiency of the final post-storage packing operation, more complete inventories and savings in total storage space requirements.

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INTRODUCTION

Most of the stored Michigan apples are placed directly into storage from the orchard without classification other than perhaps by variety, date of harvest and grower. The fruit is sorted and sized when removed from the storage as needed for the wholesale or retail outlet. Undersized, poorly-colored and cull fruit occupy valuable storage space which could be utilized for better fruit if the sorting and sizing operation were done before storage. Growers must pay for the storage of these utility and cull fruit but usually do not receive enough from their sale to pay the storage cost.

Presizing and presorting of the apples before storage offers benefits other than the obvious one of better utilization of storage space. It is likely that improved merchandising programs could be developed from information offered by an inventory of size, quality and variety of fruit in storage. Also, certain efficiencies might be gained when packing the apples for market if the low quality fruit is removed before storage.

An apple sorting system involving another handling procedure before storage is not without drawbacks. A presizing and presorting system would require the hiring of extra labor which may be difficult to obtain during the busy harvest season. Mechanical damage due to bruising and stem puncture would increase as a result of the added handling. The cost of the equipment necessary to perform the presizing and presorting operation adequately with a minimum amount of damage, labor and time would most likely be quite high.

Washington State apples have been sized, sorted and packed in market containers before storage. Problems of decay in storage have been encountered which have made some of the packages coming out of storage undesirable for marketing. This system has been used, however, to avoid the problems involved in handling the fruit an extra time. A solution to both the decay and the handling problem would be the development of a system to presize and presort the apples with a minimum of damage and then return the fruit to the field containers for storage. Apples which decay during storage could be removed when the fruit is packed for marketing.

Recently studies were undertaken at Michigan State University to determine the feasibility of sizing and sorting apples destined for storage. Laboratory tests (8, 16) demonstrated on a pilot model scale that apples could be handled in water and returned to field containers. The development of prototype equipment for testing and operating on a commercial scale was recommended. The possible economic values of a presorting and presizing system for the storage of apples in bulk boxes was suggested for study.

The Michigan apple industry is characterized by rapid growth. Of the five major apple producing states, Michigan has had by far the greatest increase in production in recent years in both absolute and percentage terms (4). Its dynamic growth is reflected by the changing tree population. Although the overall number of trees remained nearly constant at 2.9 million from 1954 to 1959, the percentage of non-bearing trees increased from 7.3 percent to 24.1 percent during this same period

(14). A more recent survey of a leading Michigan apple producing county indicates that large new plantings of apple trees have increased the percentage of non-bearing trees to over 50 percent (19).

Growth of the Michigan apple industry is indicated to continue in the future. Estimates made in conjunction with Michigan's "Project '80" indicate that acreage should increase from the present 63,000 acres to nearly 70,000 by 1980 (14).

While production is increasing, controlled atmosphere (CA) storage capacity is also on an upward trend. In 1963 there was reported to be a refrigerated storage capacity in Michigan of 5 million bushels and CA capacity of over 2 million bushels (4). The increase in CA storage space has been around one-half million bushels per year for the last four years (7).

The rapidly changing characteristics of the industry are evident. Changes in containers, varieties, merchandising programs, handling and transportation methods are made every year. It is likely that a unique system for presizing and presorting apples such as the one utilizing water as the handling medium would be important to this dynamic industry.

With this system and industry in mind, it was the purpose of this study to establish the economic feasibility of a presizing and presorting system, to determine its possible value to a modern and progressive storage and marketing operation, and to establish a framework of analysis through which an individual storage operator might evaluate the system in relation to his own needs.

LITERATURE REVIEW

Sorting, sizing and packaging of storage fruit at harvest-time or soon after has long been a normal practice of the Washington State apple industry. Hukill and Wooten (11) described a typical commercial procedure for handling and packing of apples in 1947. After picking, the fruit was transported to the packing shed or storage. The packing line was operating at peak capacity, but still the entire crop could not be handled during the harvest period. The packed apples were then moved to storage or market as determined by demand. The excess volume which could not be packed at harvest was placed initially in storage and then removed for packing later so that the packing operation covered a period of three to four months while harvest lasted only four or five weeks. All of the apples were packed as soon as possible and then placed back into storage in the market package.

Decay in these market containers sometimes caused trouble. Also, placing the fruit in the market container soon after harvest limited the flexibility of sales and merchandising programs later in the marketing season. A recent report by Bosch (2) describes changes in the Washington system which call for segregation of the fruit at harvest-time into grade and size categories and then placement into bulk containers for storage. Packing of the apples takes place later when the fruit is removed from storage for marketing. He notes that this allows for a more flexible marketing program, offers savings in space and provides a solution to the decay problem. One storage operator interviewed by Bosch estimated the cost of the presorting operation at $ .06 per bushel. A breakdown of this cost was not given, however.

Most Michigan apples are placed directly into storage and packed after storage. French and Gillette (9) in 1959 estimated that only ten percent of the stored fruit is packed during the harvest season.

Gaston and Levin (10) studied the operation and economics of a mobile orchard grading system for Michigan conditions. It consisted of a feed belt, eliminator and sorting belt mounted on skids to allow for movement through the orchard. They found that this system reduced handling and bruising and eliminated a considerable amount of off-grade fruit. In their tests, 13 percent of the apples were removed in the orchard due to small size and defects. Assuming a handling and storage charge of $ .50 per bushel and a selling premium of $ .14 per bushel for field-graded fruit, they calculated an increased net return of $ .20 per bushel of field-graded fruit over fruit which had not been field-graded. Although there were several models of this system on the market it did not become popular with the growers. It was not practical in many orchards because the orchard layout caused too much time to be lost in walking to and from the grading equipment. Also, many growers were changing their operation at that time to take advantage of bulk handling techniques. Since the system was developed for the one bushel field crate as the basic handling unit, it did not fit into future plans for most growers. Development of a mobile field grading system using bulk boxes is now underway.

Since presorting and presizing means the fruit must be handled an extra time, it creates a bruising problem. This has further stimulated interest in handling techniques which help avoid this injury. The use of water as a medium for handling the fruit is one possibility.

In 1962 Martin (15) obtained a patent on certain aspects of a hydro-processing system. He envisioned an entirely new concept in the fruit and vegetable marketing system whereby the commodity is moved from the farm through processing plants to the retailer entirely in water.

Matthews in 1963 (16) studied the requirements of a hydro-handling system for presorting and presizing storage apples. He was able to develop several satisfactory components for such a system including an underwater sizing device and an accumulator type box filler.

The sophistication of storage procedures as exemplified by controlled atmosphere storage has increased costs and, thereby, stressed the need for increased efficiency in the use of storage space. The effect of grade defects of CA apples on storage returns was suggested by Dewey in 1958 (6). He found that fruit defects originating on the tree affected approximately one quarter of the apples examined in the storage for both the McIntosh and Jonathan varieties. Another one quarter of the McIntosh fruits had been damaged during harvest and movement to storage while only ten percent of the Jonathans were injured during the same operation. Assuming a sorting and packing cost of $ .15 per field crate and a CA storage charge of $ .50 per field crate, it was shown that if 95 percent of the fruit were sound, the CA storage and sorting costs would be $ .65 for each 40 pound unit of U. S. No. 1 grade apples packed out. As the percentage of sound fruit decreased the cost per packed unit increased. He estimated that the 25 percent of the McIntosh fruit which were damaged during harvest and handling resulted in an increased cost of $ .20 per 40 pound unit of U. S. No. 1 fruit packed. A premium in profit of $ .50 which the CA fruit could expect to command would be nearly eliminated by the increased storage and handling costs if 45 percent of the stored apples are culls.

Procedures for improving the quality of the fruit placed in CA storage recommended by Dewey (6) included selection of the fruit by orchard, by tree and by field crate. In the event of a short crop he suggested that the storage operator would profit by purchasing high quality fruit to fill the storage (if available) rather than fill it with low quality fruit.

Methods of selecting better fruit for CA storage such as spot picking, picking in the middle part of harvest season and avoiding hormone-treated blocks are described by Dalrymple (5). He also noted that some growers who were packing their fruit in layer packs before storage were dropping the operation because of the lack of time during harvest and because apples decaying during storage made the package unsalable when removed. He found the pack-out of McIntosh apples from CA storage in 1956 was about 78 percent U. S. No. 1 grade or better, 19 percent utility grade and 3 percent culls. This was estimated to be somewhat higher than the normal grade-out for utility grade.

Hunter (12) related the quality of the fruit to the efficiency of an apple packing line. The number of apples inspected per sorter was cut in half when the percent of C grade and cull fruit was increased from 10 percent to 40 percent. The dumping rate on a spiral roll sorting table was found to decrease from 310 boxes per hour to 250 boxes per hour as the percent C grade and cull apples increased from 17 to 45.

Carmen (3) has found similar savings on the packing line as the percentage of U. S. No. 1 and better fruit increases. His data show that sorting labor costs increase 50 percent when culls and utilities increase from 10 to 40 percent on a line operating at a rate of 360 bushels per hour.

The change which occurs in apple prices between the times of harvest and removal from CA storage is of major importance to growers or storage operators. The expectation of a price change helps to determine whether to store or sell the apples immediately. Boger's (1) analysis of monthly apple price changes from 1923 to 1950 showed an average monthly increase in price of 5 percent from September to April. The price increase averaged over the same years was $ .37 per bushel. This was done before CA storage apples were of importance, but the marketing season covered nearly the same period of time each year. This is a weighted average of all varieties and grades sold in Michigan during those years and should not be taken as indicative of the potential gain for the higher quality grades.

Thompson (18) in 1962 reported on the price premiums CA apples received over regular storage apples in New York. His data show an eight-year average price premium for Red Delicious of $1.14 per unit sold as compared with McIntosh at $ .91 per unit and Romes at $ .53 premium per unit. The average premium for the three varieties was $ .86 per unit.

He noted no significant decrease in the average premium as the volume of CA apples increased from year to year. Also, the increased volume of CA apples had no effect on the price of apples sold from regular storage or from CA storage.

PROCEDURES AND METHODS

An analysis of the economic feasibility for utilizing a presizing and presorting system required information as to the expected gain to be attained, as well as the expected cost of the new system. The information concerning the costs is limited since the hydro-handling system is still in the planning stage and without commercial evaluation. A range of possible costs for operating the equipment can be estimated, however, and the operation then examined for net gain or loss at several levels within the range.

Therefore, much attention in this analysis is directed toward estimating benefits and gains in an attempt to answer such questions as: "How much can one afford to spend on a system for presorting and presizing apples before CA storage?" and "What are the individual effects of each of the many variables which can influence the net gain or benefits?"

The benefits or gains from the proposed system can be categorized into two groups: one, the measurable economic advantages, and two, the less measurable benefits such as convenience, reduction of risk and increased service to customers. Only the actual dollar gains are measurable, but they must be considered in light of the other benefits which may be equally important though not as easily measured.

Variables

Six major variables affecting the economic feasibility of the system were considered. First was the change (usually an increase) in market price of the fruit during the period between harvest and removal from CA storage. Apple sales were divided into three groups for the purpose of this analysis (U. S. No. 1 and better, utility, and cull or cider apples) and the price change or differential from harvest to removal from storage for each of these three classifications was considered.

The second variable is the percentage at which these various grade classifications are packed out of CA storage. This relationship will vary from year to year and from orchard to orchard and will be referred to as the grade-out percentage in this paper. Another variable is the relative volume of each of the varieties in storage. This relationship will be referred to as the "variety mix" in the remainder of this paper. Price differentials and pack-out percentages will both vary from one variety to another. A fourth factor is the efficiency at which this pregrading system will remove the utility and cull fruit. A presizing and presorting system will not remove all of the utility and cull fruit for several reasons. First, some fruit will be missed in the operation due to a failure of the sorters to see and remove all of the existing utilities and culls. Other fruit may be damaged by the pregrading equipment itself. Also some apples may change grade after they have been placed in storage as a result of storage-caused disorders. Since the system is not fully developed at the operational level, this efficiency is unknown and should be considered as another variable.

The capacity of the storage operation is another important factor when considering the life of the equipment, depreciation and spread of fixed cost, because it determines the amount of use of the equipment. The sixth factor considered is the cost of operating the system or the variable costs (labor, power, water, etc.) over and above the fixed investment. This may vary from one operation to another due to management or local differences in the cost of labor and materials.

Assumptions

Two assumptions were initially necessary in order to reduce the number of variables affecting the analysis. The first assumption deals with the projection of past data into future situations. It was assumed for these purposes that prices and price differentials will remain equal to the average levels of recent years. Secondly, it was assumed that there will be enough high quality fruit available to fill the storage and replace the utility and cull fruit which would be removed if the presizing and presorting system is used.

Sources and Collection of Data

A relatively large storage and packing organization having a history of efficient and progressive operation was chosen as the primary source of data for this study. The management was agreeable to making their records of operation available for use in this analysis.

Seven kinds of information were needed: apple prices, relative volume of varieties in storage, relative volume of each grade of fruit in storage, expected efficiency of operation of the pregarding system, total CA storage capacity, storage costs and charges to growers, and an estimate of the variable cost of operating the presizing and presorting system.

The prices needed were those for the fruit at harvest and prices after CA storage for the three classifications - U. S. No. 1 and better, utility grade and cull grade - and for each of the three major varieties used in the analysis - McIntosh, Jonathan and Red Delicious. The price information for the U.S. No. 1 and better grades was available from the records of the individual packer and an average for West Michigan packers published by the U. S. D. A (13). The latter, being averages for West Michigan packers, were selected as more representative of the Michigan industry. The prices are given as a weekly range of prices received, F. O. B. shipping point. CA apple prices were reported separately from regular storage apple prices. Estimates were made as accurately as possible from the price ranges given for the first four week's quotations in the fall, in the case of harvest prices and from the weekly ranges given for the entire CA marketing season to obtain an average for CA apples. All prices were converted to 43 pound bushel units.

These prices were gathered for the crop years of 1961, 1962, 1963, and 1964 and for the varieties of McIntosh, Jonathan and Red Delicious. Price differentials were obtained by subtracting the harvest price from the CA price for each year and each variety. Average price differentials for the four year period were then obtained for each of the three varieties.

Price data for utility and cull grades were not available from the same source, so the records of the selected individual Michigan packer were utilized as a basis. The utility price differentials for the 1961, 1962 and 1963 crops were obtained from the records which gave prices at harvest, from regular storage and from CA storage. The values used are estimates made by the sales manager from these records. The price differentials were determined and averaged over the three years for each of the three varieties.

Cull or cider apple price differentials determined from the records were also obtained in consultation with the sales manager. Cull prices are averages of varieties since no variety distinction was made at their sale. Price differentials were determined as for the other grades and averaged for three crop years, 1961, 1962, and 1963.

The "variety mix" or relative volume of each variety in storage was determined from the records of the individual packer. Three major varieties, McIntosh, Jonathan and Red Delicious were used as the basis for the analysis because they represent the bulk of the CA storage holdings. The CA pack-out records for the 1961, 1962, 1963 crop seasons were analyzed and total volume for each variety were obtained. The percentage of volume of each variety was calculated and averaged for the three years.

The grade-out percentage of each variety into the three classifications, U.S. No. 1 and better, utility grade and cull grade, was determined from the same records. These records contained the volume of each type of pack (tray, 12/3 lb. poly-bag, etc.) by lot, year and variety. These various types of packs were grouped according to their grade specifications. The volume in each grade classification was totaled for each year and variety. From these data, relative volumes of each grade classification were determined for each variety.

A CA storage charge of $ .55 per bushel was used for this analysis. Dalrymple (5) in 1956 estimated the minimum CA storage cost at $ .50 per bushel while CA storage charges were estimated at $ .65 per bushel.

Values used for efficiency of the pregrading system, storage capacities and variable costs are estimated ranges. The efficiency of this system to remove the utility and cull grade apples is unknown and probably will vary with changes in quality of supervision and labor and "variety mix." Three efficiencies, 90, 80, and 70 percent, were chosen arbitrarily. The 90 percent efficiency was chosen as the upper limit since some change in fruit grade would be anticipated during the handling and storage period, thus there would always be some utility and cull grade fruits to remove after storage.

A range of CA storage capacities from 25,000 to 150,000 bushels at increments of 25,000 was considered. It is believed that this range will include most Michigan operations in the immediate future.

The variable cost of operating the system, another unknown, is represented by a range of values. To determine the general level which this range should cover, a preliminary estimate was made. Estimated labor requirements of 15 workers of $1.75 per hour plus 2 lift trucks at $1.25 per hour give a cost of $28.75 per hour or about $ .05 per bushel at 600 bushel per hour capacity. This cost plus \$ .01 or \$ .02 per bushel for power and other variable expenses gives a \$ .06 or \$ .07 per bushel variable cost. Intervals of \$ .02 in an arbitrarily chosen range of \$ .04 to \$ .10 per bushel was used.

Methods of Analysis of Economic Gain

The method used for determining the net gain over variable costs basically involved the calculation of possible measurable economic gains offset by an estimate of the cost of operation. The measurable monetary gains can be divided into two categories: minimizing the loss from the failure of utility and cull fruits to cover their storage costs and the opportunity to take advantage of a potential profit on U.S. No. 1 apples.

Direct loss on storage: For a given storage capacity, the number of bushels of each variety was found by applying the estimated "variety mix." Then, for each variety, the number of bushels of utilities and culls was determined by multiplying by the appropriate grade-out percentages for that particular variety and grade. The amount of total utilities and culls which would be graded out before storage was determined for each of the different combinations of variety and storage capacity at three different efficiencies of the pregrading operation.

A \$ .55 storage charge was subtracted from the utility and cull price differential for each of the three varieties. This determined the amount by which each bushel of these two grades and for each variety failed to cover the storage charge. This was then multiplied by the number of bushels, respectively, for each variety-grade combination, each size storage and each level of efficiency. When the products are totaled for each storage capacity and efficiency level, the total amount by which storage costs have not been covered is determined for that storage operation.

Opportunity cost: To calculate the opportunity cost, the storage charge was subtracted from the price differential for U.S. No. 1 fruit of each variety. The result was then multiplied by the number of bushels which would be graded out as utilities and culls for each variety. This, when totaled for a given storage capacity, determined potential profit which could have been obtained by grading out the utility and cull fruits and storing U.S. No. 1 fruit instead. Adding this to the loss on storage costs determines the total gains available if a presorting and presizing system were used. This figure was calculated for a range of storage sizes and three levels of efficiency at a pre-determined "variety mix" and pack-out percentage for each variety.

Net gains: Each of the four levels of variable costs of pre-grading in the range estimated earlier were multiplied by each of the six alternative storage capacities. This determines the total variable costs for each storage size at each of the four levels of variable costs. Each of these costs was then subtracted from the total gains available for each respective storage capacity and efficiency. The result is the amount available each year for equipment investment and other fixed costs with various assumed conditions of efficiency, storage capacity and variable cost.

Example of analysis: An example calculation follows based on these conditions:

1. Price differentials:

McIntosh	- U.S. No. 1	$1.34 per bushel
	- Utility	$ .17 " "
Jonathan	- U.S. No. 1	$1.38 " "
	- Utility	$ .38 " "
Red Delicious	- U.S. No. 1	$ .95 " "
	- Utility	$ .27 " "
All varieties	- Cull	$ .12 " "

2. Grade-out percentages:

McIntosh	- U.S. No. 1	70 percent
	- Utility	22 "
	- Cull	8 "
Jonathan	- U.S. No. 1	75 "
	- Utility	20 "
	- Cull	5 "
Red Delicious	- U.S. No. 1	78 "
	- Utility	17 "
	- Cull	5 "

3. "Variety mix":

McIntosh	45 percent
Jonathan	30 "
Red Delicious	25 "

4. Storage cost: $ .55 per bu.

5. Storage capacity: 25,000 bushel.

6. Assumed level of efficiency: 90 percent.

A. Direct loss on storage cost: First, the relative volume of each of the three varieties in storage is obtained by multiplying the storage capacity by the "variety mix."

McIntosh: 25,000 bu. X 45% = 11,250 bu.
Jonathan: 25,000 bu. X 30% = 7,500 bu.
Red Delicious: 25,000 bu. X 25% = 6,250 bu.

The result for each variety is multiplied by the appropriate grade-out percentage for utility and cull grade from Table 1 (see below) to determine the volume of each of these grade classifications for each variety.

McIntosh:
11,250 bu. X 22% = 2475 bu. utilities
11,250 bu. X 08% = 900 bu. culls

Jonathan:
7,500 bu. X 20% = 1500 bu. utilities
7,500 bu. X 05% = 375 bu. culls

Red Delicious:
6,250 bu. X 17% = 1062 bu. utilities
6,250 bu. X 05% = 312 bu. culls

Each of these variety-grade categories is multiplied by 90 percent efficiency to determine the quantities which would be removed by pre-sorting and presizing.

McIntosh:
2475 bu. X 90% = 2228 bu. utilities
900 bu. X 90% = 810 bu. culls

Jonathan:
1500 bu. X 90% = 1350 bu. utilities
375 bu. X 90% = 338 bu. culls

Red Delicious:
1062 bu. X 90% = 956 bu. utilities
312 bu. X 90% = 281 bu. culls

The average price differentials for utility and cull fruit, given in Table 2, are subtracted from the \$ .55 storage charge to determine the loss per bushel from failure to cover the storage charge.

McIntosh:
\$ .55 - \$ .17 = \$ .38 loss per bu. (utilities)
\$ .55 - \$ .12 = \$ .43 loss per bu. (culls)

Jonathan:
\$ .55 - \$ .38 = \$ .17 loss per bu. (utilities)
\$ .55 - \$ .12 = \$ .43 loss per bu. (culls)

Red Delicious:
\$ .55 - \$ .27 = \$ .28 loss per bu. (utilities)
\$ .55 - \$ .12 = \$ .43 loss per bu. (culls)

The appropriate loss per bushel is now multiplied by the volume removed in each variety-classification category and added to give the total amount lost by failure of the receipts from utilities and culls to cover the storage charges.

McIntosh:
2228 bu. X \$ .38 = \$846.64
810 bu. X \$ .43 = \$348.30

Jonathan:
1350 bu. X \$ .17 = \$229.50
338 bu. X \$ .43 = \$145.34

Red Delicious:
956 bu. X \$ .28 = \$267.68
281 bu. X \$ .43 = \$120.83

Direct loss on storage costs \$1958.29

B. Opportunity cost: The storage charge is subtracted from the price differential for U.S. No. 1 and better fruit to determine the potential profit per bushel.

McIntosh:	\$1.34 - \$ .55 = \$ .79	potential profit
Jonathan:	\$1.38 - \$ .55 = \$ .83	potential profit
Red Delicious:	\$ .95 - \$ .55 = \$ .40	potential profit per bu.

These values are multiplied by the respective volumes of storage space which could have been filled with U.S. No. 1 and better fruit if the utilities and culls had been removed before storage.

McIntosh:	\$ .79 X (2228 + 810) bu. =	\$2400.00
Jonathan:	\$ .83 X (1350 + 338) bu. =	\$1401.04
Red Delicious:	\$ .40 X (956 + 281) bu. =	\$ 494.80
	Opportunity cost	\$4295.86

This value represents the total potential profit which could not be attained because utility and cull fruits occupied the space in which U.S. No. 1 and better fruit could have been stored. Adding this amount to the direct loss by storage of the utilities and culls gives the gross economic gain which could be obtained as a result of presizing and presorting.

\$1958.29 + \$4295.86 = \$6254.15 = gross economic gain.

C. Net gains: To determine the net economic gain, the storage capacity is multiplied by the estimated variable cost per bushel of the presizing and presorting operation.

25,000 bu. X \$ .04 = \$1000.00

Subtracting this variable cost value from the gross economic gain gives the net economic gain. (See extreme upper left value in Table 4 under Results and Discussion.)

\$6254.15 - \$1000.00 = \$5254.15 or \$5254.

RESULTS AND DISCUSSION

Grade-out Percentages and Variety Mix

A summation of the quantities of fruit by variety and grade held in the storage operation examined in this study is given in Table 1. The volumes of fruit by variety varied from year to year depending upon crop conditions. Nevertheless, the volume of McIntosh was consistently higher than either Jonathan or Red Delicious. Jonathan was the second most important variety in volume stored by this operation; however, the volume of Red Delicious was almost equal to Jonathan in 1962. The average values for the 3 years, expressed as percentages of the total for these three varieties was 45 percent McIntosh, 30 percent Jonathan and 25 percent Red Delicious. This relationship of varieties ("variety mix") was used in the analysis as a specific example of a representative firm.

The Red Delicious variety was consistently of higher quality than the other varieties. The three-year average grade-out was 78 percent U.S. No. 1 and better, 17 percent utility and 5 percent cull grade fruit. The Jonathan variety varied more than the Red Delicious from year to year, but averaged in grade-out from storage as 75 percent U.S. No. 1 and better, 20 percent utilities and 5 percent culls. McIntosh did not vary as much as Jonathan from year to year, but graded out the poorest of the three with 70 percent U.S. No. 1 and better, 22 percent utilities and 8 percent culls.

Table 1. The grade-out and quantity of three varieties of apples stored in controlled atmosphere during three seasons by a Michigan firm.

Crop Season	U.S. No. 1 and Better		Utility		Cider		Total
	Bu.	%	Bu.	%	Bu.	%	Bu.
			Jonathan				
1961	23,407	79	5,139	17	1,172	4	29,718
1962	23,945	75	6,281	20	1,603	5	31,829
1963	28,463	71	9,285	23	2,281	6	40,029
Total	75,815	75	20,705	20	5,056	5	101,576
			McIntosh				
1961	34,501	67	14,812	29	2,424	4	51,737
1962	38,873	71	9,556	17	6,183	12	54,612
1963	30,663	72	9,403	22	2,767	6	42,833
Total	104,037	70	33,771	22	11,374	8	149,182
			Red Delicious				
1961	17,158	78	3,529	16	1,379	6	22,066
1962	23,974	78	5,021	16	1,641	6	30,636
1963	14,746	78	3,805	20	406	2	18,957
Total	55,878	78	12,355	17	3,426	5	71,659

Examining these results in relation to the findings of Dewey (6) it appears that this individual storage operation stored higher quality apples than the average. His examination of fruit from three grower-operated storages in Michigan showed the McIntosh variety averaged 55 percent U.S. No. 1 and better and Jonathan averaged 67 percent U.S. No. 1 and better.

Price Differentials

The price data standardized by conversion of all values to 43-pound bushel units are presented in Table 2. The average price for the several weeks during harvest is given for each variety, grade and year. The same is shown for the average price during the CA marketing season. Average price changes are determined for each variety and grade. The averages were taken over four years for the U.S. No. 1 and better fruit and over three years for the other two grades.

The Jonathan and McIntosh consistently showed a greater seasonal gain than Red Delicious in value for U.S. No. 1 fruit. The utility price gains were more erratic than price gains for the other two classifications, but Jonathan showed the greatest average differential over the three years studied. This is partially due to the fact, no doubt, that some of the utility Jonathans were re-graded and sold in special packs which were sold at higher prices than the rest of the utility fruit.

All varieties were combined for calculating the price differentials for cull apples. This grade showed a relatively consistent gain in value

Table 2. Average prices (dollars per bushel) received by grade for three varieties of apples at harvest and upon removal from CA storage for three seasons.

Variety	Crop Season 1961 Harvest	1961 C.A.	1961 Change	1962 Harvest	1962 C.A.	1962 Change	1963 Harvest	1963 C.A.	1963 Change	1964 Harvest	1964 C.A.	1964 Change	Ave. Change
U.S. No. 1 and better (a)													
McIntosh	2.05	3.68	1.63	2.30	3.68	1.38	2.82	3.73	.91	1.95	3.40	1.45	1.34
Jonathan	2.05	3.73	1.68	2.46	3.96	1.50	2.66	3.62	.96	2.05	3.40	1.35	1.38
Red Delicious	3.33	3.85	.52	3.58	4.92	1.34	3.58	4.24	.66	2.97	4.24	1.27	.95
Utility (b)													
McIntosh	.65	.70	.05	1.00	1.25	.25	1.00	1.20	.20	----	----	----	.17
Jonathan	.75	1.00	.25	1.00	1.40	.40	1.00	1.50	.50	----	----	----	.38
Red Delicious	1.00	1.60	.60	1.25	1.65	.40	1.50	1.30	-.20	----	----	----	.27
Cull (b)													
All Varieties	.36	.49	.13	.36	.49	.13	.75	.86	.11	----	----	----	.12

(a) Source: Keller, R. E. Marketing Michigan Apples; Summary. U.S.D.A., Benton Harbor, Michigan.

(b) Source: Records of one Michigan Storage and Sales Organization.

during storage each season even though the actual prices were much higher in 1963 than they had been in 1961 and 1962.

A comparison was made between the U.S. No. 1 price differentials obtained from the individual storage operation and those determined from the industry average to ascertain if the utility and cull prices obtained from the individual storage operation were representative of the industry average. The price differentials from the published industry average have been shown in Table 2. To determine the U.S. No. 1 price differentials for the individual operation, harvest prices were obtained from records of sales and the CA prices were obtained from the CA pool records for the three years, 1961, 1962, and 1963. Price differentials were calculated in the same manner as for the utilities and culls and averaged over the three years for each of the three varieties. The resulting price differentials at the example plant are shown in Table 3 along with the industry price differentials obtained from the published data.

The results from two sources seem to be reasonably similar in value, and also the varieties fall in the same order for both sources. On this basis, it is believed that utility and cull price differentials obtained from the individual packer are similar to industry averages and suitable for use in this study.

Economic Gains

The results from the analysis for possible economic gain are tabulated in Table 4 and graphically presented in Figures 1, 2 and 3. Table 4 shows the calculated net return over variable costs which could

Table 3. The increase in value (dollars per bushel) for three varieties of U.S. No. 1 and better apples between harvest and removal from CA storage for four seasons in Michigan.

Variety	1961	1962	1963	1964	Average
		Selected Individual Packer (a)			
McIntosh	.89	1.14	1.27	----	1.10
Jonathan	.99	1.58	1.09	----	1.22
Red Delicious	.98	1.32	.83	----	1.04
		Michigan Packer Average (b)			
McIntosh	1.63	1.38	.91	1.45	1.34
Jonathan	1.68	1.50	.96	1.35	1.38
Red Delicious	1.52	1.34	.66	1.27	.95

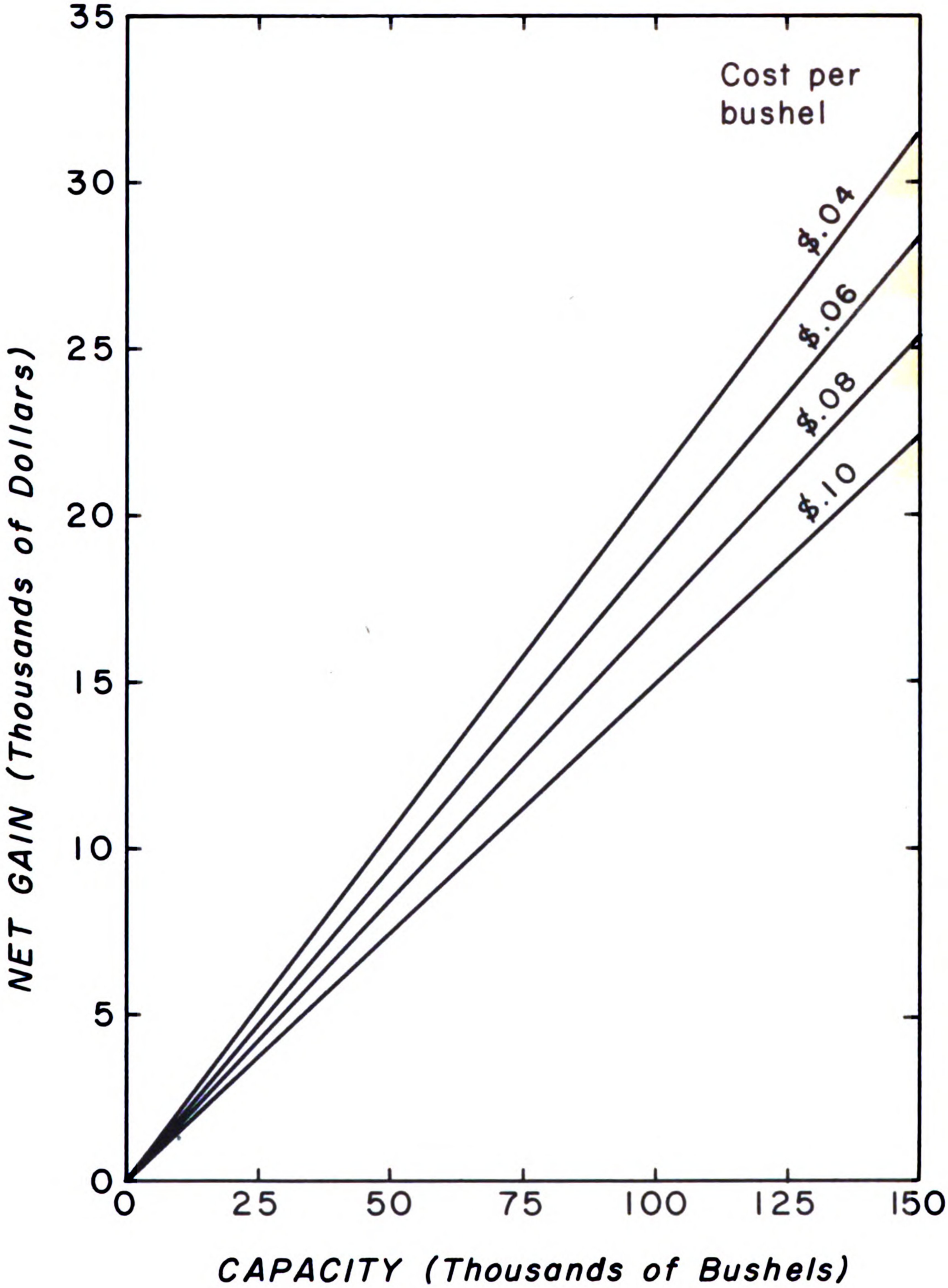
(a) Source: Records of a selected Michigan storage and sales organization.

(b) Source: Keller, R. E. Marketing Michigan Apples; Summary, U.S.D.A., Benton Harbor, Michigan.

Table 4. The effects of fruit volume, equipment operating costs and efficiency of operation on the economic gain from presizing and presorting apples for CA storage where the relative volume of each variety is 30 percent Jonathan, 45 percent McIntosh and 25 percent Red Delicious.

Storage Capacity	Efficiency	Net Return with Variable Equipment Operating Costs Per Bushel of: $ .04	$ .06	$ .08	$ .10
(bu.)	(%)	(total dollars)			
25,000	90	5,254	4,754	4,254	3,754
	80	4,558	4,058	3,558	3,058
	70	3,864	3,364	2,864	2,364
50,000	90	10,505	9,505	8,505	7,505
	80	9,117	8,117	7,117	6,117
	70	7,728	6,728	5,728	4,728
75,000	90	15,758	14,258	12,758	11,258
	80	13,675	12,175	10,675	9,175
	70	11,592	10,092	8,592	7,092
100,000	90	21,010	19,010	17,010	15,010
	80	18,234	16,234	14,234	12,234
	70	15,454	13,454	11,454	9,454
125,000	90	26,263	23,763	21,263	18,763
	80	22,792	20,292	17,792	15,292
	70	19,320	16,820	14,320	11,820
150,000	90	31,515	28,515	25,515	22,515
	80	27,351	24,351	21,351	18,351
	70	23,182	20,182	17,182	14,182

Figure 1. The effects of fruit volume and equipment operating costs on the economic gain from presizing and presorting apples for CA storage where 90 percent of the utility and cull fruit are removed and the relative volume of each variety is 30 percent Jonathan, 45 percent McIntosh and 25 percent Red Delicious.


Cost per bushel
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NET GAIN (Thousands of Dollars)
CAPACITY (Thousands of Bushels)
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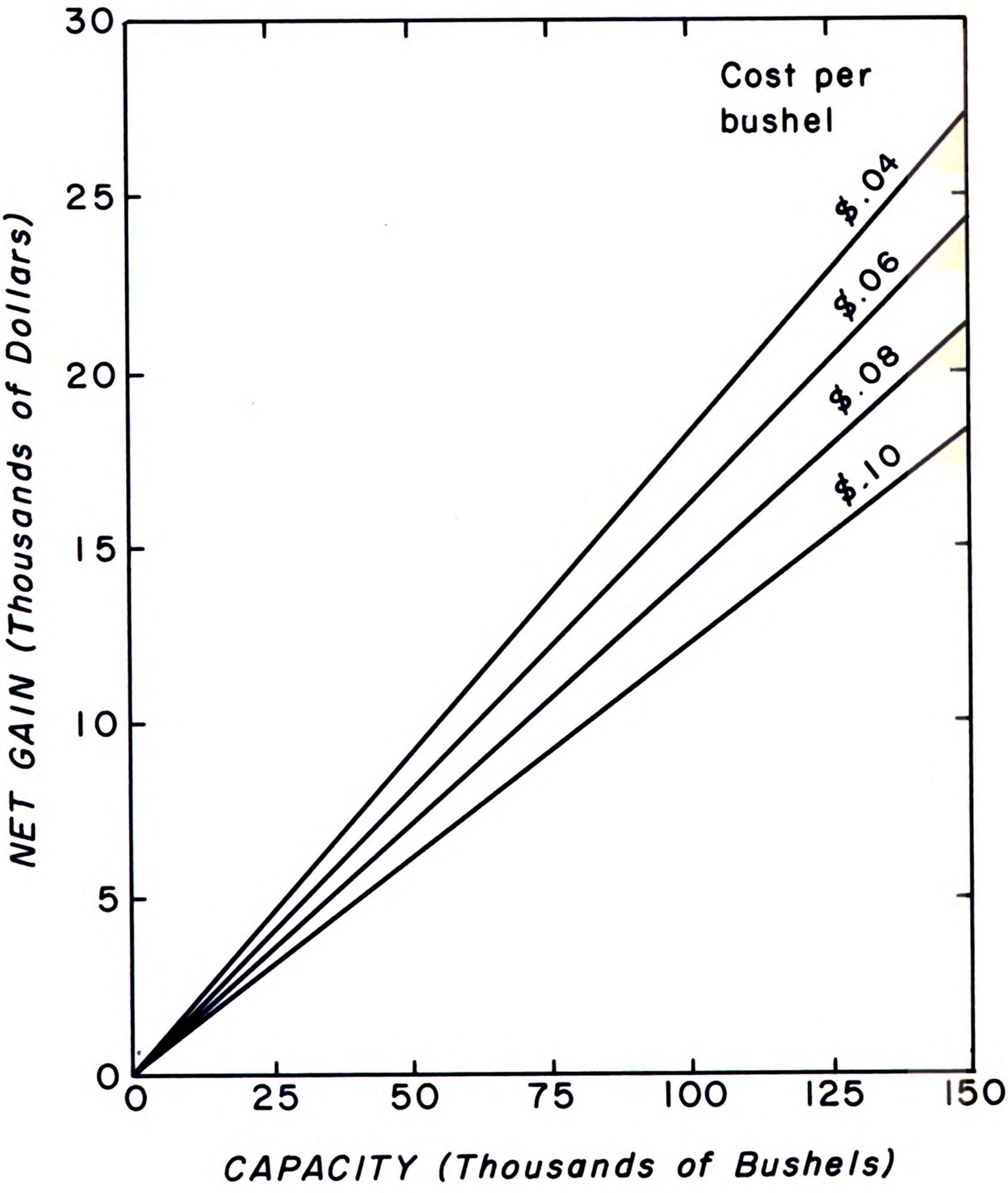
Figure 2. The effects of fruit volume and equipment operating costs on the economic gain from presizing and presorting apples for CA storage where 80 percent of the utility and cull fruit are removed and the relative volume of each variety is 30 percent Jonathan, 45 percent McIntosh, and 25 percent Red Delicious.



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NET GAIN (Thousands of Dollars)
Cost per bushel
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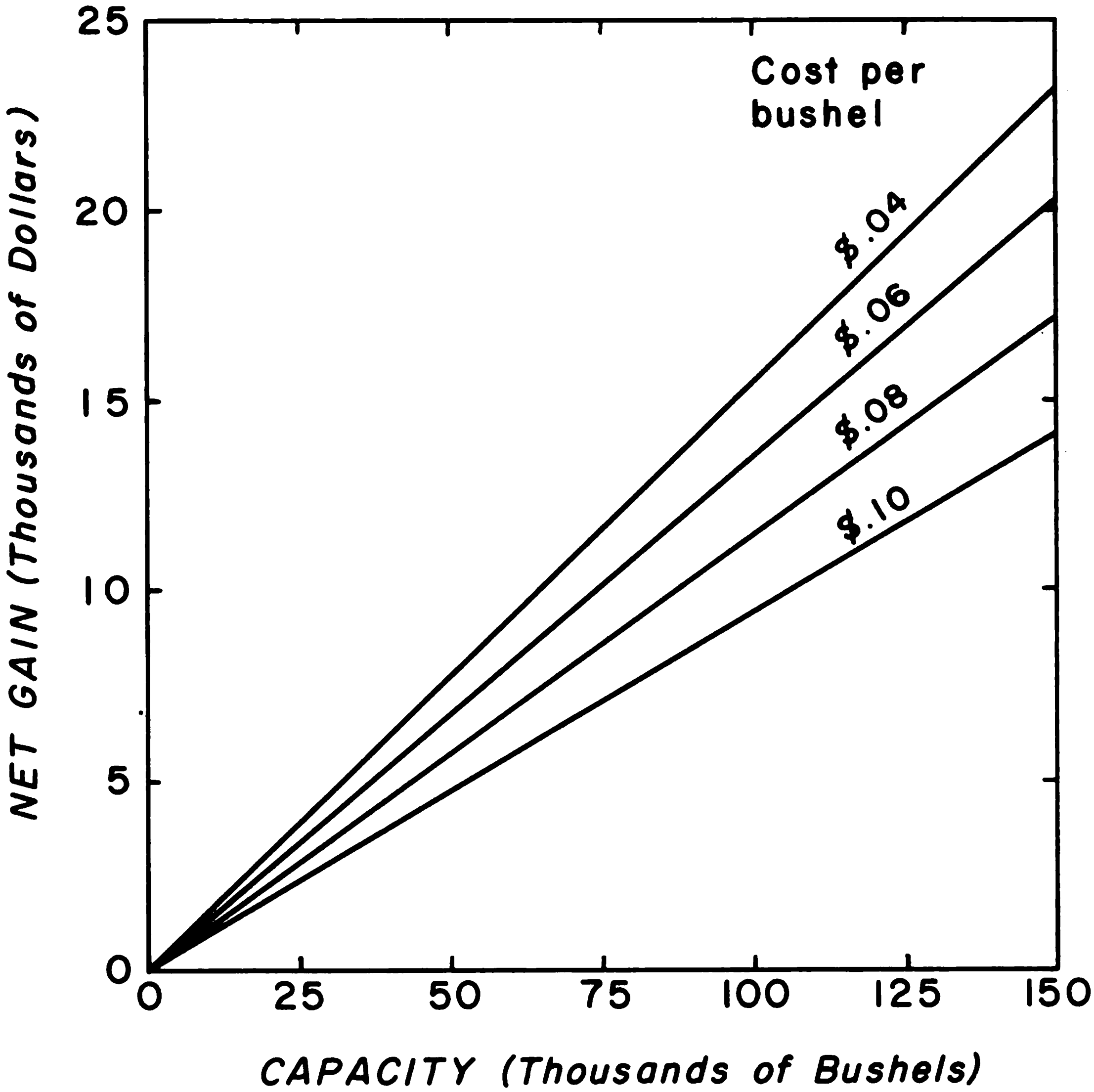
CAPACITY (Thousands of Bushels)

Figure 3. The effects of fruit volume and equipment operating costs on the economic gain from presizing and presorting apples for CA storage where 70 percent of the utility and cull fruit are removed and the relative volume of each variety is 30 percent Jonathan, 45 percent McIntosh and 25 percent Red Delicious.



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NET GAIN (Thousands of Dollars)
Cost per bushel
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CAPACITY (Thousands of Bushels)

be expected from adoption of a presizing and presorting operation at six storage sizes, three levels of pregrading efficiency and four levels of variable cost. The charts facilitate the determination of the net gain over variable costs for any storage size in the range of 25,000 to 150,000 bushels.

The results indicate that for a given level of cull out, "variety mix" and price differentials, the net gain over variable costs increases as the efficiency of operation and storage capacity increases or as the estimated variable cost decreases.

To analyze a particular situation, a storage operator or packer would first determine CA storage capacity, and then select a representative variable cost and efficiency factor for his pregrading operation. By consulting the appropriate figure, the monetary gain from adopting the presorting and presizing system for that particular operation could be ascertained.

For example, consider the individual storage used as a source of data for this study. With a total CA storage capacity of 100,000 bushels, an estimated efficiency of operation of 80 percent and an estimated variable cost of $ .08 per bushel, the expected gain over variable costs for one season would be approximately $14,250. Table 4 would give a more exact solution of $14,234. This is the amount which the individual storage operation studied would gain each year if a system of presizing and presorting were adopted with the assumed efficiency and variable cost.

If one considered that the investment in the presizing and presorting system was $25,000, investment in the equipment would appear economically sound. Depreciating the equipment over five years, the annual depreciation cost would be $5000 and interest at 5 percent would average $750 per year. Repairs, taxes and insurance could add another $750 per year bringing the total fixed costs per year to $6500. Since the expected net gain over variable costs is $14,250, the fixed costs would be more than covered and this storage operation would be justified in adopting the presizing and presorting system. If the net gain over variable costs were less than $6500 the new operation would not be economically justified. The final decision would probably also depend upon a consideration of the other indirect benefits such as convenience in relation to the loss.

Influence of Other Individual Factors

The above analysis results have shown how the net gain will change with changes in storage capacity, efficiency of operation and variable costs. The other factors were held at constant values on the basis of data for recent years. Although the latter are presently realistic, they may change and affect the evaluations. The three variables which should be considered for future change are "variety mix," price differential, and grade-out rate.

Variety mix: The "variety mix" used in this study is 30 percent Jonathan, 45 percent McIntosh and 25 percent Red Delicious. In view of the future prospects for the Michigan apple industry, it is unlikely this relationship will remain static. The Kent County tree survey of 1963 showed more than 50 percent of the apple trees in that county were under nine years of age, and, of these, 36 percent were Red Delicious and 25 percent were Jonathan. Less than 10 percent of the young trees were McIntosh (19). Therefore, one must expect Red Delicious to increase in percentage of future storage holdings with McIntosh to decrease. Jonathan will likely hold steady at approximately 30 percent.

The consequences of this change in "variety mix" are important since the price differentials (Table 2) show Red Delicious to realize a consistently smaller price gain during storage than either McIntosh or Janathan. Also, Red Delicious had a lower grade-out record of utilities and culls and more of the higher grades than the other varieties. Obviously any increased Red Delicious volume would decrease the potential economic benefit of a presizing and presorting system holding other variables constant.

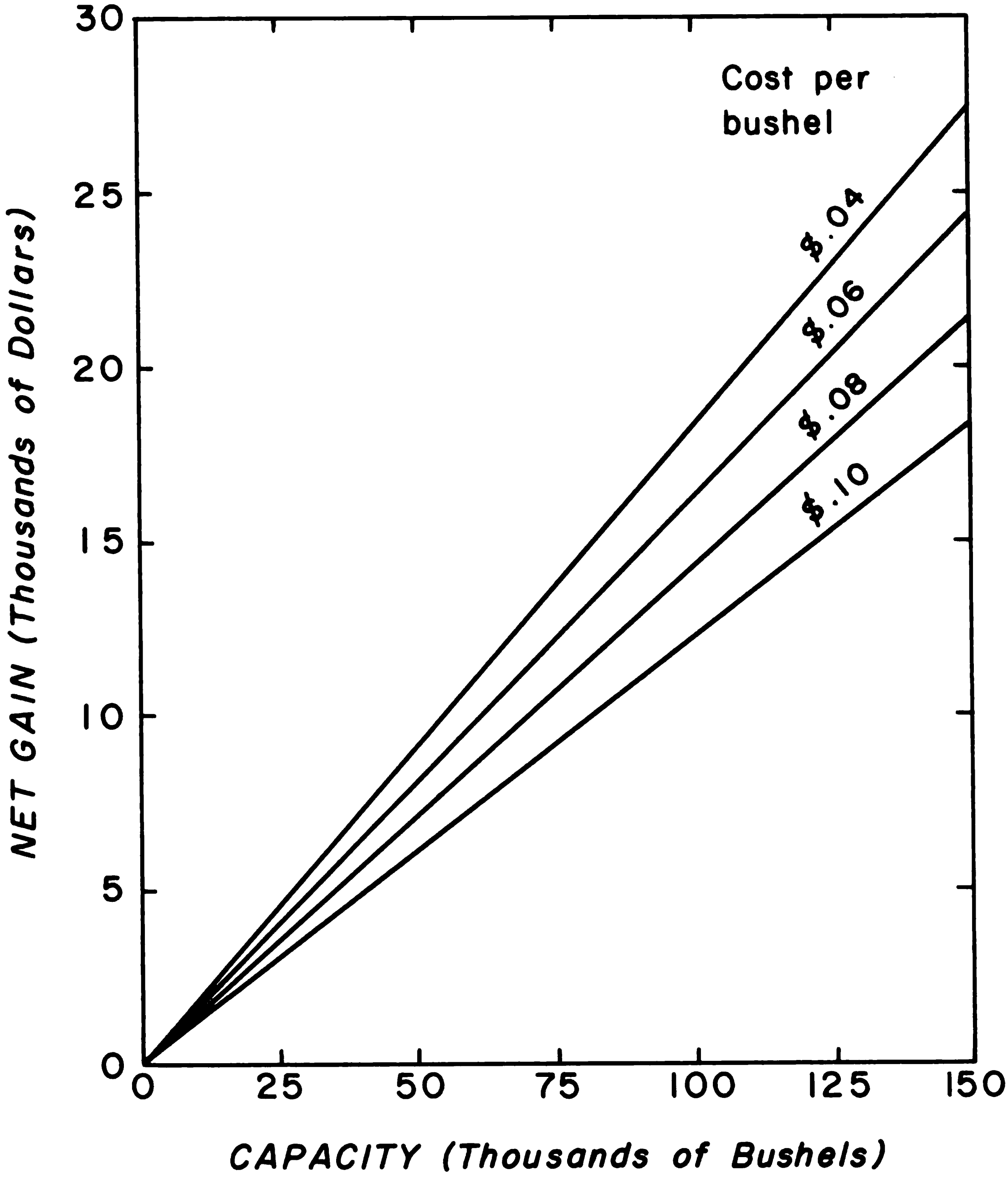
To illustrate the effect of variety changes, an analysis of net gains in which the "variety mix" is 30 percent Jonathan, 30 percent McIntosh and 40 percent Red Delicious gives the results shown in Table 5 and Figures 4, 5, and 6. Here the net gain over variable cost is consistently less because of the greater percent of Red Delicious and the smaller percent of McIntosh in CA storage.

The importance of these results is obvious. As the relative percentage in storage of a variety such as Red Delicious increases, the amount of money which can be applied toward fixed costs of the system

Table 5. The effects of fruit volume, equipment operating costs and efficiency of operation on the economic gain from presizing and presorting apples for CA storage where the relative volume of each variety is 30 percent Jonathan, 30 percent McIntosh and 40 percent Red Delicious.

Storage Capacity	Efficiency	Net Return with Variable Equipment Operating Costs Per Bushel of: $ .04	$ .06	$ .08	$ .10
(bu.)	(%)	(total dollars)			
25,000	90	4,585	4,085	3,585	3,085
	80	3,964	3,464	2,964	2,464
	70	3,344	2,844	2,344	1,844
50,000	90	9,170	8,170	7,170	6,170
	80	7,929	6,929	5,929	4,929
	70	6,689	5,689	4,689	3,689
75,000	90	13,755	12,255	10,755	9,255
	80	11,894	10,394	8,894	7,394
	70	10,033	8,533	7,033	5,533
100,000	90	18,341	16,341	14,341	12,341
	80	15,859	13,859	11,859	9,859
	70	13,377	11,377	9,377	7,377
125,000	90	22,926	20,426	17,926	15,426
	80	19,823	17,323	14,823	12,323
	70	16,721	14,221	11,721	9,221
150,000	90	27,510	24,510	21,510	18,510
	80	23,788	20,788	17,788	14,788
	70	20,066	17,066	14,066	11,066

Figure 4. The effects of fruit volume and equipment operating costs on the economic gain from presizing and presorting apples for CA storage where 90 percent of the utility and cull fruit are removed and the relative volume of each variety is 30 percent Jonathan, 30 percent McIntosh, and 40 percent Red Delicious.



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Cost per bushel
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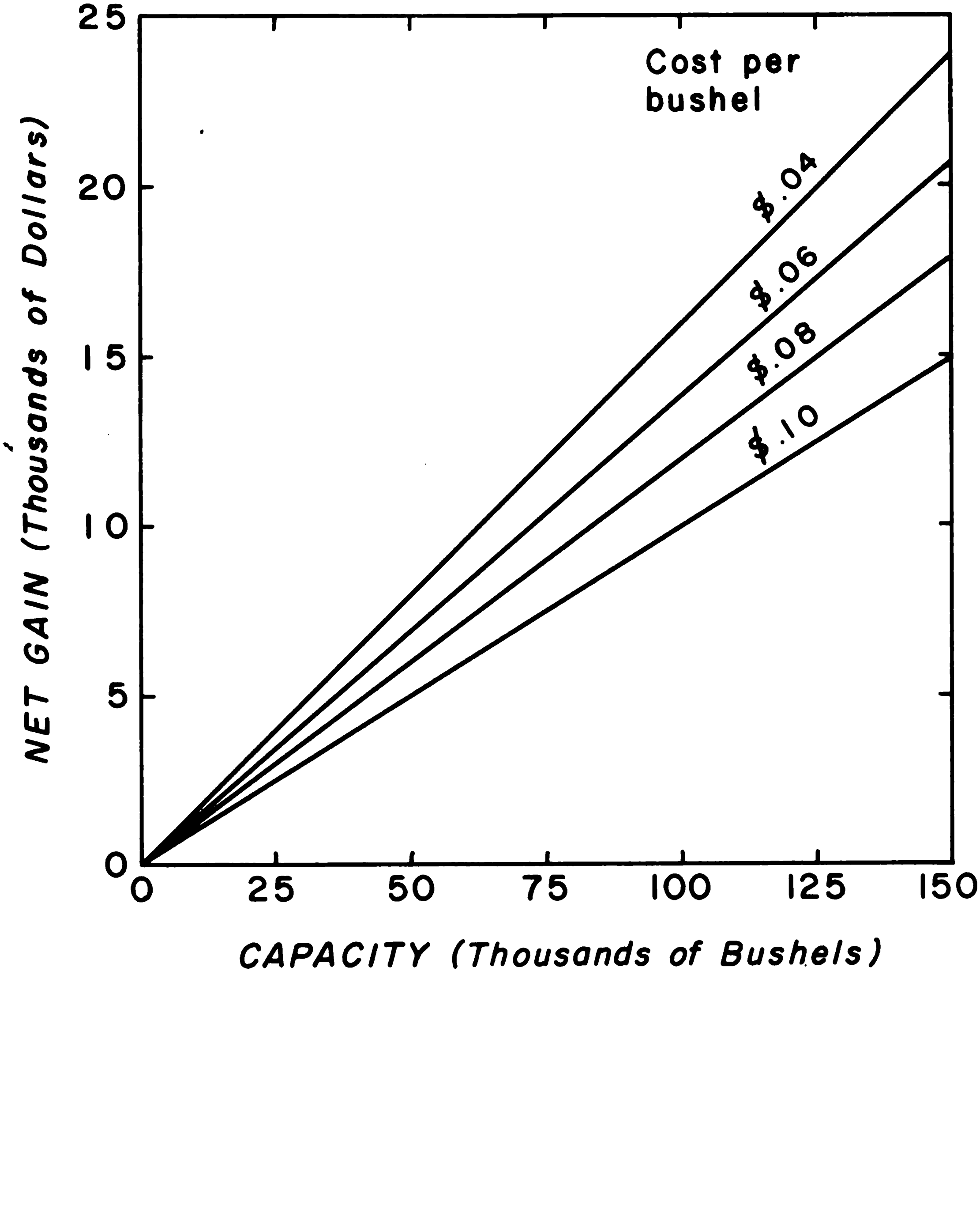
NET GAIN (Thousands of Dollars)
CAPACITY (Thousands of Bushels)

Figure 5. The effects of fruit volume and equipment operating costs on the economic gain from presizing and presorting apples for CA storage where 80 percent of the utility and cull fruit are removed and the relative volume of each variety is 30 percent Jonathan, 30 percent McIntosh and 40 percent Red Delicious.



NET GAIN (Thousands of Dollars)
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Cost per bushel
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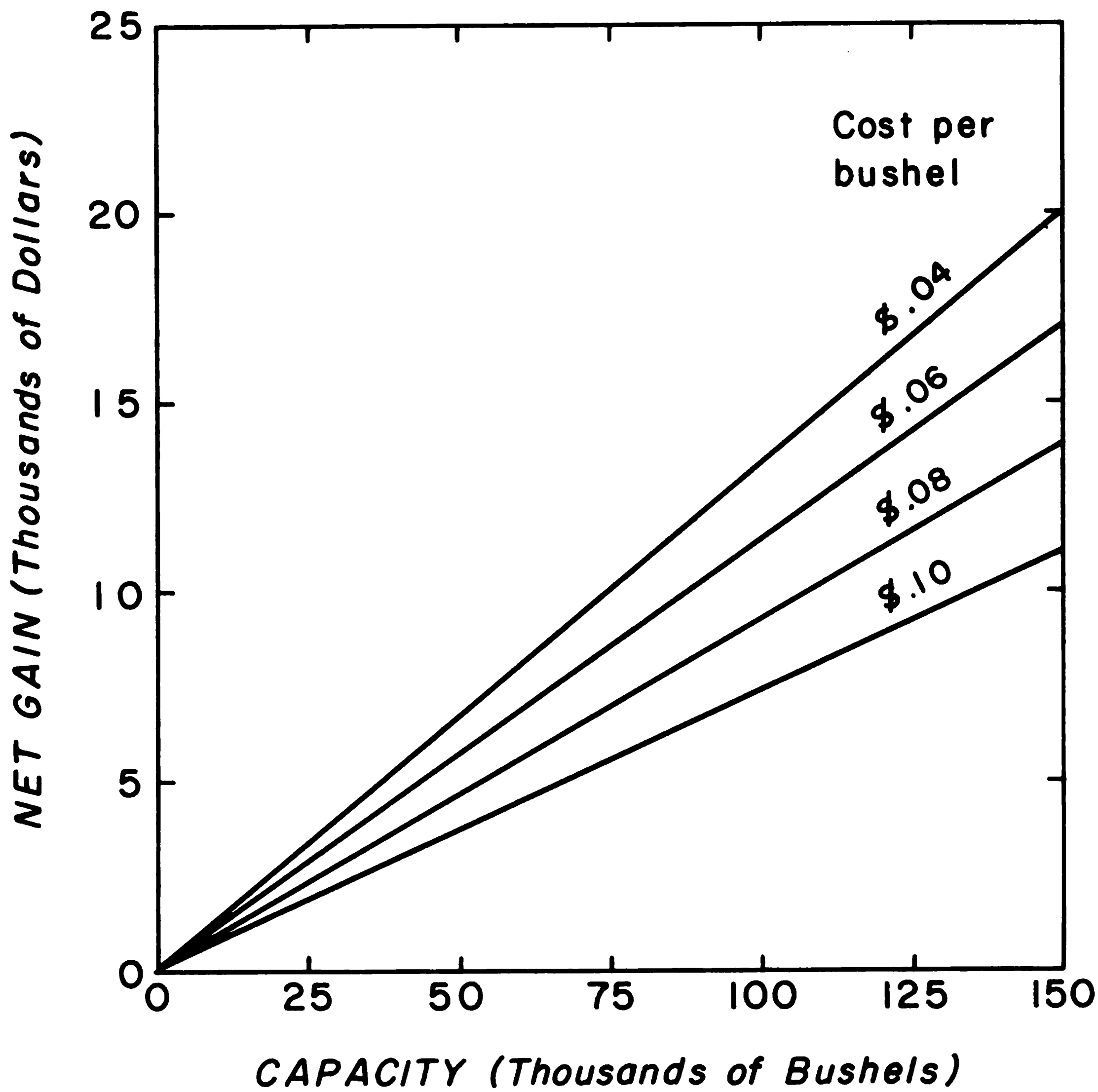
CAPACITY (Thousands of Bushels)

Figure 6. The effects of fruit volume and equipment operating costs on the economic gain from presizing and presorting apples for CA storage where 70 percent of the utility and cull fruit are removed and the relative volume of each variety is 30 percent Jonathan, 30 percent McIntosh and 40 percent Red Delicious.


Cost per bushel
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NET GAIN (Thousands of Dollars)
CAPACITY (Thousands of Bushels)
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decreases. It will decrease as the price differential for U.S. No. 1 apples of that variety decreases and the grade-out of utility and cull fruit of that variety decreases.

Price differentials: One effect of price differentials on net gain was illustrated in connection with changes in "variety mix." In general, as the price differential of the utility and cull grade fruit of a given variety increases and the differential for the U.S. No. 1 fruit decreases the net gain decreases.

The adoption of a fruit presizing and presorting system may lower price differentials in that an increased volume of high quality fruit available from CA storage might force prices of that type of fruit down. Also, the use of this system could increase the volume of utilities and cull apples on the market at harvest time; a resultant depression of utility and cull prices at harvest time would increase the price differential for these two grades. These two characteristics, increased utility and cull grade price differentials and decreased U.S. No. 1 price differentials, would have an accumulative effect of decreasing the net gain. In the short run, these two factors may have little effect unless a large number of storage operators adopt the system. Once the system has become established and adopted by many operators, however, it might have considerable influence on price differentials.

Grade-out percentages: The effect of the grade-out in relation to "variety mix" has already been described. As the percentage of utility and cull fruits increases, the net gains increase. Grade-out percentages depend on physical characteristics of the fruit (size, bruises, decay and color) and upon the quality demands of the market. To maintain high standards of quality, the apples must often be graded more rigorously than the government standards require. On the other hand, in a short crop year, the standards may be lowered somewhat to maintain enough volume in a certain grade.

It is obvious that grade-out percentages will frequently change. To illustrate the effect of this on net returns another analysis was carried out varying the grade-out percentages. The "variety mix" used was one-third McIntosh, one-third Jonathan and one-third Red Delicious. The efficiency of the pregrading operation was held constant at 80 percent. The six alternative storage capacities and four levels of variable cost used in the previous analysis were used. Price differentials used previously were also used. Four combinations of grade-out percentages were used with the U.S. No. 1 grade varying from 80 percent to 50 percent, utility grade changing from 16 percent to 40 percent and cull grade from 4 percent to 10 percent.

The results of this analysis (Table 6) indicate that net returns over variable costs from a presizing and presorting system increase as the grade-out percentage for utilities and culls increase. With a large storage operation and a high grade-out of utilities and culls, the value of a presizing and presorting is quite high relative to the probable cost of the pregrading system.

Table 6. The effects of fruit volume, equipment operating costs and grade-out percentages on the economic gain from presizing and presorting apples for CA storage where the relative volume of each variety is one-third Jonathan, one-third McIntosh and one-third Red Delicious.

Storage Capacity	Grade-out No. 1-Utility-Cull	Net Return with Variable Equipment Operating Costs Per Bushel of: $ .04	$ .06	$ .08	$ .10
(bu.)	(%)	(total dollars)			
25,000	80-16-4	2,920	2,420	1,920	1,420
	70-24-6	4,880	4,380	3,880	3,380
	60-32-8	6,840	6,340	5,840	5,340
	50-40-10	8,800	8,300	7,800	7,300
50,000	80-16-4	5,840	4,840	3,840	2,840
	70-24-6	9,760	8,760	7,760	6,760
	60-32-8	13,680	12,680	11,680	10,680
	50-40-10	17,600	16,600	15,600	14,600
75,000	80-16-4	8,760	7,260	5,760	4,260
	70-24-6	14,640	13,140	11,640	10,140
	60-32-8	20,520	19,020	17,520	16,020
	50-40-10	26,400	24,900	23,400	21,900
100,000	80-16-4	11,680	9,680	7,680	5,680
	70-24-6	19,520	17,520	15,520	13,520
	60-32-8	27,360	25,360	23,360	21,360
	50-40-10	35,200	33,200	31,200	29,200
125,000	80-16-4	14,600	12,100	9,600	7,100
	70-24-6	24,400	21,900	19,400	16,900
	60-32-8	34,200	31,700	29,200	26,700
	50-40-10	44,000	41,500	39,000	36,500
150,000	80-16-4	17,520	14,520	11,520	8,520
	70-24-6	29,280	26,280	23,280	20,280
	60-32-8	41,040	38,040	35,040	32,040
	50-40-10	52,800	49,800	46,800	43,800

Other Benefits

There are other possible benefits of a pregrading system which cannot be evaluated readily or accurately. The plant layout, management and financial structure of each individual operation varies widely and may alter the influence or importance of these benefits. Possible benefits lie in an increased packing line efficiency during the final packing operation, improved inventory control and the use of the system as an alternative to expanding the storage capacity.

Packing line efficiency: Reports by Hunter (12) and Carmen (3) indicate that savings can be realized on packing line operation by decreasing the percentage of culls. With the adoption of a presizing and presorting system, the amount of cull fruits left to be removed when packing for market would be considerably decreased. Dewey (6) indicated that only 10 to 15 percent of the total defects of apples upon removal from storage originated after harvest. It would seem logical to conclude that some savings could be gained on the variable costs of packing the fruit for market due to this decreased percentage of fruit to be removed.

Inventory control: A presizing and presorting system would provide the storage operator and sales manager with accurate information about the stored fruit. By using this system, the apples to be placed in storage would be sized into at least two or more categories. An inventory would be kept for each room so that the exact amount of each size as well as variety would be known. With this information the sales manager would know how much of each of the varieties and sizes he had to sell. He would be able to make a more confident commitment to the customer when negotiating a sale.

The packing line manager could more effectively prepare an order because he could readily locate the appropriate variety and sizes needed. If the apples are pooled in storage and an average pool price is paid to the producer, a knowledge of each grower's contribution to the quality of the fruit at harvest-time would be helpful in determining a fair payment for each grower.

Alternative to expansion: Perhaps one of the greatest potential values of a pregrading system lies in its relationship to the present need for expansion of storage capacity. The estimated expanding future production of apples in Michigan suggests a need for a similar expansion of storage capacity. A logical approach to solving this is the better use of existing facilities. Perhaps the most ideal and least expensive way for expansion and continued increase in the value of the fruit in storage would be a presizing and presorting system. A greater volume of apples could be handled by removing and selling the low quality fruit at harvest, leaving more storage space for high quality fruit.

CONCLUSIONS

The many variable factors that must be considered in determining the economic feasibility of a presizing and presorting system for apples require that each particular situation be analyzed separately.

From the records of past seasons, the Michigan storage and packing operation selected for this study, could expect a net gain over variable costs of $14,234 per year from adoption of a presizing and presorting system if 80 percent of the utilities and culls are removed by this operation at a variable cost of $ .08 per bushel.

In analyzing the economic feasibility of a presizing and presorting system to a particular storage and packing operation, six major variables must be considered: price differentials, "variety mix," grade-out rates, CA storage capacity, expected rate at which the system will remove utility and cull fruit and the expected variable cost of the pregrading operation. The net gain over variable cost calculated from these values, offset against the investment and other fixed costs provides a basis for making a decision concerning the adoption of a presizing and presorting system.

SUMMARY

The relative volumes of the three major varieties held in controlled atmosphere storage by a selected Michigan packer during three seasons were 30 percent Jonathan, 45 percent McIntosh and 25 percent Red Delicious. For these stored apples, the Jonathan were 20 percent utility and 5 percent cull, the McIntosh 22 percent utility and 8 percent cull, and the Red Delicious 17 percent utility and 5 percent cull; with the rest of each variety being classified as U.S. No. 1 or better grade. Prices received for apples for four years (crop seasons 1961-1964) by West Michigan apple packers for U.S. No. 1 and better fruit showed the McIntosh and Jonathan varieties had an average gain in value during storage of $1.34 and $1.38 per bushel, respectively; whereas Red Delicious gained $ .95 per bushel. McIntosh utility grade averaged $ .17 gain in value per bushel during storage, Red Delicious of this grade increased $ .27 and a similar grade of Jonathan gained $ .38.

The net gain over variable cost as a result of utilizing a presizing and presorting system will increase as the efficiency of operation and storage capacity increases, or as the estimated variable cost decreases provided variety grade and "mixture" and price differentials remain constant. The mixture of varieties greatly affects the possible net gain because of varietal differences in grade-out and price differentials. When other factors are held constant, the net gain over variable costs will increase as grade-out percentage of utility and cull

fruit increases. Also, net gain will decrease as the price differential for U.S. No. 1 apples decreases and differential for utility and cull grades increases. Therefore, with an increase in relative volume of a variety which grades out less utility and cull apples and/or has smaller price differentials for U.S. No. 1 apples and larger differentials for utility and cull grades, the net gain will decrease.

Several other benefits are possible through the use of a presizing and presorting system. Increased efficiencies could be achieved during the final packing of apples from storage as they are prepared for market. Better inventories are possible and the additional information and control of supplies would offer sales advantages. The reduction in quantity of low-grade fruit in storage would provide additional space for premium-grades, and thereby, satisfy certain expansion requirements without need for increasing physical facilities.

The decision to incorporate a presizing and presorting system into an CA apple storage, packing and selling operation must be based on an analysis of the particular firm's situation. In the case studied, the analysis indicates that measurable economic gain, as well as other benefits, could have been realized during the seasons of 1961-62, '62-'63 and '63-'64, by the use of a system that was 80 percent efficient in removing off grade fruit before storage and had a variable cost of operation of $ .08 per bushel.

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