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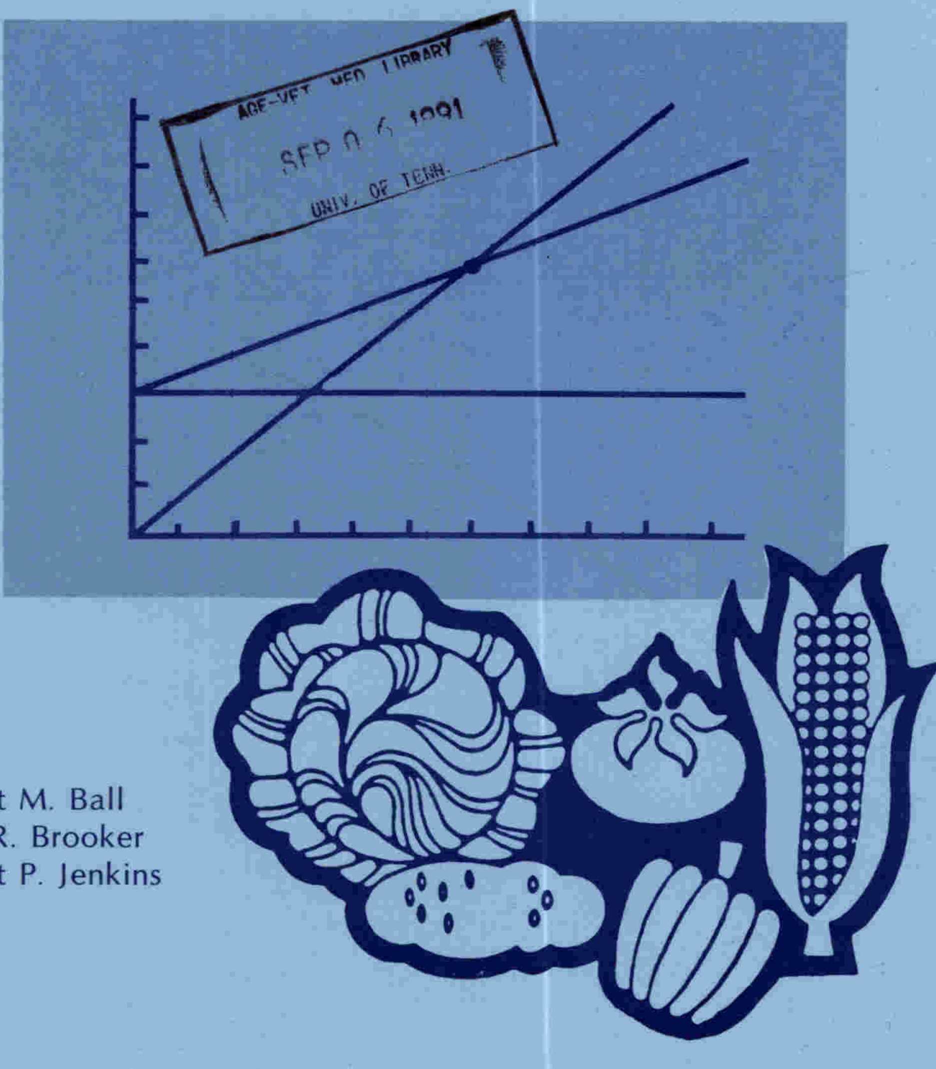

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Abstract

A computer simulation program was used to estimate the break-even volumes of five single-crop, one three-crop and two four-crop vegetable packinghouse models. The packinghouse models were developed according to the economic-engineering approach. A representative study area was selected to permit identification of appropriate vegetables. Out of an original group of 15 vegetables, five were examined in two or more of the packinghouse models. Sensitivity analysis was also conducted on the multi-crop models to reveal the effects of adjustments in various specifications regarding the operations of each model.

Packing three vegetables required 173 acres of tomatoes, 172 acres of bell peppers, and 344 acres of cabbage for the packinghouse to break even, with packing charges of $2.30, $3.00, and $2.55, respectively. Adding potatoes as a fourth crop added another 136 acres to the amount required for the packinghouse to reach the break-even point. Adding sweet corn instead of potatoes increased the total acreage by 375. Sweet corn required the addition of an expensive hydrocooler, and potatoes required some special equipment, so total break-even volumes increased to cover higher fixed costs. Average fixed, variable, and total cost curves were generated for each vegetable.

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Introduction

The recent decline in profitability for many traditionally Southern commodities and the increased profitability of other minor crops have forced producers to reexamine traditional farm production decisions [Estes and Ingram]. As a result, many farmers are considering vegetables for the commercial fresh market as a substitute or addition to their present sets of production enterprises. Before undertaking commercial production, farmers should be aware of the unique production requirements and marketing opportunities for vegetables. They should study the needs of the commercial vegetable market and grow those crops that are most compatible with their own resources [Runyan et al.].

In 1982, a total of 2,070 Tennessee farms with 30,096 acres were involved in the production of fresh vegetables [U. S. Bureau of Census]. As producers switch from the more traditional commodities to production of fresh vegetables, one problem to be solved is the establishment of consistent markets for their produce. The Tennessee fruit and vegetable industry is characterized by numerous small-scale growers who produce a large assortment of crops, even though there are several large scale

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Tennessee growers [Brooker 1985]. However, considering any one particular crop, Tennessee is a minor supply region with respect to total U.S. production.

The diversity of crops produced, widely scattered small-scale production, and relatively minor position with respect to total U.S. production create serious market access barriers for Tennessee fruit and vegetable growers attempting to enter commercial wholesale markets. In order to interest large-volume commercial buyers, new as well as experienced small-scale vegetable producers have the option of organizing an assembly-packing facility to package and sell their produce collectively instead of trying to perform these functions individually. The formation of a growers' cooperative or growers' association provides an opportunity for pooling resources and for establishing a reputation of marketing quality vegetables. Both aspects will help to open more marketing opportunities for local production [Runyan et al.].

Objectives

There were three specific objectives of this study:

1. to determine the costs involved in constructing and operating a packinghouse facility for fresh vegetables,
2. to analyze the impact on cost and returns from handling selected combinations of fresh vegetables, and
3. to analyze the sensitivity of returns from adjusting various specifications regarding the operation of each packinghouse model.

Procedure

Approaches to estimating packinghouse cost and efficiency relationships may be grouped into three broad categories. One method is the descriptive analysis of accounting data, which mainly involves combining point estimates of average costs into various classes for comparative purposes. A second method is the statistical analysis of accounting data, which attempts to estimate functional relationships by econometric methods. The third method is to use the economic-engineering approach, which "synthesizes" production and cost relationships from engineering data or other estimates of the components of the production function [French]. The economic-engineering approach was used in this study.

The total packinghouse production function is obtained by combining the production functions for the various operating stages or components. The "building blocks" for the stages of the production functions are the building and equipment capacities and the associated input-output relationships for labor, energy, and materials.

Once the production functions have been specified, the cost functions are determined by applying factor prices. Short-run cost functions are obtained by the specification of a set of production techniques and their capacities (thus defining a unique hypothetical packinghouse) and computing variable operating costs for a range of output rates up to or in excess of the design capacity limits.

To develop long-run cost functions, considerations must be given to all alternative stage production techniques and to the measurement of prices of durable inputs. The usual procedure for the later is to specify an expected life of the equipment, divide this into the installed cost, and add an amount to cover the cost of borrowed capital, taxes, insurance, and in some cases, a portion of average maintenance costs.

The economic-engineering approach has been criticized for the lack of findings pertaining to diseconomies of scale. This has been attributed to the use of constant input coefficients (especially for labor) and the inability to measure or account for coordination problems as plant scale increases. Furthermore, although the engineering approach may handle technical aspects of production processes with considerable accuracy, estimates pertaining to management, sales, and service activities are apt to be very crude [French].

A computer simulation program was used to facilitate analysis of these hypothetical packinghouse operations [Falk, Tilly, and Schatzer]. This computer program allows the user to adjust various components of the packinghouse model to observe the resulting effects on cost and returns. In this study the determination of the crop acreages necessary for the packinghouse model to break even was the primary focus of adjustments to the base packinghouse model. In other words, after the crops were selected and the acreages arbitrarily set at a beginning level, the computer program calculated the acreages required for this particular packinghouse model to break-even financially. The computer simulation model adjusts the initial acreages in unison. In an application to a particular situation the model could be constrained to hold some crop acreages constant and force the adjustments required to reach the break-even level on one or more of the remaining crop acreages. If any of the input-output coefficients of the packinghouse model are changed, such as the packing fee charged the grower or the cost of a particular piece of equipment, then the break-even acreage for each crop will change.

In order to facilitate specification of certain expenses, such as land and the selection of crops to examine, a representative study area was chosen. Grundy County and its seven contiguous counties were chosen as the study area. The small-scale production of vegetables in the study area necessitated emphasis on the break-even acreages revealed the supply levels necessary to support a viable fresh vegetable packinghouse. Whether or not the assumed f.o.b. price received for the packed products provides an adequate return to the grower is not examined in this report. Initially, 15 crops were examined in a multi-product packinghouse scenario. These 15 crops were identified as currently being grown, or suitable for growth, in the study area. Based on analysis with the 15-crop model, the number of crops included in two or more of the packinghouse models presented in this report was reduced to five vegetables—bell peppers, cabbage, Irish potatoes, sweet corn, and tomatoes. These five vegetables were selected because of potential for development, current production in the area and/or expressed interest in expanded production, and compatibility in a multiproduct packinghouse.

Packinghouse Operation

The basic operations in a vegetable packinghouse are sorting, sizing, grading and packing. A floor plan of the model packinghouse is shown in Figure 1. Depending on the kind of produce, additional activities may include degreening, curing, washing, bunching, chemical treatments, and precooling [Akamine et al.]. The sequence of activities varies with different crops. These operations are essential preparatory steps to storage, transportation, and subsequent marketing.

High temperatures are detrimental to the keeping quality of fruits and vegetables. However, elevated produce temperature is inevitable, especially when harvesting is done during hot days [Akamine et al.]. Precooling is a means of removing this field heat. The general aim is to slow down the respiration of the produce, minimize the susceptibility to attack of micro-organisms, reduce water loss, and ease the load on the cooling system of the transport vehicle. Methods of precooling include air cooling, vacuum cooling, and hydro-cooling.

Most fruits and vegetables are washed after harvesting. Washing may improve the appearance of the produce if grime, soil, scale insects, sooty molds, etc. are present. Washing with a detergent will remove residues of fungicides and insecticides.

Drying removes excess surface water from the vegetable. Heated air is blown on the vegetables as they pass through sponge roller conveyors. Drying may also be done by a series of rotating brush dryers made of soft bristles. Minimum heat and dryer brush speed should be used to avoid injury to the fruits. Some vegetables have a natural waxy layer on the outer surface that is partly removed by washing. A layer of wax applied artificially with sufficient thickness and consistency to prevent anaerobic conditions within the produce provides the necessary protection against decay organisms. Waxing is especially important if tiny injuries and scratches on the surface of the vegetable are present. These can be sealed by wax. Another advantage of waxing is the enhancement of the gloss of certain vegetables. Appearance may be improved by waxing, thus making the produce more acceptable to consumers.

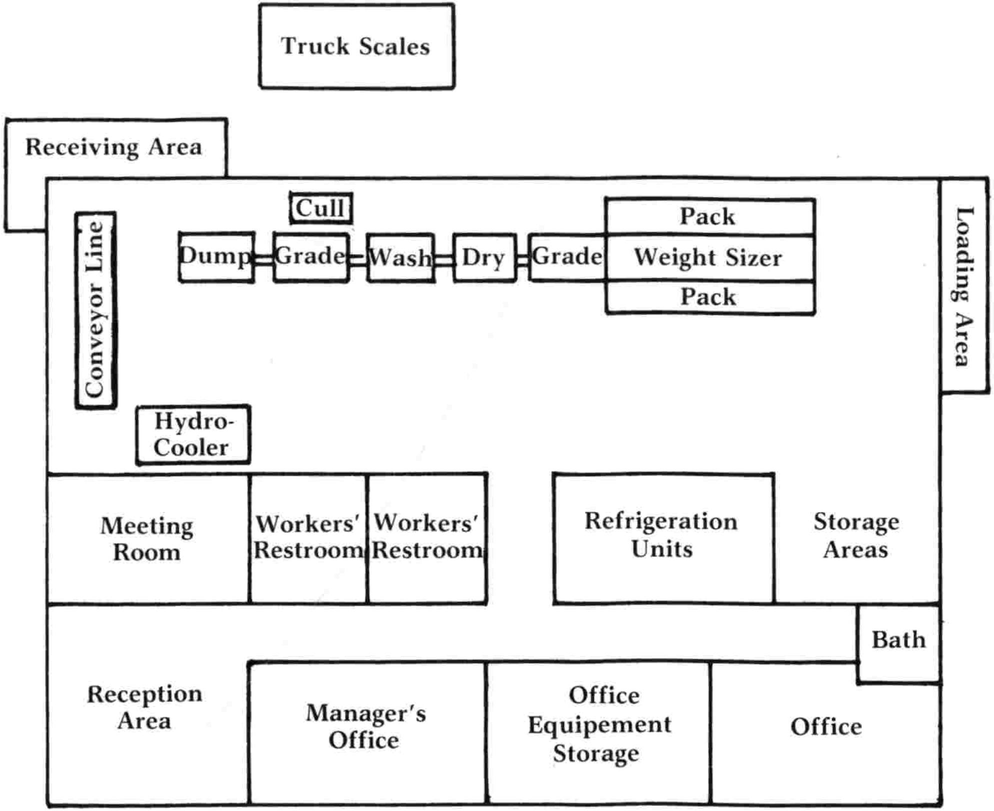

Figure 1. Layout for vegetable packinghouse model (not to scale).

Vegetables show considerable variations in quality due to genetic, environmental, and agronomic factors. Grading is necessary to get suitable returns commensurate with quality. Grades are based on soundness, firmness, cleanliness, size, weight, color, shape, maturity, and freedom from foreign matter and diseases, insect damage, and mechanical injury.

After grading, the produce is sized for uniformity. Hand-sizing is useful for small-scale packing. One packer is assigned to each size. However, this method is inadequate for consistent separation of commodities into uniform size groups. For commercial operations various sizing devices are necessary, based on either shape or weight of the produce. Sizing devices may consist of rollers that have varying spacing, conveyor lines with differing size holes, or spring-balance scale cups.

Most vegetables require some refrigeration during storage and shipment. Mechanically refrigerated storage gives the packinghouse manager some flexibility to delay sales in anticipation of a more favorable price at a later date.

Equipment capacities needed for storage facilities should be chosen so that temperatures are lowered quickly as produce is loaded. Good insulation, sound design and construction, use of plastic curtains on doors, and loading in small batches can increase the refrigeration equipment's efficiency.

Factors Affecting Operating Costs

Packinghouse size, season length, operating level, and total volume are factors that affect the cost of fresh vegetable packinghouse operations. Evaluation of the feasibility (or profitability) of fresh vegetable packing operations depends upon three necessary components: sufficient quantities of the product at mutually acceptable prices, ability of the packinghouse to operate efficiently, and ability of the organization to sell its finished product [Brooker and Pearson].

Workers usually insist on being paid for a minimum of four hours each day they report for work. Therefore, a short supply of incoming fruit may encourage the packinghouse manager to operate at less than desired capacity in order to retain an adequate labor force.

A successful vegetable marketing organization must be able to assure customers that they will receive uniform quality produce. To fill requirements of different classes of buyers, the packinghouse must use objective grading standards and controls [Berberich]. Although quality is sometimes only cosmetic, growers and packinghouse managers must recognize the importance of marketing and realize they must satisfy the buyers standards and not their own [Motes et al.].

The quality of the incoming vegetables affects the operational efficiency of the packinghouse. If the quality is low, then the pack-out rate may be limited by the number of graders. If quality is high, then dumpers and packers may limit pack-out productivity. Because the percentage of culls depends on the quality of incoming produce, costs vary with changes in quality of incoming supplies.

Costs directly related to the number of hours a packinghouse operates will also vary with quality. Quality influences costs through limiting the volume packed in any given hour. With lower quality produce being received by the packinghouse, either output will be lower or a longer number of hours will be worked to pack the desired volume. In either event, those costs related to the hours of operation will increase. Therefore, costs directly related to the number of hours a packinghouse is operated are considered as quality associated costs [Bohall et al.].

Quality will also affect costs which are fixed aggregate amounts per year. With a given acreage of vegetables harvested and delivered to the packinghouse, the total pack-out will decrease with poorer quality [Bohall et al.]. Hence, the fixed annual expenses must be spread over fewer total crates of output, and average total cost per crate will rise.

Packinghouse Investment and Operating Cost

The economic-engineering method was used to specify the investment and operating cost of the vegetable packinghouses. Information was obtained for the cost of labor, packing materials, facilities, administration, land, general expenses, and cost of packing. The equipment was designed to pack-out 400 crates per hour when operating at 100 percent of rated capacity. This is the smallest size packing line that could be constructed with the automatic sizing (weighing) machinery. Several operational specifications concerning the packing facility were necessary to facilitate this analysis.

1. The packing facility has a beginning cash balance of $10,000. This may come from several varied sources such as producer fees, government support, or possible funding from development oriented public agencies.

2. The organization is able to borrow ninety percent of the cost for equipment, facilities and operations to finance the operation at an interest rate of ten percent. The remaining ten percent of the cost for equipment, facilities and operations would have to come from similar sources mentioned in assumption number one.

3. Payments on the building, machinery, and equipment are made quarterly.

4. Salvage value is based on ten percent of initial value. The estimated life of the grading and sizing equipment and hydrocooler is fifteen years. The conveyor, refrigeration, forklifts, scales, field crates and bulk bins have an estimated life of ten years and the building has an estimated life of twenty years.

5. The operating level of the packinghouse is set at 70 percent of rated capacity, i.e., the pack-out rate is 280 crates per hour.

Labor

The number of workers required at each stage of the packing operation is presented in Table 1. It was presumed that only one product would

Table 1. Number of workers required at each station in a fresh vegetable packinghouse designed to handle 400 crates per hour.

Labor	Bell Pepper	Tomato	Sweet Corn	Fall Cabbage	Spring Cabbage	Irish Potato
	workers					
Dumper, Culls	2	2	2	2	2	2
Forklift	1	1	1	1	1	1
Dumper	2	2	2	2	2	2
Unloading	0	0	2	2	2	0
Grader	6	6	6	6	6	6
Packer	20	20	20	20	20	20
Crate Former	4	4	4	4	4	4
Hydrocooler	0	0	2	0	0	0
Storage	3	3	3	3	3	3
Records	1	1	1	1	1	1

Source: Ball

be packed during a given work shift. While the packing line requires 20 packers for the tomato line and 20 packers for the potato line, it may or may not be the same 20 individuals. The packinghouse was designed to operate as a multi-product facility, so the packing line was designed to utilize complementary equipment wherever possible.

The minimum wage of $3.35 per hour was paid to all the employees except forklift operators. The forklift operator was paid a slight premium above minimum wage ($4.00 per hour) due to the special skills needed to operate the forklift. The State unemployment tax is 2.7 percent of the first $7,000. The Federal unemployment tax rate is 6.2 percent, but if the employer pays the state tax on time, the law permits a 5.4 percent credit.

Packing Materials

The cost of 50-pound capacity potato bags was set at $0.44. Packaging materials for bell peppers was set at $0.80 per 1⅑ bushel waxed carton, 20-pound cartons for tomatoes cost $0.95, 50-pound cartons for cabbage cost $1.10, and wire crates for 4½ dozen ears of sweet corn cost $0.94. The cost of wooden pallets was covered by charging 19 cents per packed crate.

Administrative Expense

The executive secretary was paid $5.00 per hour, for 40 hours per week

[Snell]. The manager's salary was set at $24,000 per year. If a packing facility hired an inspector for sixteen weeks (average length of a season), it would cost the packinghouse about $8,000.

General Expenses

Expenses for utilities, telephones, office supplies, and postage are presented in Table 2. The cost of office furniture, a computer system, typewriter, copy machine, check writer, and time clock were obtained from appropriate business firms in Knoxville. An air conditioning/heater unit was provided for the offices and reception area.

Building, Equipment and Land

A blueprint design of the packing facility was obtained from Agri-Tech Incorporated [Johnson]. The 25,000-square-foot building was estimated to cost $500,000 (Table 2). The weight sizer costs $134,717, and was used to size the tomatoes, bell peppers, and potatoes. The conveyor belt used to grade and size the sweet corn and cabbage, cost $6,692. A hydrocooler, that was used only for sweet corn, cost $125,000. The field crates were used by growers for delivering tomatoes and sweet corn to the packinghouse. The bulk bins were used by the producers growing potatoes, bell peppers, and cabbage.

The Monteagle, Tennessee area was chosen as a representative site location due to access to the interstate and because it is fairly centrally located within the study area. The Marion County tax office quoted that land was selling for about $1,500 per acre and taxes would be $65 per year. Three acres were needed for the hypothetical packinghouse.

Packing Charges and Produce Prices

Crop yields were based on the estimated yields published by the Tennessee Agricultural Extension Service (Table 3). Market prices were specified to be the average of those received on the Atlanta wholesale market during the summer months of 1982-1986 (Table 4). These Atlanta prices were adjusted for brokerage fees and transportation expenses from the study area (Table 5). The computer model used in this study required the input of selling prices received by the packinghouse. However, the possible effect of fluctuations in the selling prices is neutralized in the model because of the specification that growers receive the difference between the selling price and the packing charge. Hence, the profitability of the packinghouse is directly impacted by the volume packed and the per crate fee charged to the grower for packing the vegetables. The grower would be impacted by volume packed and by the magnitude of the difference between selling price and packing fee.

Table 2. Initial investment and annual expenses for a fresh vegetable packinghouse.

Item		Expense Amount
BUILDING AND EQUIPMENT:		
Building	(25,000 square feet)	$500,000.00
Equipment	(Weight Sizer)	$134,717.00
Hydrocooler		$125,000.00
Refrigeration Units	(2 40' X 40', 5 Ton Units)	$ 20,000.00
Forklift	(electric)	$ 18,500.00
Hand Forklift	(manual, 4 at $500)	$ 2,000.00
Return Flow Belt	(conveyor)	$ 6,692.00
Field Crates	(7500 @ $6.00)	$ 45,000.00
Bulk Bins	(1000 @ $40.00)	$ 40,000.00
Truck Scales		$ 30,000.00
LAND:		
Current Value	(3 acres @ $1,500/acre)	$ 4,500.00
GENERAL:		
Office Furniture & Equipment		
Furniture (Reception area, Manager's Office and Meeting Room)		$ 5,538.00
Computer System		$ 4,080.00
Copy Machine		$ 2,000.00
Check Writer		$ 359.00
Time Clock		$ 435.00
Air Conditioning/Heating Units		$ 1,790.00
ANNUAL EXPENSES		
Utilities		$11,100.00
Telephone		$10,500.00
Office Supplies		$ 3,420.00
Property Taxes		$ 65.00
Postage		$ 2,040.00
Insurance on Building		$ 4,200.00
Maintenance & Repair on Building		$10,000.00
Insurance on Machinery & Equipment		2%
Maintenance on Machinery & Equipment		2%

Source: See Ball for details regarding sources of particular cost values.

Table 3. Crop yields specified for packinghouse feasibility analysis.

Crop	Pounds per Crate	Yield per Acre	Marketable[a]
	pounds	crates	percent
Irish Potato	50	300	75
Tomato	20	700	70
Bell Pepper	40	350	75
Sweet Corn	42	155	75
Spring Cabbage	50	450	80
Fall Cabbage	50	450	80

[a]Percentage of total yield that is marketable obtained from Jenkins and Rutledge.
Source: Jenkins et al.

Table 4. Months vegetables packed, specified distribution of quality, and product prices used in packinghouse models.

		Quality[a]			Selling Price[b]		
Crop	Month	#1	#2	#3	#1	#2	#3
		----------pecent----------			-------------dollars-------------		
Irish Potatoes	July	100			6.15		
Tomato	July	40	40	20	7.47	7.47	3.72
	August	40	40	20	7.15	7.15	3.75
	Sept.	40	40	20	6.38	6.38	3.19
Bell Pepper	July	15	85		11.40	9.12	
	August	15	85		9.01	7.21	
	Sept.	15	85		11.17	8.94	
	Oct.	15	85		9.51	7.61	
Sweet Corn	June	100			6.15		
	July	100			5.89		
Spring Cabbage	June	100			7.34		
	July	100			6.36		
Fall Cabbage	Oct.	100			4.95		
	Nov.	100			4.93		
	Dec.	100			5.90		

[a]Distribution of packout by U.S.D.A. grade categories obtained from Rutledge, and Jenkins.
[b]Average monthly wholesale market price in Atlanta, 1982-1986, adjusted for transportation and brokerage expenses from packinghouse study area [Neely].
Source: Federal-State Market News Service.

Table 5. Freight and brokerage fees used to adjust Atlanta wholesale market prices to f.o.b. packinghouse prices.

Crop	Transportation[a]	Brokerage Fee[b]
	---------- dollars per crate ----------	
Irish Potato	0.30	0.10
Tomato	0.30	0.25
Bell Pepper	0.24	0.25
Sweet Corn	0.18	0.25
Spring Cabbage	0.30	0.15
Fall Cabbage	0.30	0.15

[a]Transportation cost from Grundy County to Atlanta, Georgia.
[b]Brokerage fee included in wholesale price quoted in Atlanta market.
Source: Neely.

The packing season in the study area for these four crops is June through December (Table 6). The distribution of the crops among the seven months is an approximation and could be altered by weather conditions during the growing season and/or by adjustments in traditional planting dates. Coordination of the harvesting dates for each crop in order to assure an even flow of incoming supplies over an extended harvesting season is critical to the operation of the packinghouse.

Income to the packinghouse operation is generated by the packing fee it charges the growers. The packing fees specified in the base models were obtained from two sources. The per crate packing charge for potatoes was $1.30, $2.30 for tomatoes, $3.00 for bell peppers, and $2.40 for sweet corn [Zwingli et al.]. The packing charge for cabbage was $2.55 per 50-pound bag [Kirkpatrick].

Results of Break-even Simulations

The simulation results of three different packinghouse models are presented in this section. First, a four-crop facility that packed tomatoes, bell peppers, sweet corn, and spring and fall cabbage. Second, a four-crop facility without a hydrocooler that packed potatoes, tomatoes, bell peppers, and spring and fall cabbage. And third, a three-crop facility that packed tomatoes, bell peppers, and spring and fall cabbage. After examining the impact of various factors on the crop acreages required for the packinghouse to break even, each of the five crops was examined in a single-crop packinghouse configuration. For each of these single-crop models, the assumed annual volume handled by the packinghouse was varied to measure cost scale relationships.

The acreage specified for each crop was set at an initial beginning point and adjusted by the same percentage up or down, as guided by the com-

Table 6. Distribution of crops by harvest month, Grundy County study area, Tennessee[a]

Month	Bell Peppers	Spring Cabbage	Fall Cabbage	Sweet Corn	Irish Potatoes	Tomatoes
	percent					
June		50		25		
July	5	50		75	100	35
August	45					35
September	45					30
October	5		45			
November			45			
December			10			

[a]Study area includes Grundy and its seven contiguous counties.
Source: Rutledge, and Jenkins.

puter program, until the volume handled by the packinghouse allowed it to operate at the break-even point. Except for sweet corn, all of the other crop acreages were set equal to each other and vary a few acres in the results because of rounding errors generated in the simulation model. Sweet corn acreage was arbitrarily set higher than the other crops because of the need to cover the cost of the expensive hydro-cooler.

Cabbage, Corn, Pepper, and Tomato Packinghouse

The facility packing cabbage, sweet corn, bell peppers, and tomatoes requires a total of 1,064 acres (165 acres of tomatoes, 169 acres of bell peppers, 400 acres of sweet corn, 165 acres of spring cabbage and 165 acres of fall cabbage) to operate at the break-even level (Table 7). While the total number of crates delivered to the packinghouse was 385,150 crates, 290,513 crates were packed. This is because of the specification that 30 percent of the tomatoes, 25 percent of the bell peppers, 25 percent of the sweet corn, and 20 percent of the cabbage would not be marketable.

Even though this four-crop packinghouse model breaks even financially under the specified conditions, the cost of packing sweet corn and spring and fall cabbage exceeds the specified packing charge. However, the cost of packing tomatoes and bell peppers is less than the packing charge. The packinghouse model uses the profitable difference in the packing costs and packing charges for tomatoes and bell peppers to offset the negative difference in the packing cost and packing charge for the sweet corn and spring and fall cabbage. To prevent the packing charge for one vegetable from being used to subsidize the cost of packing another, the packinghouse manager would probably need to readjust the packing charges. Except for sweet corn, the acreages of the other crops were purposely kept

Table 7. Facility packing four crops: crop acreage, volume packed, cost per crate, and packing charge at the break-even level of operations.

Crop	Acres Harvested	Yield Per Acre	Total Volume Received	Total Volume Packed	Average Cost Variable	Average Cost Fixed	Average Cost Total	Packing Charge
	Number	Crates	Crates	Crates	Dollars	Dollars	Dollars	Dollars
Tomato	165	700	115,500	80,850[a]	1.70	0.54	2.23	2.30
Bell Pepper	169	350	59,150	44,363[b]	1.53	0.94	2.48	3.00
Spring Cabbage	165	450	74,250	59,400[c]	1.85	0.78	2.63	2.55
Fall Cabbage	165	450	74,250	59,400[c]	1.85	0.78	2.63	2.55
Sweet Corn	400	155	62,000	46,500[d]	1.73	1.27	3.00	2.40
Total	1064		385,150	290,513				

[a] Assuming 70-percent of harvested tomatoes are marketable.
[b] Assuming 75-percent of harvested bell peppers are marketable.
[c] Assuming 80-percent of harvested cabbages are marketable.
[d] Assuming 75-percent of harvested sweet corn is marketable.

close to being equal to each other since the goal was to reveal minimum acreages for a packinghouse to break even. An unconstrained optimizing model would of course eliminate the total acreage of any crop that received a packing charge lower than the cost of packing. Another constraint placed on the packing-house simulations is the higher acreages specified for sweet corn. This was permitted because of the high cost of the hydrocooler, which is necessary for the proper handling of sweet corn.

Cabbage, Pepper, Potato, and Tomato Packinghouse

The second packinghouse model was designed to pack four crops, but in contrast to the first model, sweet corn was replaced by Irish potatoes. This eliminated the expense of a hydrocooler. At the break-even level of operation, this packinghouse model requires 150 acres of potatoes, 167 acres of tomatoes, 168 acres of bell peppers, 170 acres of spring cabbage, and 170 acres of fall cabbage (Table 8). The total crop acreage is reduced from 1064 in the first model to 825 in this second model. The main adjustment is the replacement of the 400 acres sweet corn by 150 acres of potatoes. The required acreages of tomatoes, bell peppers, and cabbage remained near the same levels.

The average cost of packing potatoes and spring and fall cabbage exceeds the per crate packing charge. The cost of packing tomatoes and bell peppers is less than the per crate packing charge. As with the first packinghouse model, the simulation program uses the difference in the packing cost and packing charge of tomatoes and bell peppers to offset the difference of the packing cost and packing charge of the potatoes and cabbage. The model is constrained to pack at least 150 acres of potatoes. Otherwise, based on the $2.23 per crate cost of packing and the $1.30 per crate packing charge, the logical actions would be to eliminate potatoes or increase the packing charge.

Cabbage, Pepper, and Tomato Packinghouse

Based on the results of the two four-crop packinghouse models, this third model is designed to pack three crops—tomatoes, bell peppers, and cabbage. With the packing charges at the same values as those used in the two four-crop models, the break-even crop acreages results in a pack-out of 253,760 crates (Table 9). This is a smaller number of crates for the packinghouse to handle than either of the four-crop break-even models. As expected with this smaller volume, the average fixed cost at the break-even point increases and average variable cost remains constant, thus forcing average total cost to increase. The cost of packing tomatoes increases from $2.24 in the four-crop model to $2.33 per crate in this three-crop model, which is slightly higher than the specified packing charge of $2.30. Bell peppers remain on the positive side, and cabbage becomes even more costly per crate in comparison to the packing charge.

Table 8. Facility packing four crops without a hydrocooler: crop acreage, volume packed, cost per crate, and packing charge at the break-even level of operations.

Crop	Acres Harvested	Yield Per Acre	Total Volume Received	Total Volume Packed	Average Cost Variable	Average Cost Fixed	Average Cost Total	Packing Charge
	Number	Crates	Crates	Crates	Dollars	Dollars	Dollars	Dollars
Tomato	167	700	116,900	81,830[a]	1.70	0.54	2.24	2.30
Bell Pepper	168	350	58,800	44,100[b]	1.53	0.85	2.38	3.00
Spring Cabbage	170	450	76,500	61,200[c]	1.85	0.78	2.63	2.55
Fall Cabbage	170	450	76,500	61,200[c]	1.85	0.78	2.63	2.55
Irish Potato	150	300	45,000	33,750[d]	1.17	1.06	2.23	1.30
Total	825		373,700	282,080				

[a]Assuming 70-percent of harvested tomatoes are marketable.
[b]Assuming 75-percent of harvested bell peppers are marketable.
[c]Assuming 80-percent of harvested cabbages are marketable.
[d]Assuming 75-percent of harvested sweet corn is marketable.

Table 9. Facility packing four crops: crop acreage, volume packed, cost per crate, and packing charge at the break-even level of operations.

Crop	Acres Harvested	Yield Per Acre	Total Volume Received	Total Volume Packed	Average Cost Variable	Average Cost Fixed	Average Cost Total	Packing Charge
	Number	Crates			Dollars			
Tomato	173	700	121,100	84,770[a]	1.70	0.64	2.33	2.30
Bell Pepper	172	350	60,200	45,150[b]	1.53	1.04	2.57	3.00
Spring Cabbage	172	450	77,400	61,920[c]	1.85	0.90	2.75	2.55
Fall Cabbage	172	450	77,400	61,920[c]	1.85	0.90	2.75	2.55
Total	689		336,100	253,760				

[a]Assuming 70-percent of harvested tomatoes are marketable.
[b]Assuming 75-percent of harvested bell peppers are marketable.
[c]Assuming 80-percent of harvested cabbages are marketable.

Single-Crop Packinghouse Models

Analysis of the three multi-crop models indicates that not all vegetables are able to cover their packing cost with the specified packing charge. To determine the economies of scale associated with packing each vegetable included in the multi-crop models, each vegetable was examined separately in single-crop packinghouse models. The only adjustment in the fixed cost items was the addition or deletion of any specialized equipment needed by a particular vegetable. The assumed volumes handled by the packinghouse are varied to generate the appropriate cost functions.

The average cost curves for a single-crop facility packing potatoes is illustrated in Figure 2. When the packing charge is set at $1.30, which is the fee specified in the multi-crop models, the packinghouse is required to pack 1,575,000 crates of Irish potatoes to reach the break-even level of operation. At the previously specified levels of yield and quality, it would require 7,000 acres to obtain this volume. Irish potatoes would be harvested during July in the study area. If the packinghouse operated 24 hours a day for 31 days at 100 percent of rated capacity (400 crates per hour), the facility could pack-out 297,600 crates. If the packing charge is raised to $2.07, the facility could break-even with a pack-out of 225,000 crates. However, to handle this volume in 31 days would require a pack-out of 7,259 crates per day. To handle this volume at 400 crates per hour, the facility would still need to operate 18 hours per day. It is unrealistic to assume that a packinghouse could operate at 100 percent of rated capacity for 18 to 24 hours per day over an extended period of time. There would be problems with obtaining the required labor force, break-down of equipment, and difficulty securing a continual flow of incoming supplies to keep the packing facility operating smoothly.

The shape of the average total cost curve emphasizes the importance of attaining the economies of scale available from increasing the volume handled. This is especially true at the smaller volume levels when the cost curve declines rapidly with increases in output. While the examination of a single-crop packinghouse cost curve can be discouraging, because of the large volume required to break even, it does provide considerable insight into the need to have adequate packing fees and product volumes to support a economically viable packinghouse. It also supports the concept of packing complementary products to increase the total volume packed over the entire season.

A single-crop facility packing tomatoes must handle approximately 343,000 crates to reach the break-even level of operation (Figure 3). This pack-out volume would require 700 acres of tomatoes. Because tomatoes are harvested during July, August, and September in the study area, the packinghouse has a longer operating season than the single-crop potato model. Therefore, the total volume could be handled in 12

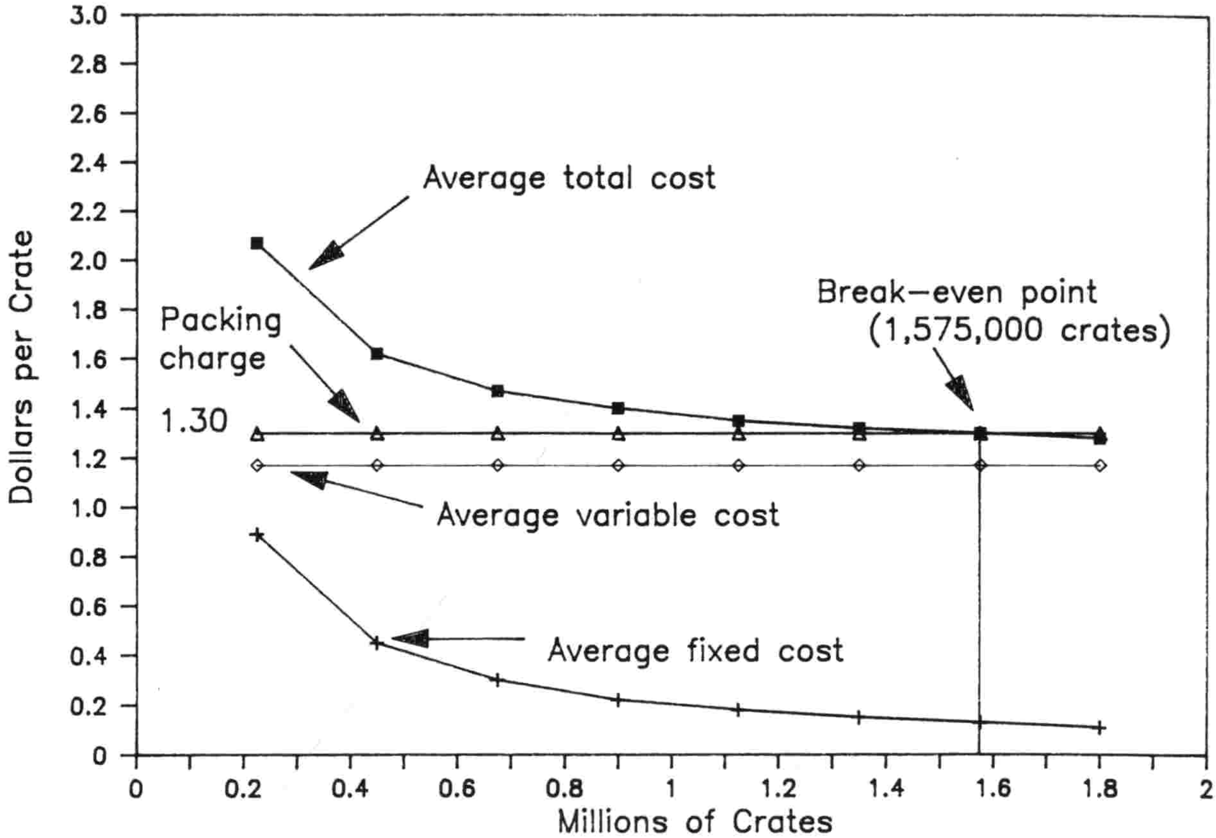

Figure 2. Relationship between cost per crate and volume of potatoes packed in a single-crop packing house.

weeks if the facility operated at 100 percent of rated capacity (400 crates per hour), for 72 hour per week. At the previously specified level of operating over a packing season at 70 percent of rated capacity (280 crates per hour), the packinghouse would need to run 102 hours per week for the full 12 weeks. Raising the packing charge from $2.30 to $2.75 reduces the required break-even volume to 200,000 crates.

The single crop model for bell peppers is presented in Figure 4. It should be noted that bell peppers are the only vegetable that had a packing charge that exceeded the derived packing cost in all three multi-crop packinghouse models examined in the previous section. The packing charge for bell peppers was specified as $3.00 per crate. Hence, the packinghouse would need to pack-out 140,000 crates to operate at the break-even point. This would require about 533 acres of bell peppers. The harvest season for bell peppers is July, August, September, and October. To handle this volume in 16 weeks at an operating level of 280 crates per hour would require a pack-out of 8,750 crates per week, which would take slightly less than 32 hours per week. If the packing facility were to decrease the packing charge to $2.81, the total pack-out needed to maintain the break-even level of operation would be 157,800 crates (about 600 acres). Packing this larger volume would require the facility to operate 36 hours per week for 16 weeks.

In the single-crop facility packing sweet corn, with a packing charge of $2.40, the packinghouse would need to pack-out 290,000 crates to break even (Figure 5). Producers would be required to harvest 2,495 acres of sweet corn to supply the required volume. Sweet corn is harvested in June and July (8 weeks), so the facility would need to pack-out 36,250 crates per week. Operating at the 70-percent of rated capacity level, the facility would be required to operate 131 hours per week. To accomplish this task, the facility would be required to operate 19 hours per day, 7 days per week. The packinghouse would encounter the same problem as the single crop facility packing Irish potatoes, since maintaining a labor force and operating the facility for this length of time 7 days per week would create several problems. If the packing charge for sweet corn is raised to $2.89, the break-even volume would be reduced to 117,000 crates. To handle this volume in eight weeks, the packinghouse hours of operation would be reduced to 53 hours per week.

In the multi-crop models, the packing charge for spring and fall cabbage is not high enough to cover the cost of packing. With the packing charge value of $2.55, a single-crop facility packing cabbage would need to pack about 131,000 crates to reach the break-even point (Figure 6). Approximately 364 acres at the specified yield could provide this volume.

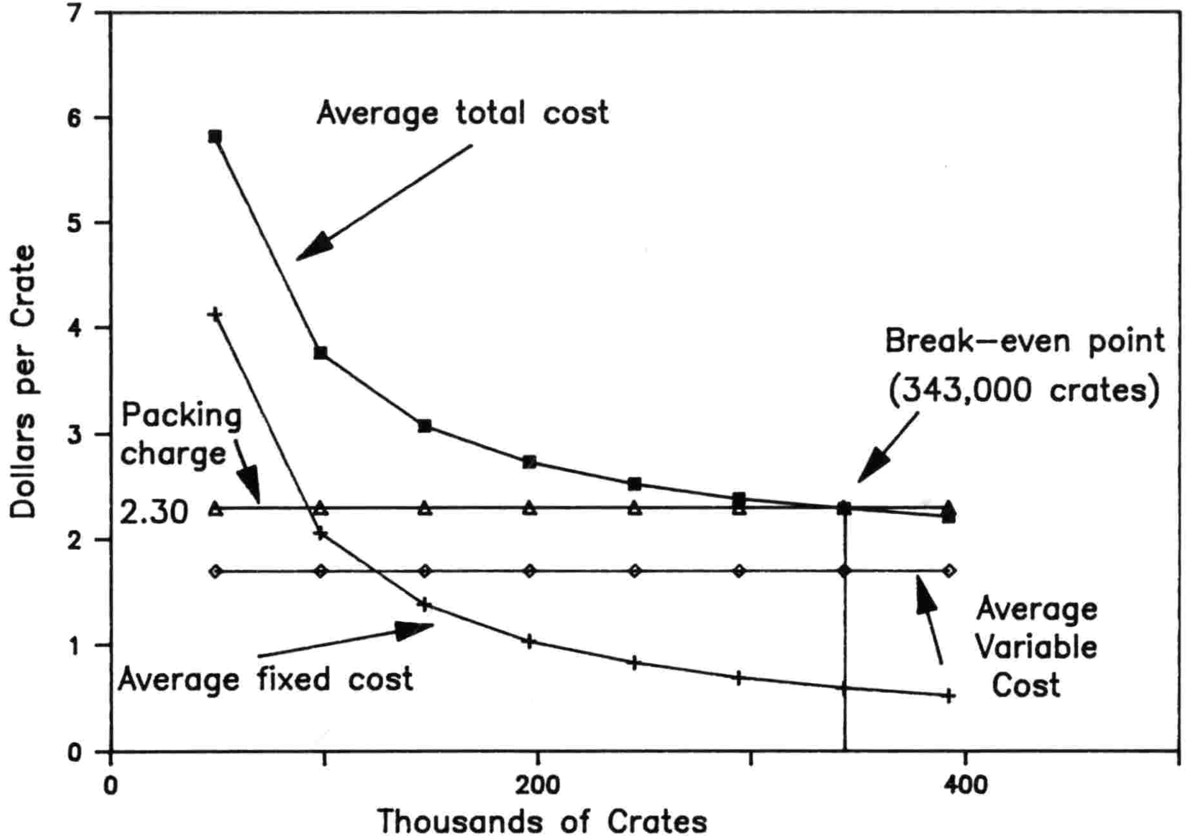

Figure 3. Relationship between cost per crate and volume of tomatoes packed in a single-crop packinghouse.

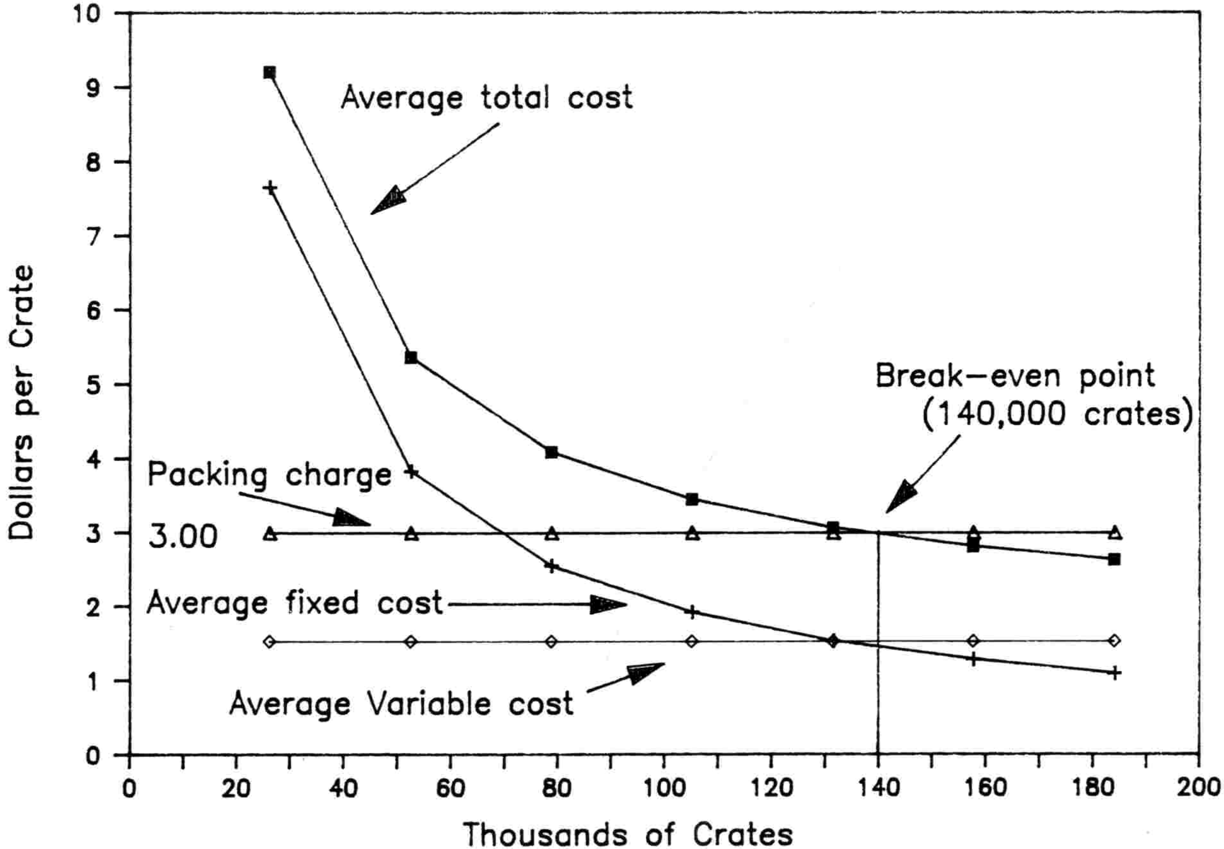

Figure 4. Relationship between cost per crate and volume of peppers packed in a single-crop packinghouse.

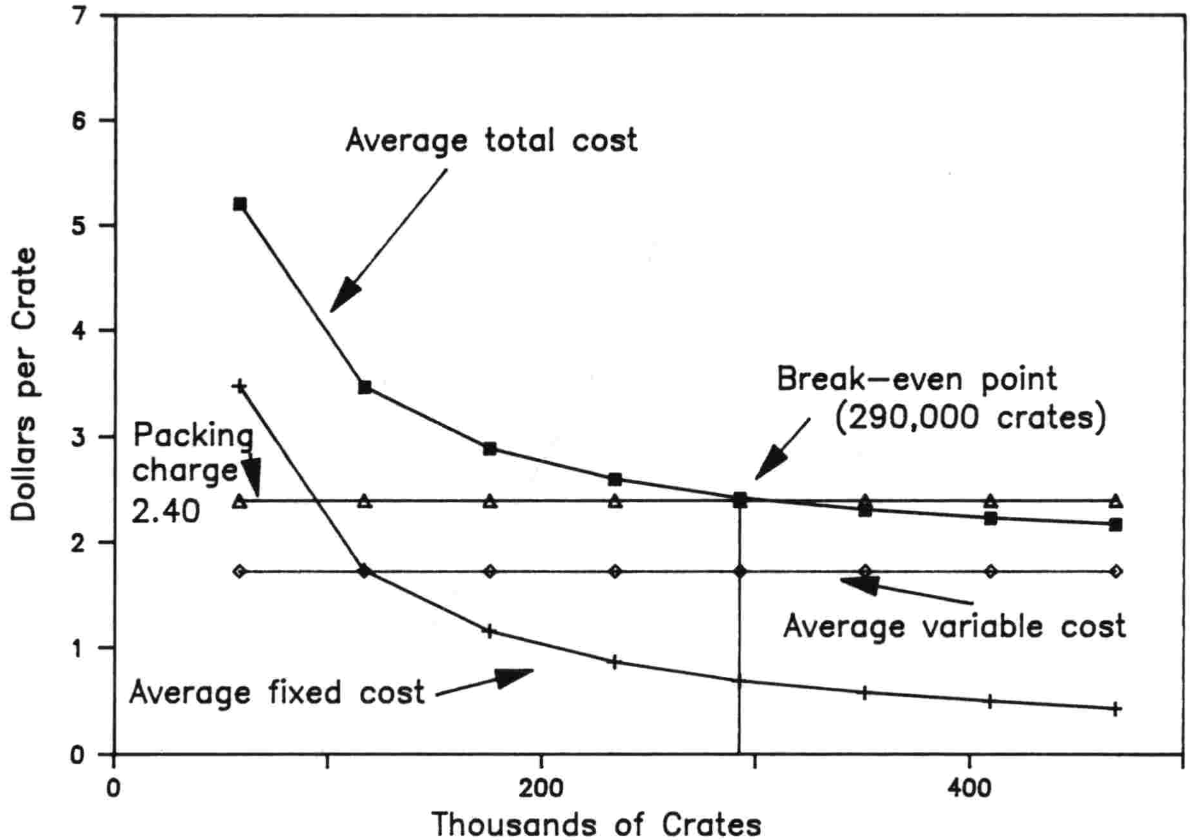

Figure 5. Relationship between cost per crate and volume of sweet corn packed in a single-crop packinghouse.

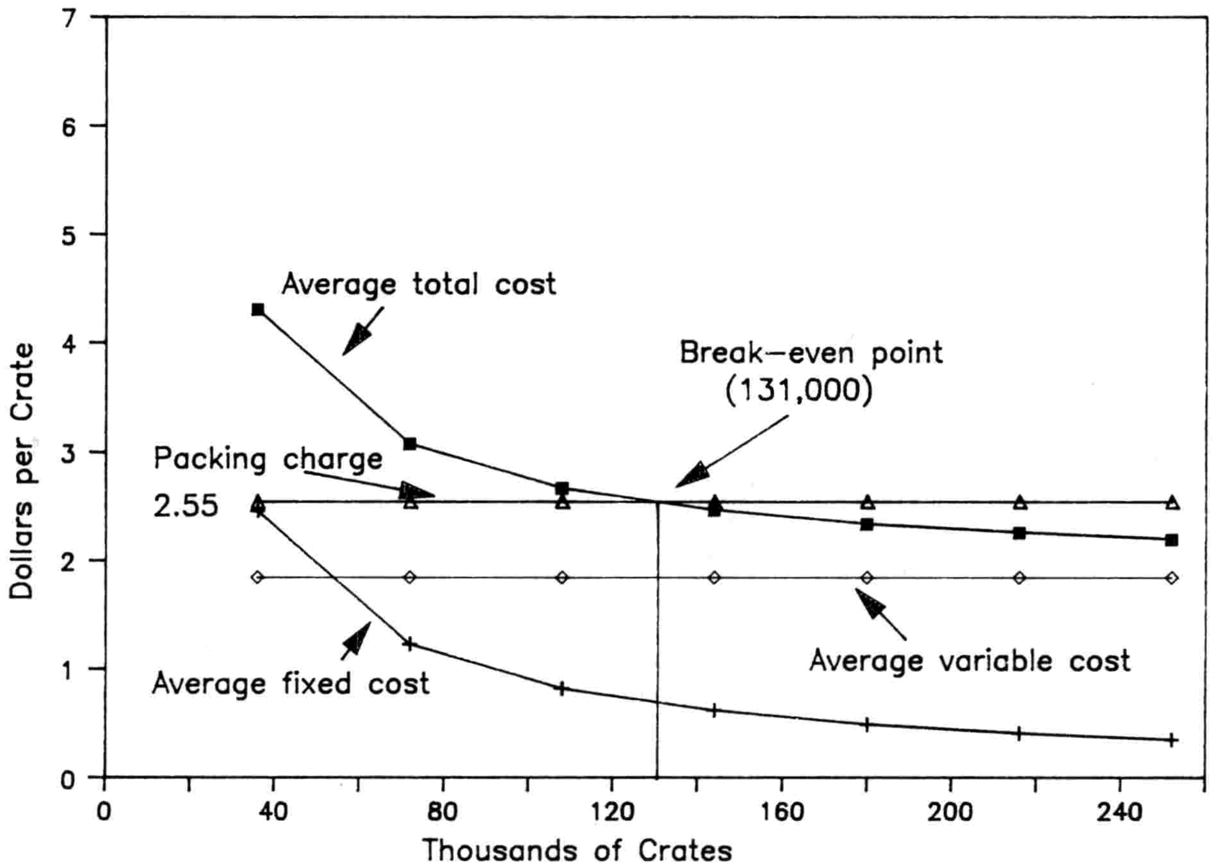

Figure 6. Relationship between cost per crate and volume of spring and fall cabbage packed in a single-crop packinghouse.

Spring cabbage is harvested in June and July and fall cabbage is harvested in October, November, and part of December. This would provide a packing season of about 18 weeks in total. The packing facility would need to pack an average of 7,278 crates per week. Operating at 70-percent of rated capacity (280 crates per hour), the facility could handle this weekly volume in 26 hours per week.

Cost Curves for Three-Crop Packinghouse

Analysis of the single crop packinghouse models reveals that several crops require a larger volume than the facility could handle during a typical harvesting period. To examine the impact of a multi-crop packinghouse model on the packing cost curves, the three-crop model presented earlier was used to generate the data. The cost curves should be observed as a set, in that the break-even acreages of tomatoes, bell peppers, spring cabbage, and fall cabbage were determined simultaneously. From this break-even beginning point, the acreages of all three crops were increased and decreased in unison. The resulting increase and decrease in volume packed allowed the cost curves to be estimated (Figures 7, 8, and 9).

Operating at the break-even level of operation would require 88,000 crates of tomatoes, 32,000 crates of bell peppers, and 160,000 crates of spring and fall cabbage. At these levels, the packing charge is equal to the packing cost for each individual vegetable.

If the packinghouse manager was able to contract producers to plant 800 acres (equally distributed among tomatoes, peppers, spring cabbage, and fall cabbage), the packinghouse would be able to pack-out 98,000 crates of tomatoes (packing charge set at $2.30); 52,600 crates of bell peppers (packing charge set at $3.00); and 144,000 crates of spring and fall cabbage (packing charge set at $2.55). The packing charge exceeds packing cost for tomatoes and bell peppers, but packing cost exceeds packing charge by $0.05 for spring and fall cabbage. If the acreage planted was increased to 1000 acres and distributed equally among the crops, the packinghouse would be capable of packing out 122,500 crates of tomatoes, 65,750 crates of bell peppers, and 180,000 crates of spring and fall cabbage. By leaving the packing charges at $2.30 for tomatoes, $3.00 for bell peppers, and $2.55 for spring and fall cabbage, each vegetable packing charge would cover the packing cost.

Effect of Selected Factors on Packing Costs

Sensitivity of the cost functions from the three multi-crop packinghouse models is discussed in this section. The interest rate, level of financing, operating level, and packing charge were varied from the values used to generate the base solutions of the four-crop with a hydrocooler, four-crop without a hydrocooler, and the three-crop packinghouse models. The effect on investment and operating costs, and on pack-out volume required to maintain the break-even level of operation, are presented in Table 10.

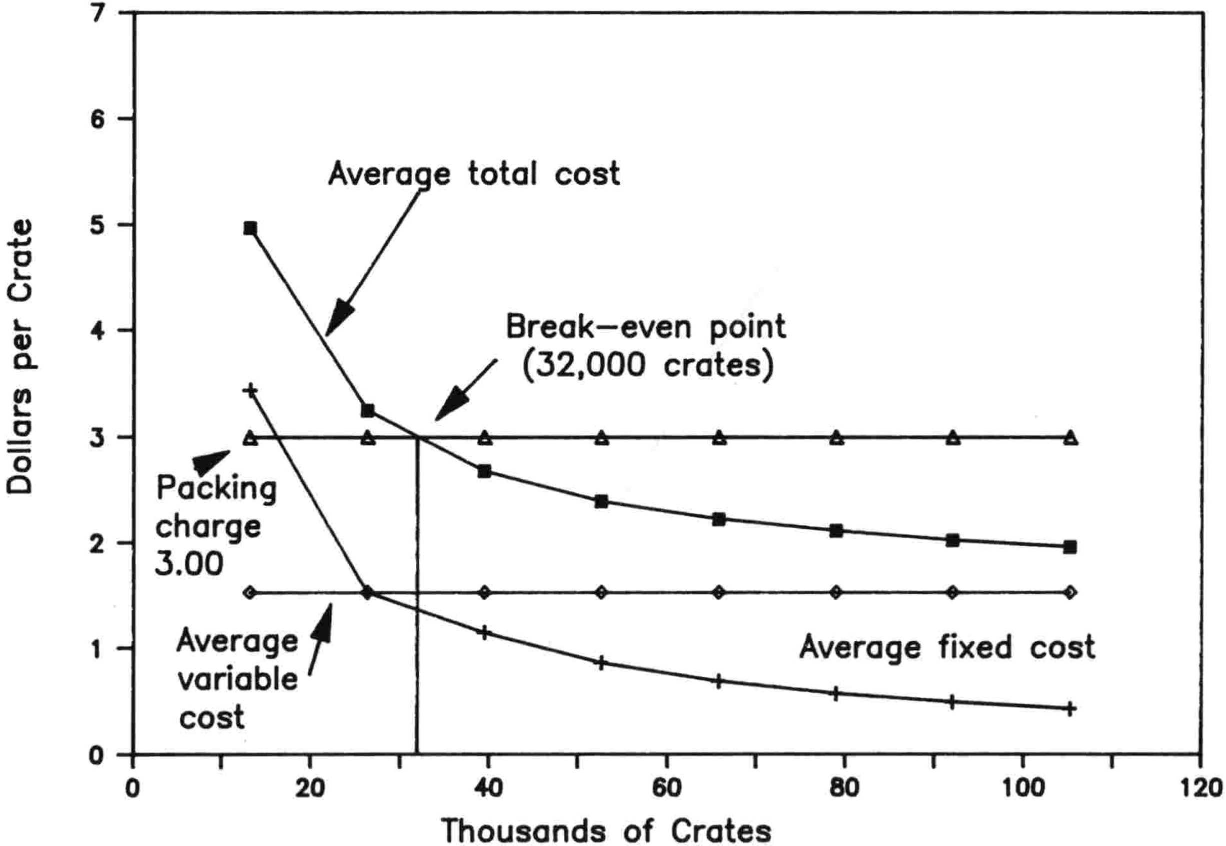

Figure 8. Relationship between cost per crate and volume of peppers packed in a three-crop packinghouse.

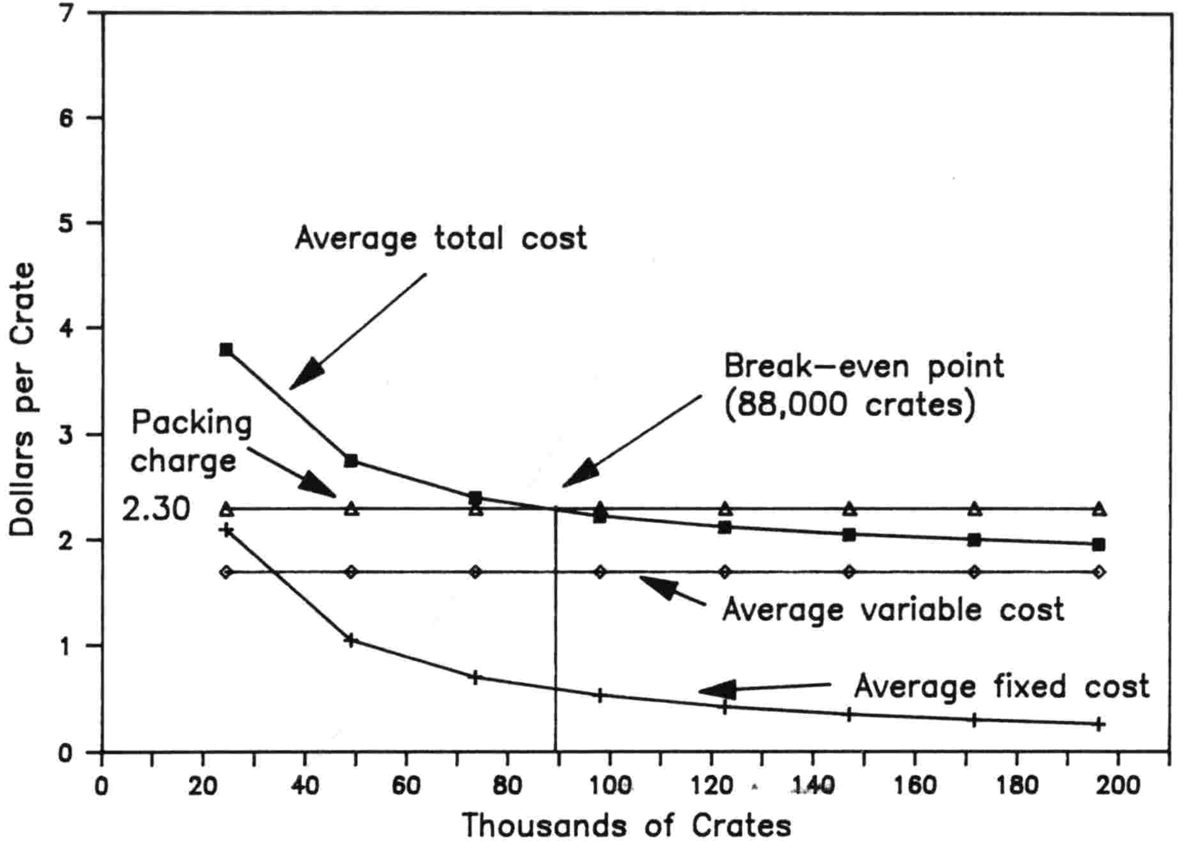

Figure 7. Relationship between cost per crate and volume of tomatoes packed in a three-crop packinghouse.

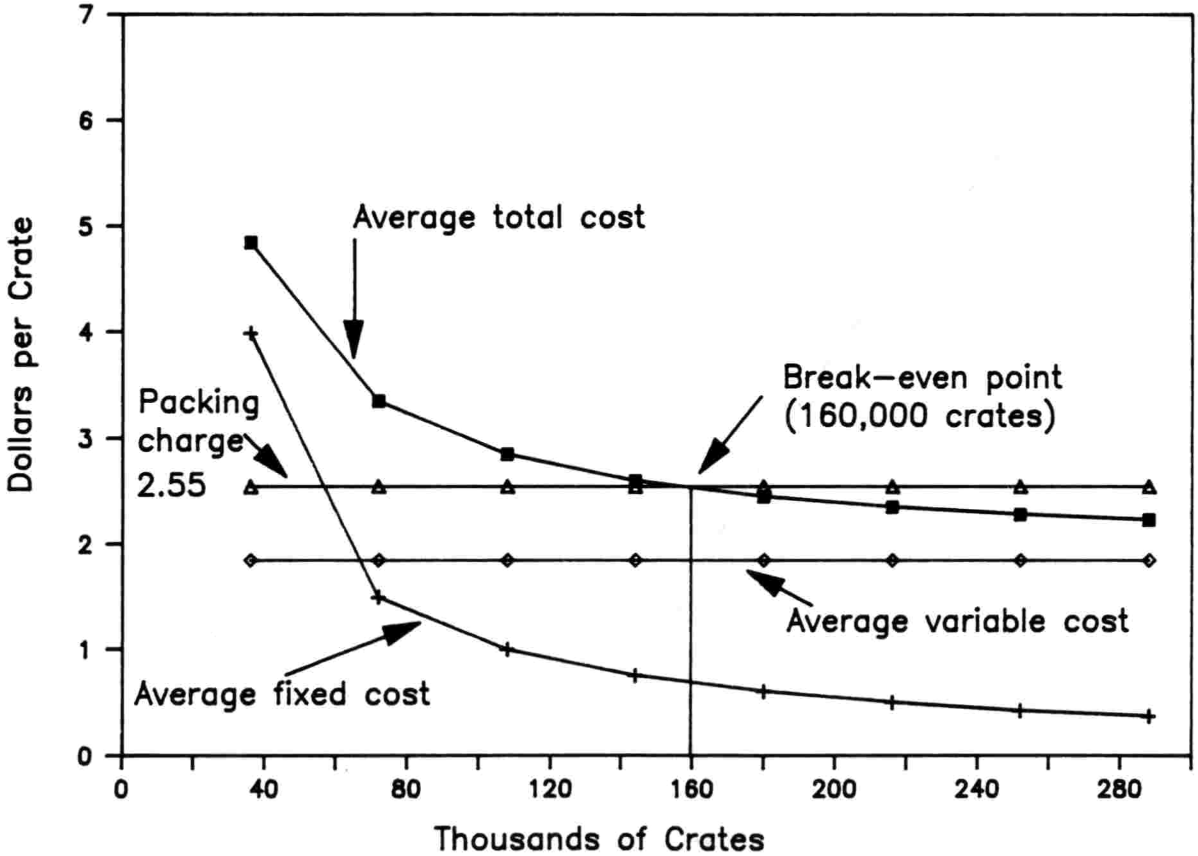

Figure 9. Relationship between cost per crate and volume of cabbage packed in a three-crop packinghouse.

Table 10. Sensitivity of packinghouse cost and pack-out to adjustments in the interest rate, proportion of investment financed, operating level, and packing charge.

Packinghouse model total costs, and pack-out	Interest Rate		Financing	Operating Level		Packing Charge
	8%	12%	80%	50%	90%	+ $0.10
	Percentage change from base solution					
Four-crop:[b]						
Fixed Cost	-7	+7	-4	0	0	0
Variable Cost	-8	+7	-5	+62	-21	-18
Crates Packed	-8	+7	-5	+43	-15	-18
Four-crop: (With hydrocooler)[c]						
Fixed Cost	-7	+7	-4	0	0	0
Variable Cost	-7	+8	-4	+58	-20	-17
Crates Packed	-7	+8	-4	+40	-13	-17
Three-crop:[d]						
Fixed Cost	-7	+7	-4	0	0	0
Variable Cost	-7	+7	-4	+55	-19	-17
Crates Packed	-7	+7	-4	+37	-13	-17

[a]Packing charges were increased $0.10 above the packing cost derived in the base solution.
[b]Cabbage, peppers, potatoes, and tomatoes.
[c]Cabbage, corn, peppers, and tomatoes.
[d]Cabbage, peppers, and tomatoes.

The interest rate was decreased from the solution level of 10 percent to 8 percent and also increased to 12 percent to reveal the impact of this factor on the break-even position of the packinghouse models. As anticipated, the direction of the cost change coincided with the decrease or increase in the specified interest rate. For all three multi-crop packinghouses, the two percent change in the interest rate resulted in a seven to eight percent change in total costs. This decrease (increase) in cost allowed the simulation model to decrease (increase) the pack-out volume required for the packinghouse to break even.

In the base solutions, a specification was included regarding the percentage of the total investment being financed with borrowed capital. This percentage was reduced from 90 percent to 80 percent to observe the impact on the break-even analysis. Reducing the required level of financing 10 percent generated a four percent reduction in both cost and pack-out of the break-even simulations of the three multi-crop packinghouses.

The percentage of rated pack-out capacity at which a packinghouse operates is referred to as the operating level. This factor identifies the efficiency of the packinghouse with respect to utilization of rated capacity. Few processing operations run at 100 percent of rated capacity over an entire processing season. In most processing plants the percentage would vary during the season. The level selected for the base solutions was 70 percent. Total fixed cost is not affected by adjustments in the operating level. However, reducing the operating level to 50 percent had a substantial impact on variable cost. In the four-crop model without the hydrocooler the total variable cost increased 62 percent (Table 10). This variable cost increase was associated with a 43 percent increase in the pack-out volume required for the packinghouse to break even at this lower level of operating efficiency. The impact on the other two packinghouse models was similar, but not quite as severe. This fact emphasizes the importance of being able to operate the packinghouse at a high percentage of rated capacity. Operating at a low level of rated capacity increases the per crate variable cost, thereby forcing the simulation model to require larger volumes to reduce average fixed cost until it eventually compensates for the higher variable cost.

Increasing the level of operating efficiency to 90 percent reduced the total variable cost of the packinghouse approximately 20 percent in all three models (Table 10). The cost reduction was possible due to the smaller pack-out necessary to reach the break-even level of operation. An important point here is the level at which the packinghouse operates has substantially more impact on the economic viability of the packinghouse than moderate adjustments in the interest rate or financing level.

As noted earlier, the per crate packing charges entered into the three base packinghouse models were obtained from sources reporting actual industry rates. The simulation results also revealed the inadequacy of some of the packing fees when compared to the per crate packing cost of the model packinghouse operating under the specified conditions. Using the per crate packing cost calculated in the break-even analysis of the three models as base values, the packing charges were adjusted to be $0.10 above the base value for each vegetable. This modification resulted in an increase in the packing charge for cabbage, corn, and tomatoes and a decrease for peppers. The adjustment in packing fees did not affect total fixed cost (Table 10). With each crop supposedly paying its own way, the pack-out volume required for the packinghouse to operate at the break-even point dropped about 17 percent.

CLOSING REMARKS

Among the three multi-crop packinghouse models presented, the required pack-out volume for the operations to reach the break-even point was lowest when only three vegetables were being handled. The addition of potatoes to a product group of tomatoes, bell peppers, and cabbage did absorb some of the fixed cost, but changes in the break-even acreages of the original three commodities were nominal. This was primarily due to the specified packing changes. Similarly, the addition of sweet corn instead of potatoes to the packinghouse product mix substantially increased the fixed expense because of the need for a hydrocooler. To break even the packinghouse needed to pack the sweet corn from 400 acres, plus nearly the same acreages of tomatoes, peppers, and cabbage as required by the three-crop model.

The impact on operating costs from adjustments in the specified packing charges for each crop was visually emphasized in the cost curves generated for the single-crop packinghouse models. Without any other products to help cover part of the fixed expenses the break-even volumes identified for each product were substantially higher than in the multi-crop models. The L-shaped acreage total cost curves for each vegetable revealed the economics of scale available to the packing operation that can increase the volume packed. The single-product cost curves also emphasized the necessity for growers and packinghouse managers to agree on a packing charge that is reasonable—a fee that allows the packing operation to be economically viable and also allow the grower to receive an adequate return for supplying the products. Growers receipts from the packinghouse will vary in response to industry wide supply and demand conditions because of the normal price variation in vegetable prices within a marketing season and from season to season. The packinghouse's receipts will depend directly upon the volume handled, and sometimes the volume handled will be larger when f.o.b. prices are low. This possible conflict between the interests of the growers and a packinghouse may be resolved by the development of a packing fee based partially on the f.o.b. price.

While the single-crop packinghouse cost curves provide insight into the packing fees that may be appropriate at various pack-out levels, the multi-crop packinghouse cost curves reveal the need to examine particular scenarios. The three-crop and two four-crop models presented in this report were selected to illustrate the volumes required for the packinghouse model to break even. The packing charges were set at current industry levels. Growers working together in a packing cooperative, or dealing with an independent packinghouse, should consider the packing fee appropriate for that particular packinghouse.

Analysis of the sensitivity of packinghouse costs and returns revealed the substantial impact of the specified operating level. Adjusting the operating level from 50 to 70 to 90 percent of rated capacity dramatically illustrated the importance of operating a packing facility as close to full capacity as possible. Adjustments in the specified interest rate and percentage of investment being financed also affected the packinghouse, but less dramatically.

The packinghouse scenarios examined in this report provide introductory evidence for application in a unique feasibility study. In other words, growers and packers need to work together to determine the selection of crops to be packed and the acreage committed to the packinghouse. Then they should assess the likelihood of both the growers and the packinghouse attaining satisfactory net returns.

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