Packing Box Distribution Costs

deciduous fruit packing house operation studies include cost and efficiency analysis of several methods of supplying boxes

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The following article is one of a series of reports of studies on Efficiency in Fruit Marketing made co-operatively by the Giannini Foundation of Agricultural Economics, University of California, and the Agricultural Marketing Service, U. S. Department of Agriculture, under the authority of the Research and Marketing Act. Detailed reports are available by addressing the Giannini Foundation, 207 Giannini Hall, University of California, Berkeley 4, California.

A key stage in packing house operation is the supply of empty boxes to the packers. In most plants this includes receiving the box materials as shook, labeling, assembling, and distributing the boxes to the packers.

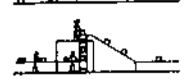
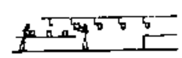
To provide a good basis for comparing costs and efficiency of different methods, a standardized cost-estimating procedure was devised. This involved production studies of actual plant operations to provide estimates of net time requirements for different jobs and of the additional time allowances required for rest and unavoidable delays. The average net labor requirements for each job—with an allowance for rest and delay of 10% of the total work time—were used to estimate the production standards for the various jobs.

Since variation occurs in the working conditions in different plants and in the output rates of different workers, the production standards may not be strictly applicable in a particular plant, but they provide a good basis for determining relative costs with different box-distribution methods. The data are primarily from studies of pear, apple, and grape packing house operations. Similar methods are used with other deciduous fruits, and the results described in this report should be generally applicable.

Five different methods of box distribution were studied. In the following descriptions of the five methods, the numerals set off by dashes represent the production standards expressed in boxes per man-hour.

Method A: The box moves by gravity conveyor from the boxmaker to a set-on man who places it on an elevator to a mezzanine—860 production standard in boxes per man-hour. Here the boxes are nested, stacked, and hand trucked to box liner stations above each packing line—715; boxes are transferred individually to a bench where pads and liners are inserted and the lined boxes are placed in a chute leading to a gravity conveyor extending the length of the packing line—250.

The Effect of Box Distribution Method on Annual Fixed Costs for Equipment and Variable Costs of Labor, Power, and Equipment Repair in a Deciduous Fruit Packing Plant of 600-Boxes-per-Hour Capacity.

Method and operations		Annual fixed costs*	Variable costs, per hour**
A. Elevate boxes to mezzanine, set off, stack, and truck to liner, line box and chute to packer....		$310	$6.70
B. Line box on conveyor from box-maker, elevate to mezzanine, chute to packer................		350	4.53
C. Set off and stack boxes, truck to end of packing line, line box and place on conveyor to packers		180	5.16
D. Transfer box from conveyor to bench, line box and chute to packer.........................		200	3.45
E. Line box on conveyor, hang box on overhead monorail		220	2.98

* Annual fixed costs for equipment can be converted to replacement costs at the 1953 level by dividing the figures in these columns by 0.13, the percentage annual charge.

Annual fixed costs with other rates of box supply can be estimated as follows: Compute the difference in boxes per hour between 600 and the desired box-supply rate. Multiply this difference by the following rates in cents per box: Method A—35; Method B—41; Method C—27; Method D—28; and, Method E—20. Add or subtract this amount to the figures in the table.

** Variable costs with other box-supply rates can be approximated in the same manner described for equipment costs. Adjustment rates per box are as follows: Method A—0.83; Method B—0.51; Method C—0.71; Method D—0.49; Method E—0.37.

Wage rate $1.20 per hour. Since variable repair and power costs are very small, variable costs with a wage rate of $1.00 per hour can be approximated by dividing the above adjustment rates, and the variable costs by 1.20.

Method B: As the box rolls from the boxmaker on a gravity conveyor, pads and liners are dropped into place—610; lined boxes are hand-transferred to an elevator, which delivers them to a gravity conveyor on a mezzanine extending across one end of the packing lines—860; on the mezzanine, boxes are hand transferred to chutes leading to gravity conveyors to the packers—760.

Method C: Boxes are nested on a gravity conveyor leading from the boxmaker, then set off in stacks—1,000; stacked boxes are hand-trucked to the end of the packing line, transferred individually to a bench, where pads and liners are inserted, and each box is pushed down a conveyor leading to the packers—220.

Method D: All boxmaking and box-distribution operations are performed on a box mezzanine. Boxes roll on a gravity conveyor from the boxmaker to a box-lining station above each packing line. Boxes are transferred individually to a bench, pads and liners are inserted, and the lined boxes are placed in a chute to the packers—250.

Method E: Pads and liners are placed in each box as it rolls on a gravity conveyor from the boxmaker—610; lined boxes are hand transferred to hooks on an overhead monorail conveyor—860, which carries the boxes through the packing area.

With low rates of box supply, some of the operations can be combined to minimize crew size. At low output rates, with Method *A*, for example, all the operations on the box mezzanine can be performed by one man. Unit time requirements then are 0.322 man-minute per box with a production standard of 185. This standard also applies if all operations performed with Method *C* are combined. Combining the box-lining and box-transfer jobs with Methods *B* and *E* results in a production standard of 355.

The methods described and the analysis assume direct movement of the boxes from the boxmaker to the packers. If minor differences between the rates of boxmaking and packing require that part of the boxes be set aside temporarily without removal to storage, labor requirements would be increased by about 2.0 man-hours for each 1,000 boxes so handled.

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Crew requirements—in relation to the method used—and rate of box supply can be estimated from the production standards. With Method *E*, for example, one man—by combining the jobs of lining boxes and transferring them to the monorail hooks—can supply boxes at rates up to 355 boxes per hour. For rates of box supply between 355 and the production standard of 610 boxes per hour—on the box-lining operation—one man is required on each job. Two box liners and one box-transfer man are required for box-supply rates between 610 and the production standard of 860 boxes per hour—for the box-transfer man—and so on for still higher rates of box supply.

When crew requirements are estimated as described, the crew size evidently increases in a series of steps, as larger rates of box supply are considered. In studies of a group of actual plants, however, variations in crew size in exactly this manner would not occur. Adjustment of crew size in the neighborhood of the box-supply rates indicated by the production standards would occur. An average relationship can be developed in which labor requirements vary uniformly—rather than by sharply defined steps—as the rate of box supply is varied. Such relationships are used in this analysis.

Estimates of the equipment required with the different methods were based on a plant layout in which packer output averages 10 boxes per plant hour and the spacing between packing stations is 3′ 8″. These factors determine the amount of conveyor equipment required at a given rate of plant output for final delivery of boxes to the packers. As plant layout varies, conveyor equipment requirements and costs also vary.

By applying suitable cost rates to the estimated quantities of labor and equipment, costs for different rates of box supply can be determined.

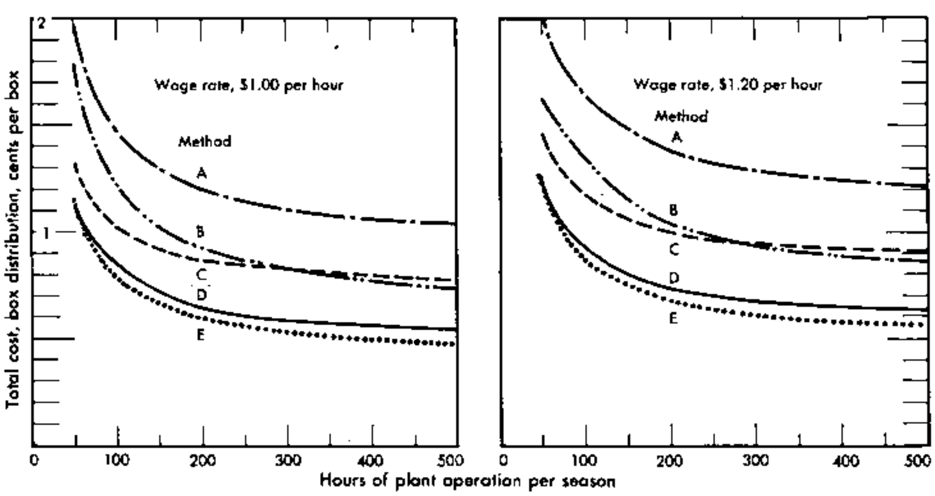
Two categories of costs must be considered—annual fixed costs for equipment and variable costs of labor, power, and equipment repair.

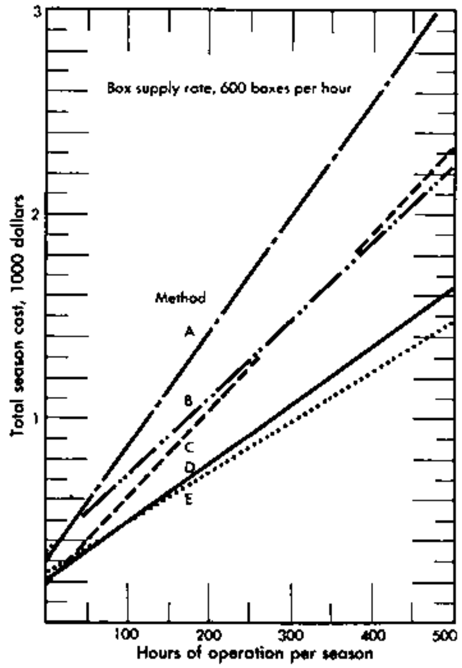
Annual fixed costs for equipment with each method studied were estimated by applying a uniform annual charge of 13% to the 1953 replacement costs. This percentage figure includes depreciation, based on a 15-year use life, and allowance for taxes, insurance, fixed repair expense, and interest on the investment.

Variable costs were computed on an hourly basis. Two levels of wages were considered—a $1.00-per-hour rate considered typical for the box-distribution jobs in the San Joaquin Valley grape packing districts, and $1.20 per hour applicable in the Tokay district and in some of the pear packing districts. Power costs were estimated at the rate of 3¢ per motor horsepower per hour, and variable repair expense was estimated at the rate of 0.5% of the equipment replacement cost per 100 hours of use.

Annual fixed costs for equipment and variable costs per hour, estimated with the above procedure, are given in the table on page 3 for a box-supply rate of 600 boxes per hour. The variable costs given are based on a wage rate of $1.20 per hour. Means of converting the variable costs to a wage level of $1.00 per hour and of adjusting the variable and annual fixed costs to other rates of box supply are indicated in the table.

The data in the table can be used to estimate total costs per season. With a box-supply rate of 600 boxes per hour and 100 hours of operation per season, for example, variable costs with Method *A* are $670; fixed costs for equipment are $310; and total season costs are $980. Similar calculations for other lengths of operating season show total season costs with a given method to rise uniformly as length of season increases. This relationship for a supply rate of 600 boxes per hour is indicated for the five different methods as shown in the graph in column 3 on this page.





Costs with two common variations of Method *B* can be visualized with the aid of the graph. In some packing houses, boxes are placed by the box maker directly on a power conveyor leading to the mezzanine, with operations otherwise the same as in Method *B*. With the revised procedure, equipment costs are unchanged, but the variable costs are reduced to the level of Method *E*. This result could be represented in the graph by a cost line paralleling that for Method *E*, but at a level $130 higher.

A second variation in Method *B* is to perform the box making operations in a basement, with a separate box elevator at each supply line, which feeds directly into the conveyors to the packers. The effect of this change on costs could be represented in the graph by a line paralleling the cost line with Method *E*, but at a level $200 higher.

Comparison of the total season costs given in the graph indicates that the monorail system—Method *E*—is lowest in cost, unless the operating season is very short. Method *A* appears as the high-cost method, with Methods *B*, *C*, and *D* at intermediate levels.

The cost relationships with different methods can also be shown in terms of average costs per box. Average costs can be calculated from the season total costs as shown in the graph in this column. With Method *A*, for example, the total season cost with 100 hours of operation is given in the graph as about $980. If the plant operates for 100 hours at the specified rate of 600 boxes per hour, 60,000 boxes will be used, and the unit cost of box distribution will be 1.64¢ per box. The results of such calculations for other lengths of season and with the

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