respiration rate of sound oranges and lemons has been demonstrated by Eaks (2), but that the effect can nullify decay control has been demonstrated only for 'Dancy' tangerines (5).

Diphenyl provided considerably less decay control with all varieties than has been obtained in previous years and concern is felt lest this be associated with resistant strains of Penicillium digitatum recently reported by Smoot and Winston as being present in Florida (7). It may, however, be yet another aspect of the marked variability between crops and seasons that is characteristic of this type of study with Florida citrus.

The new fungicide, 2-AB, continues to show promise, but it has not yet been approved by the Food and Drug Administration.

ACKNOWLEDGEMENTS

Appreciation is expressed to the Florida Fresh Citrus Shippers Association and Minute Maid Company for donations of fruit, to Mr. Hayden Leigh for donation of the 2-mil large hole bags, to the Crown Cork and Seal Corporation for preparing the aerosol cans of 2-AB, and to the Diamond National Corporation for donation of the trays to Reynolds Metals Co. for films used in shrink-film packaging.

LITERATURE CITED

3. Florida Citrus Commission. Regulation 105-1.03: Adoption and use of containers, including packs, stamping and marking of containers and fruits. Regulations pursuant to Chap. 601, Florida Statutes, as amended Aug. 8, 1967.
INTRODUCTION

Annual cost estimates for packing and selling fresh Florida oranges have been made since the 1935-36 season (1). Similarly, estimates of cost for picking and hauling Florida oranges have been derived since 1950-51 (2). Packing and selling cost estimates have been made for all types of containers. All estimates were made on a per box basis for the average cost of all firms, for the average cost of firms classified by volume packed, and for each firm in the sample.

These published cost estimates have shown sizeable interpack, internrm, and interyear variations. The cost variations have obscured any relationship between cost and size of firms in the annual estimates. In this study the annual cost estimates for the period 1954 through 1963 were combined within the framework of covariance analysis to estimate the relationship between cost and volume of picking, hauling, packing and selling fresh Florida oranges. In order to express costs in constant dollars, items of costs were deflated by indexes (1957-59 = 100) derived from information published in the December issues of Survey of Current Business, U. S. Department of Commerce.

The study is an attempt to empirically verify the economic concept of a long-run average cost curve. The analysis was based on recorded accounting data which represent the actual experiences of the sampled firms.

THE RESULTS

Economic theory implies that long-run average costs decrease as plant size increases up to some point at which they may begin to rise. A quadratic function approximates this theoretical specification. All equations were estimated by the method of least squares.

Equations 1-3 could be adjusted to conform with the economic theory of long-run average cost curves by substituting for X in the equations. For example if X = .8 S, Equation 1 would be

\[ Y = 0.3978 - 0.00148X + 0.0000024X^2 \]

\[ R^2 = 0.55 \]

Equation 2, Hauling Oranges:

\[ Y = 0.1631 - 0.00061X + 0.0000005X^2 \]

\[ R^2 = 0.70 \]

Equation 3, Packing and Selling Fresh Oranges:

\[ Y = 1.7523 - 0.03065X + 0.00035X^2 \]

\[ R^2 = 0.71 \]

where in each equation:

- Y = deflated costs in dollars per box for the respective operation
- X = volume of oranges for which the operation was performed in 10,000 box units
- S = Size of plant in terms of the volume of oranges that could be handled

Equations 1-3 are presented in an abbreviated form, but the R^2's presented are for the complete equations. The objective was to estimate the relationship between costs and volume free of the unique effects of the individual firms and the years in which firms were observed. The complete equation fitted to the picking and hauling data included nine and 31 zero-one variables for years and firms, respectively (3, 4). The equation fitted to the packing and selling data included zero-one variables for each of nine years and 38 firms. The latter equation also included eight variables to measure the effect of type-of-pack on costs. These effects will not be discussed in this paper. The effect of one year and one firm were included in the intercept of the original functions fitted.

The intercepts for Equations 1-3 were estimated by requiring the functions to pass through the means of the variables. This procedure is consistent with the classical method of estimating the intercept in regression analysis.

There are some conceptual difficulties in the use of least squares regression to estimate the long-run average cost curve since least squares estimates define a function through the middle of the data rather than an envelope of the data. However, if there is homogeneous variation in the data throughout its range, the coefficients of the quantity variables would provide an unbiased estimate of how costs change with firm size and consequently guidelines for firm size decisions.

2Volume of oranges handled by a firm was used in place of plant size in this study. The use of volume as a proxy variable for plant size assumes a high correlation between size and volume.

3Linear and exponential functions were also fitted to the data. The linear specification did not explain as much variation in costs as did the quadratic and exponential. The latter two specifications performed about equally well when judged by the amount of explained variation in cost. Only the results of the quadratic function are presented here.

4Numbers in parentheses are standard errors of the regression coefficients. Unless indicated otherwise, coefficients are significant at the .001 level. The picking and hauling equations were derived from 241 observations while 398 observations were used to estimate cost functions for packing and selling oranges.
A zero-one variable was introduced for each firm to allow for the average variation of those costs which are unique to that firm. Hopefully the variable would eliminate such sources of variation as the firm’s accounting method, the age and condition of its equipment, etc.

A zero-one variable was introduced for each year to allow for the variations in costs which were unique to industry characteristics during that year. Hopefully, the variable would eliminate sources of variation attributable to such things as freezes.

Zero-one variables can be defined to measure interaction effects. For example, significant firm-year interactions may exist in those situations in which a firm’s costs were affected in a unique manner during a given year. Variables to estimate the interaction effects would be defined as the product of relevant combinations of firm and year variables. Interaction effects were not investigated in this study. An analysis of the effect of technology on costs indicated that the inclusion of interaction terms would not have had much influence on the regression coefficients of the volume variables.

"Least Cost" Volumes for Ten-Year Period

For picking and hauling oranges

The "least cost" volumes were determined for the quadratic functions. These volumes were 3.1 million boxes for picking oranges and 6.1 million boxes for hauling oranges (Table 1). For comparison, the average volume of all sampled firms and their respective costs per box are listed next to the respective "least cost" volume. There is a substantial difference between the average level of volume versus the "least cost" volume. These "least cost" volumes can at best be only rough approximations (see footnote, Table 1). They were presented to emphasize that firms can enjoy declining per unit cost up to volumes considerably larger than current operating levels.

For packing and selling oranges

For packing and selling firms, the "least cost" volume was found, using Equation 3, to be about 438,000 boxes annually (Table 1). The estimated per unit average cost for packing this volume was $1.05 per box. The average firm was packing and selling a volume of oranges that represented only 38 per cent of the volume that would have produced the "least cost" per box.

Table 1.--Average volumes of oranges picked, hauled, and packed and sold by firms and "least cost" volumes along with per unit costs per box at the average volume, 1954 through 1963

<table>
<thead>
<tr>
<th>Type of operation</th>
<th>Average volume per firm</th>
<th>Average cost per box all firms</th>
<th>Estimated &quot;least cost&quot; volume</th>
<th>Estimated cost per box at &quot;least cost&quot; volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>Picking</td>
<td>654,283</td>
<td>0.3248</td>
<td>3,083,000</td>
<td>*</td>
</tr>
<tr>
<td>Hauling</td>
<td>1,031,440</td>
<td>0.1113</td>
<td>6,100,000</td>
<td>*</td>
</tr>
<tr>
<td>Packing and Selling</td>
<td>166,000</td>
<td>1.34</td>
<td>438,000</td>
<td>1.05</td>
</tr>
</tbody>
</table>

* The quadratic functions underestimate the cost per box at the "least cost" volume. This result indicates that the estimated function does not fit the data well for large volumes and is due to the few observations available at the large volumes.
The "least cost" volume for an optimally or ganized plant using the latest technology is probably underestimated.\textsuperscript{5} Equation 3 is graphed in Figure 1 along with an exponential function fitted to the same data.\textsuperscript{6} The exponential function is believed to be a more accurate representation of cost-volume relationships at the larger volumes.

\textbf{Consideration of the Effect of Technology on the Cost of Packing and Selling Oranges, 1954 Through 1959}

Economic theory implies that a technological improvement, with all other factors remaining constant, will shift the industry cost curve downward and to the right. As a result it becomes more efficient to produce at a larger volume than before. An attempt to quantify the shift in costs, caused by adaptation of technology in the packing and selling operation, was made by fitting a quadratic cost function to data at two periods in time. The two periods were:

- Period I = 1954-55 and 1955-56 seasons
- Period II = 1958-59 and 1959-60 seasons

For each of the two periods chosen, an attempt was made to combine two consecutive crop years that had homogeneous technology. An additional criterion used for selecting periods was the similarity of coefficients of zero-one variables for consecutive years.

A total of 62 observations were used in Period I while 66 observations were used in Period II. The estimates of the cost function for the two periods are given in Equations 4 and 5.\textsuperscript{7} In both periods the variables identified in the models explained most of the variation in costs with $R^2$'s of 0.96 and 0.95, respectively.

\textbf{Equation 4, Period I.}

\begin{equation}
Y = 1.4227 - 0.01641 X + 0.00024 X^2
\end{equation}

($0.00916$) ($0.00024$) ** $R^2 = 0.96$

\textsuperscript{5}Using an economic engineering approach, Eric Thor (5) found that long-run cost curves continue to decline at volumes considerably larger than the "least cost" volume estimated by Equation 3.

\textsuperscript{6}The equation for this function without the zero-one variable is $Y = 1.8132X - 0.13154$. The standard error of the exponent of $X$ is 0.00962. The complete equation explained 78 per cent of the variation in $Y$ - 8 per cent more than Equation 3. The variables, $X$ and $Y$, have the same meaning as in Equation 3.

\textsuperscript{7}Coefficients whose standard errors are marked with a single asterisk are significant at the .05 level. A double asterisk indicates that the coefficient is not significant at an acceptable level.
Equation 5, Period II:
\[ Y = 1.5819 - 0.02152 \times 10^4 + 0.00023 \times 10^6 \]
\[ (0.00935) \times (0.00016) \]
\[ R^2 = 0.95 \]

where:
- \( Y \) = deflated cost in dollars per box for packing and selling oranges
- \( X \) = volume of oranges packed and sold in 10,000 box units

To get an indication of the interperiod shift in the long-run average cost curve, the points at which minimum or least costs occurred on the average cost curves were determined. The "least cost" volume increased 37 per cent, or 126,000 boxes, between Periods I and II. Respective costs at the "least cost" volumes were $1.14 and $1.08 per box. The increase in the "least cost" volume along with the decrease in the costs per box indicated the industry cost curve shifted downward and to the right, a shift probably attributable to technological improvements occurring between Periods I and II.

Some of the improvements made during this time interval were the installation of belt sizers, adaptation of pallet boxes, and installation of automatic box folding machines which made the fiberboard box a very efficient type of container to pack. A graphic representation of the two quadratic cost functions more clearly depicts the shift between the periods (Figure 2). Arrows indicate the "least cost" volume for each period. The actual shift was probably underestimated because of the interperiod reduction in the number of boxes handled which resulted from the freeze during the 1957-58 crop year.

**Conclusions**

Results suggest that volume has a significant effect on costs and that the "least cost" volume was substantially higher than the average volume handled by all firms.

---

![Figure 2. Long-run average costs for packing and selling oranges for two periods, Period I, 1954-55 and 1955-56 seasons, Period II, 1958-59 and 1959-60 seasons](image-url)
Picking and hauling oranges

Many of the estimated coefficients of zero-one variables were significantly different from zero at an acceptable level. This result substantiates the hypothesis that much of the variation in cost can be associated with firm and specific crop year differences.

In both the picking and hauling operation, volume showed a significant inverse relationship with costs in the range where firms were operating. This result substantiates the hypothesis that larger volumes can be picked and hauled at lower costs.

Packing and selling oranges

Again, many of the estimated coefficients of the zero-one variables were significantly different from zero and substantiated the hypothesis that much variation in costs can be associated with differences among firms and crop years.

Costs were affected by volume as evidenced by the significance of the estimated coefficients of volume. Over the period of the study, the firms operating at larger volumes experienced lower costs. Lower per unit costs gave the larger firms a stronger competitive position than the small firms when adequate supplies of fruit were available.

The method of analysis used in this study could be extended to analysis of costs for other products for which cost data have been collected—possibly (as in the case of this study) for another purpose. Since it uses existing data, the method provides an estimate of what happens to cost as volume increases for very little cost in terms of research time and money.

LITERATURE CITED


POSTHARVEST DECAY OF SPECIALTY HYBRID CITRUS FRUITS IN RELATION TO DEGREEING TIME

JOHN J. SMOOT AND C. F. MELVIN

Market Quality Research Division
Agricultural Research Service
U. S. Department of Agriculture
Orlando

ABSTRACT

Fruits of specialty citrus hybrid varieties, including Robinson, Lee, Nova, and Page, reach minimum eating quality early in the fall before good color break has occurred. Fruit at this stage requires long ethylene degreening periods prior to packing. In tests conducted with fruit from both East Coast and interior groves of Florida, postharvest decay was directly related to length of degreening time. Excessive amounts of Diplodia and Phomopsis stem-end rot and anthracnose decay developed in fruit ethylene for 45 hours or more. Anthracnose was more prevalent in early-harvested than in more mature fruit and was not effectively reduced for standard decay-control treatments. Decay was minimized when harvesting was delayed until little or no degreening was needed.

INTRODUCTION

The specialty citrus varieties, Robinson, Lee, Nova, and Page, are hybrids released since 1960 by the U. S. Department of Agriculture (4, 5, 6, 7). Robinson, Lee, and Nova are hybrids of Clementine mandarin x Orlando tangelo, and Page is a hybrid of Minneola tangelo x Clementine mandarin. These varieties have been planted commercially in Florida since their release and are now bearing fruit in marketable quantities.

In Florida, fruits of these varieties reach...