AgEcon SEARCH
RESEARCH IN AGRICULTURAL & APPLIED ECONOMICS

The World's Largest Open Access Agricultural & Applied Economics Digital Library

This document is discoverable and free to researchers across the globe due to the work of AgEcon Search.

Help ensure our sustainability.

Give to AgEcon Search

AgEcon Search
<http://ageconsearch.umn.edu>
aesearch@umn.edu

*Papers downloaded from **AgEcon Search** may be used for non-commercial purposes and personal study only. No other use, including posting to another Internet site, is permitted without permission from the copyright owner (not AgEcon Search), or as allowed under the provisions of Fair Use, U.S. Copyright Act, Title 17 U.S.C.*

1973

Apples
Marketing
C

SUPPLY RESPONSE AND MARKETING STRATEGIES
FOR DECIDUOUS CROPS

John L. Baritelle and David W. Price.

Abstract of Article to be published in the American Journal of Agricultural Economics, Vol. 56, No. 2, May 1974

Recent surveys show large increases in Washington apple tree plantings. When these plantings come into production, prices received by growers are expected to be below production costs. A simulation model combining supply, demand and random weather variables was used to compare future returns and production variables of present fresh-processing allocation policies with alternative policies. The discriminating monopolist policies produced higher discounted revenues, more stable prices and greater production and tree numbers during the 1972-1981 period than present policies. Thus, the monopolist short-run increase in returns over the present policy was prevalent after accounting for supply response.

Key words: apples; supply response; simulation; market allocation policies; deciduous tree crops; polynomial distributed lag models; random weather components.

John L. Baritelle is an agricultural economist with the Commodity Economics Division, Economic Research Service, USDA, stationed at Washington State University, Pullman, Washington, and David W. Price is an Associate Professor of Agricultural Economics at Washington State University, Pullman, Washington.

Contributed paper, AAEA, Edmonton, Aug. 1973

SUPPLY RESPONSE AND MARKETING STRATEGIES FOR DECIDUOUS CROPS

John L. Baritelle and David W. Price

The primary objective of this research is to examine the future consequences of the present marketing policy and compare it with alternative marketing policies of Washington's apple industry. Production of Washington apples is expected to increase much faster than U.S. population because of the current large numbers of nonbearing trees. Plantings of Washington apples has proceeded at an unprecedented rate since the late 1960s [2]. The discriminating monopolist allocation policy between fresh and processing markets is one solution to improve grower returns. However, in the absence of restraints on production, initially higher returns received by growers should increase supplies and bring returns down to their initial level. This hypothesis was tested using a recursive simulation model.

A supply response function for the Washington apple industry was estimated by relating yearly tree plantings to past prices. A polynomial distributed lag model was used for this estimation. The simulation model first generates production for stochastic weather elements and the number of bearing trees. The alternative marketing policy then determines the amount of production going into the fresh and processing markets. Using demand relationships estimated by Scott [13], fresh and processing prices are estimated. Average price to growers is calculated and used as an input into the supply equation which generates new tree

plantings. Other stochastic elements enter the simulation to determine apple production in other geographic areas, quality of the fruit and the number of trees killed by severe freezes.

Simulation of future prices, tree numbers and production offers the advantage over the deterministic models of being able to incorporate the effects of the stochastic components. In tree fruit production, weather has a substantial affect on not only current production but on tree numbers and the quality of fruit.

Supply Response

The first definitive supply response for deciduous tree fruits was French's 1956 [5] study. He allowed for production response to price in making projections of future Michigan and U.S. apple production and prices. Production was related to a simple weighted average of previous seasons' prices. In the 1962 study by French and Bressler [6], supply response to price was developed in terms of tree plantings and removals. Total production was derived by converting bearing trees into bearing acres and multiplying by the yield per acre. Yields per acre were extrapolated from a trend line based on historical data, thus ignoring the randomness of production due to weather.

In a 1969 study of the Florida citrus industry, Raulerson [12] accounted for the random characteristic of weather by including six randomly generated weather patterns and comparing the projections from each.

Recently Hamilton [8] estimated tree planting response functions for a number of California fruit crops. He hypothesized new trees

planted as a function of future expected prices. Future expected price was a function of a finite number of past prices. This was estimated using a polynomial approximation of the unknown coefficients of past prices. Thus, the effect of each specified lagged price upon the plantings of new trees could be estimated. However, Hamilton stopped short of predicting future tree numbers or future supplies of fruit.

Perennial fruit crops represent a long-term commitment of land, labor, and capital in order to derive a future stream of net revenue. In the case of apples, the first four years represent extensive cash outflows with no revenue. Generally, by the fifth year there is some harvestable production. Yield per tree gradually increases until about the twelfth year when potential production reaches a maximum. With proper cultural practices an apple tree's productive life can be maintained for at least an additional 30 to 40 years.

The following model for supply response incorporates these characteristics of perennial fruit trees. Total quantity produced is broken down into the identity, trees multiplied by yield:

$$(1.1) \quad Q_t = \sum_i Y_{i,t} A_{i,t}$$

where

Q_t = total production in year t

$Y_{i,t}$ = yield per tree for trees in age group i of year t

$A_{i,t}$ = number of trees in age group i of year t

This identity accounts for differing yields according to age of trees.

Yield is primarily a function of current and past weather conditions.¹

$$(1.2) \quad Y_{it} = F(W_t, W_{t-1}, \dots, W_{t-n})$$

where $W_{t-\tau}$ = weather conditions influencing apple yield $t-\tau$ years past. Because the management and physiological links with weather are little known and of extreme complexity, yield is a random variable with a distribution based on past yields. Another useful identity breaks down the current number of trees into three components. The current number of trees in a given age group is equal to the number in that group the previous year minus the number killed by a freeze. The total number of trees in all age groups in year t is then equal the sum of all age groups the previous year less the number killed by a freeze plus the net change in tree numbers due to economic factors (number of new plantings less removals due to natural attrition):

$$(1.3) \quad \sum_i A_{i,t} = \sum_i A_{i,t-1} + N_t - \sum_i L_{i,t-1}$$

where N_t is the net change in tree numbers exclusive of trees killed by a freeze, and $L_{i,t-1}$ is the number of trees killed by freeze. Since trees do not die immediately from a freeze, a lagged response for tree freezes is necessary. Thus,

$$(1.4) \quad L_{i,t} = h(F_{i,t}, F_{i,t-1}, F_{i,t-2}, \dots, F_{i,t-\tau})$$

$$\tau = 0, \dots, n$$

where

$$F_{i,t-\tau} = \text{a freeze } t-\tau \text{ years past}$$

The probability of different types of tree-killing freezes can be estimated from the past. In this study two different types of freezes

were used (1) those occurring early in the winter that kill primarily young trees and (2) those occurring late in the winter killing older trees.

The net change in trees due to economic factors can then be related to new plantings less removals,

$$(1.5) \quad N_t = PL_t - R_t$$

where

PL_t = new plantings in year t

R_t = trees removed in year t

These can be related to some function of expected future profitability,

$$(1.6) \quad PL_t = k [E(P)]$$

$$(1.7) \quad R_t = h [E(P)]$$

where

$E(P)$ = expectation of future profitability

The data requirements for this type of supply response are the number of trees in each age category. This should be annual data. This data requirement is not met in the case of Washington apples. What is available is (1) the total of bearing and nonbearing trees for the years 1954, 1959, 1964 and 1969 as reported in the U.S. Census of Agriculture, and (2) a sample of apple growers giving their total tree numbers, the number of bearing trees and the number of new plantings less the number of removals for years since 1953.² These two sources of data were combined to obtain an estimate of the annual number of bearing and of nonbearing trees and yearly plantings less removals.

Due to the data limitations, only the net change in trees could be estimated. Thus,³

$$(1.8) \quad N_t = g [E (P)]$$

Actual death loss due to natural attrition excluding freezes was specified as a fixed percent for trees 20 years of age and older and as a different fixed percent for those trees less than 20 years of age,

$$(1.9) \quad d_{i,t} = c_i A_{i,t-1}$$

where

c_i = percentage of death loss due to natural attrition for age group i

Therefore, new trees planted in year t were specified as:⁴

$$(1.10) \quad PL_t = N_t + \sum d_{i,t}$$

The only relationship that needs to be estimated empirically is that between net tree change and expectations of future profitability (eq. 1.8). The remaining relationships are either identities, or relationships, that are related to weather in such a manner that the links of causality are too complex to be readily measured. In the simulation these are treated as exogenous random events.

There are a number of variables that could be hypothesized as affecting growers' expectations about the future profitability of apples. Growers' gross returns or net returns per acre or pound are three such variables. Common to these is the average price received by growers for their apples.⁵ Furthermore, price is compatible with supply theory.

It was therefore used as the independent variable. Costs were accounted for by deflating the price series with the index of prices paid by farmers. Since future profitability is not an observable variable, it was hypothesized that expected future profitability is a function of recent past prices. In view of the longevity of the investment involved and the associated uncertainties, growers likely take account of several year's prices. The length of the lag and the extent to which individual past years contribute to the explanation of N_t were left to statistical estimation procedures. The hypothesis expressed in the form of a finite distributed lag is

$$(1.11) \quad g [E (P)] = k + \sum_{\tau=0}^T \beta_{\tau} P_{t-\tau}$$

so that

$$(1.12) \quad N_t = k + \sum_{\tau=0}^T \beta_{\tau} P_{t-\tau} + U_t$$

where

$P_{t-\tau}$ = the seasons average price received
by Washington apple growers τ years
past.

In applying ordinary least squares estimation techniques to equation (1.12) several difficulties are encountered. If the lag length is long, there may be too few degrees of freedom, and the lagged values of the dependent variable may be highly intercorrelated thus yielding imprecise estimates [9]. Almon [1], initially stated that the lagged coefficients can be adequately approximated by a sufficiently low order polynomial.

Malinvaud [10] and, more recently, Dhrymes [3] have proposed alternative derivations, thus avoiding the use of the Lagrange interpolation originally used by Almon. Let

$$(1.13) \quad \beta_{\tau} = \sum_{i=0}^D a_i \tau^i$$

where D is the order of the polynomial used to approximate β_{τ} . The finite distributed lag was constrained such that at some time in the past where $\tau=T$ the average price received by growers had no effect on the present rate of planting. Thus,

$$(1.14) \quad \beta_T = \sum_{i=0}^D T^i a_i = 0$$

Solving for a_0 :

$$(1.15) \quad a_0 = - \sum_{i=1}^D T^i a_i$$

Substituting (1.15) into (1.13) yields

$$(1.16) \quad \beta_{\tau} = \sum_{i=1}^D a_i \tau^i - \sum_{i=1}^D T^i a_i$$

Rearranging terms

$$(1.17) \quad \beta_{\tau} = \sum_{i=1}^D (\tau^i - T^i) a_i$$

Substituting (1.17) into (1.12)

$$(1.18) \quad N_t = k + \sum_{\tau=0}^T \sum_{i=1}^D (\tau^i - T^i) a_i P_{t-\tau}$$

Reversing the order of the summation

$$(1.19) \quad N_t = k + \sum_{i=1}^D a_i \sum_{\tau=0}^T (\tau^i - T^i) P_{t-\tau}$$

Specifying T , the lag length, and D , the order of the polynomial, and transforming the initial data set gives

$$(1.20) \quad c_{1,t} = \sum_{\tau=0}^T (\tau^i - T^i) P_{t-\tau}$$

Substituting (1.20) into (1.19) the unknown a_i can be estimated by ordinary least squares. Thus, the function that was estimated is

$$(1.21) \quad N_t = k + \sum_{i=1}^D a_i c_{1,t}$$

The β_T can be found by direct substitution of the estimated a_i into (1.17).

Using data for the years 1953 through 1971, the constrained form of the polynomial lag was parametrically varied from $T=3$ to $T=10$. Also the degree of the polynomial, D , was reduced starting from a fourth-degree polynomial until reduction reduced significantly the explanatory power of the independent variable. The multiple correlation coefficient and their associated lag length for a second-degree polynomial lag model for the undeflated and deflated price series are recorded in Table 1.

The raw price series generally provided greater explanatory power than the deflated price series. And growers may be more inclined to respond to raw prices per se. However, from a longer run point of view, it is doubtful that growers can indefinitely ignore costs. Therefore, the deflated price series was used in the subsequent simulation.

The lag length selected for the simulation model was eight years with $\beta_8=0$. This length had the highest R^2 value. The beta coefficients and the associated test statistics were:⁶

TABLE 1. Multiple correlation coefficients for constrained second order polynomial approximations.^{a/}

Independent Variable	Lag Length							
	10	9	8	7	6	5	4	3
PHD price	.548	.608	.693	.718	.622	.462	.281	.096
PHD price ÷ index								
prices paid	.296	.529	.696	.624	.392	.198	.072	.012

^{a/}The dependent variable is net change in the number of trees in the state of Washington.

$$\begin{aligned}
 (1.22) \quad N_t = & - 2,791,640 + 50,487 P_{t-0} + 77,142 P_{t-1} \\
 & \quad \quad \quad (2.718) \quad \quad \quad (4.525) \\
 & + 94,379 P_{t-2} + 102,136 P_{t-3} + 100,594 P_{t-4} \\
 & \quad \quad \quad (6.823) \quad \quad \quad (5.909) \quad \quad \quad (6.035) \\
 & + 89,574 P_{t-5} + 69,135 P_{t-6} + 39,277 P_{t-7} \\
 & \quad \quad \quad (6.046) \quad \quad \quad (6.011) \quad \quad \quad (5.971)
 \end{aligned}$$

$$R^2 = .696$$

$$\text{Durbin Watson} = 1.912$$

All of the estimated lagged equations consistently show first an increasing response and then a declining response to past prices over time. There are some plausible explanations for this. First, growers may have a certain psychological hesitancy to respond to present prices. Second, the availability of some inputs tempers planting decisions. Nursery stock must be planted one to two years prior to its sale to the orchardist.

Static micro economic theory states that there exists an equilibrium when the cost of production is equal to the market price. As a check on the validity of the supply function, the equilibrium price was compared with the average cost of production. Setting N_t of equation (1.22) equal to zero where plantings equal replacements and solving for $P_{t-\tau}$ assuming all lagged prices are equal, the static equilibrium price is equal to 4.48 cents per pound. This compares favorably with Zuroske's [19] study where the average cost of production was 4.21 cents per pound and with Doran and Lange's [4] study where the estimated production cost was 4.73 cents per pound.

Demand

There have been a number of studies estimating the demand relationships for Washington apples. Scott's [13] 1972 study estimated demand equations for Washington's fresh and processing markets at the grower level. His work is recent, in agreement with economic theory, and conforms to the needs of the simulation model.⁷

The demand equations used in the simulation model were:

$$P_{P,PHD} = .3362 - .4595 Q_P - .3005 Q_t - .04357 Q_{US} + .0011 Y \\ - .1457 D + .0562 X_t \quad R^2 = .771$$

$**$ $**$ $**$

$$P_{F,PHD} = 29.8126 - 1.8821 Q_F - .3345 Q_{US} + .00143 Y - .17024 D \\ - 2.4462 X_6 \quad R^2 = .879$$

$**$ $*$

*significant at the .95 level

**significant at the .90 level

where

$P_{P,PHD}$ = cents per pound received by Washington growers for
apples sold in the processing market

Q_P = pounds per capita of Washington processing apples sold

Q_t = preharvest estimate of pounds per capita of total
Washington apples produced

Q_{US} = pounds per capita of total U.S. apples sold less
pounds per capita of Washington apples sold

Y = disposable income per capita

D = dummy variable representing the quality of the crop;

0 equals normal, 1 equals poor crop years

X_t = trend variable representing increased handling facilities for Washington's processing apples for year t

$P_{F,PHD}$ = cents per pound received by Washington growers for apples sold in the fresh market

Q_F = pounds per capita for apples sold in the fresh market per pound

X_6 = packinghouse charges in cents per pound deflated by CPI

Other U.S. Production

The quantity of U.S. apples produced (other than Washington's) was included in the simulation model because of its effect on the demand for Washington apples. Other U.S. production and plantings have increased at a modest, but consistent, rate since the early 1950s. Thus, other U.S. production was expressed as a function of time,

$$Q_{US} = - 114,475.00 + 60.62 T$$

*** ***

$$R^2 = .442 \quad \text{Standard error of the equation} = 410.44$$

***significant at the .99 level

where

T = time expressed in years

This equation was used to predict the mean value of other U.S. production. Given the mean, the variance and assuming other U.S. production to be normally distributed, the random variable, other U.S. production, was determined stochastically in the simulation model.

Market Allocation Policies

Given total production, the quantities to be marketed in the fresh and processing market were determined by the following four market allocation policies.

Present Allocation Policy

The Washington apple industry uses its processing market as a salvage market for its culled fruit. Over the past 10 years the industry has sent 80 percent of its fruit into the fresh market and the remaining 20 percent into the processing market. In years with exceptional amounts of poor quality fruit and/or large crops, the industry diverts up to 30 percent to processing. Likewise in years of good quality fruit and/or short crops, the industry may only divert 10 or 15 percent to processing. The industry does not sell fruit that is saleable in the fresh market to the processing market despite the fact that Scott's [13] work has shown that such a policy could increase returns to the industry as a whole for a given year.

To analyze the future implications of the present allocation, certain rules were constructed for the simulation model. These rules were (1) provided the random variable yield is within one standard deviation of its mean, the industry will divert 20 percent to the processing market regardless of crop quality; (2) in years of large crops 25 percent of the crop goes to processing unless quality is poor, in which case 30 percent goes to processing; (3) in years of small crops, 10 percent of the fruit goes to processing unless the quality is poor, in which case the diversion is 15 percent.

Price Equalization Policy

With the rules specified above in years of large crops, the price in the fresh market can approach zero. Growers would not rationally make such a diversion. As an alternative, 80 percent was sent fresh, 20 percent to processing unless the fresh price is below the processing price. In this case, the industry allocates between markets such that the prices in the two markets are equal.

Discriminating Monopolist Policies

The simulation model used two discriminating monopolist policies. The first allocated annual production between fresh and processing such that marginal revenues were equated. The second allocated production among three markets: the fresh, the processing and the dump. The dump was a throwaway market whose marginal revenue was -0.5 cents per pound.⁸ The marginal revenues were equated in the fresh and processing market if they were above -0.5 cents per pound. When they were below -0.5 cents per pound, production was diverted to the dump until marginal revenues in all three markets were equated.

The Simulation Model

The supply, demand, and weather components were combined with a market allocation policy in the simulation model. Each market policy was implemented over a time horizon of ten years. Since the simulation model was stochastic, each market policy was run over the ten-year horizon thirty times. The mean and variance for the prices and quantities in the fresh and processing markets along with total revenue,

total production, the number of trees planted, and the total number of trees from the thirty runs were calculated. The four policies were evaluated by the output characteristics.

The model starts by generating the stochastic element, yield per mature tree equivalent for 1972. This element is normally distributed with the mean and variance of the 1953-71 period. The product of the yield and the actual number of tree equivalents gives production (Fig. 1). The stochastic quality variable was generated along with the stochastic variable, other U.S. production.⁹ Using the demand equations and a market policy, prices and quantities of fresh and processed apples were generated.¹⁰ Also, total grower revenue and the weighted average price were computed. This price plus the previous seasons' prices provide the input to the tree response equation. The death loss due to attrition was computed.¹¹ Two mutually exclusive stochastic freeze elements were generated--one for trees 12 years and older and one for trees under 12 years. The probability of each was 6 percent. When a freeze occurred, there was a 20 percent kill of trees in the appropriate age distribution. The death loss from a freeze took place over a period of three years, with two-fifths of those marked for death being killed in each of the first two years and one-fifth the third year. After estimating the change in tree numbers, the age distribution was updated.

Results

Under the present allocation procedure (Market Policy 1), the expected present value of the 10-year stream of income is 357.36 million dollars with a standard deviation of 26.43 million dollars (Table 2).

Figure 1. Schematic diagram of the simulation model of Washington's apple industry

Table 2. The mean and variance of the present value of the 10-year stream of income for the four market policies^{a/}

Policy Name	Policy	Mean	Standard Deviation
	Number	-----million dollars-----	
Facsimile of present rules	1	357.36	26.43
Price equalization	2	396.36	14.98
Monopolist: 2 markets	3	524.70	18.34
Monopolist: 3 markets	4	526.28	13.87

^{a/}Discount factor equal to 10 percent

This is the lowest of the four policies. The variance of the expected present value is also the greatest. This is due to the nearly constant proportion allocated to the fresh market and the more inelastic fresh demand. With large crops, fresh prices are severely depressed. Policy 4, on the other hand, has the greatest expected present value with the smallest variance. This is due to its ability to allocate to the more elastic markets as production increases. With increased returns, tree numbers also increase.

Policy 1 produces a drop in expected average PHD prices from 4.2 cents per pound in 1972 to 3.0 cents per pound in 1976. This causes a reduction in the total number of apple trees from 10.9 million trees in 1972 to approximately 7.0 million trees in 1981. Despite the removal of trees under Policy 1, expected production increases from 1,300 million pounds in 1972 to almost 1,800 million pounds in 1979. This is due to the large number of nonbearing trees now in the ground. These trees become increasingly productive and this tends to offset any decrease in production due to the removal of trees until about 1980. By 1981 Policy 1 shows a production of 1,400 million pounds and a price of 5.7 cents per pound.

Under Policy 2, the price equalization model, prices decrease from 4.1 cents per pound in 1972 to 3.3 cents per pound in 1975. This causes the total tree population to be reduced from 10.9 million in 1972 to about 8.3 million in 1981. This is 1.3 million more than under Policy 1. Under Policy 2, production is 400 million pounds more than under Policy 1 by 1981.

The discriminating monopolist type allocation, Policies 3 and 4, produce markedly different results. These policies allocated a much greater proportion of production to the more elastic processing market. Under Policies 3 or 4 the lowest price is 4.0 cents per pound despite the fact that production is considerably greater. While Policies 1 and 2 demonstrate about a 50 percent increase in expected production, Policies 3 and 4 show an almost doubling of production. Because of these relatively high prices, increases in the state's tree population take place. By 1981 expected total number of trees are 11.4 million under Policy 3 and 11.8 million under Policy 4. By the late 1970s, tree numbers are stabilized.

In summary, Policies 3 and 4 result in greater expected average PHD prices and greater expected revenues. The greater prices result in large increases in production, but by 1981 tree plantings are about equal to replacements with average PHD prices stabilized. If Washington's apple industry adopts Policies 3 or 4, it must be willing to make certain changes. A marketing board with the mandatory power to divert between fresh and processing must be established. Also, the state must expand its processing capacity.

Model Credibility

The individual components of the model were in agreement with economic theory and the estimates of the unknown structural parameters were statistically satisfactory. The output of the simulation seemed reasonable to individuals familiar with the industry. Certain structural coefficients within the model were parametrically varied and the model's output examined. The results appeared reasonable under the altered coefficients.

The authors made no attempt to replace the stochastic elements with actual past data and run the model to validate its ability to reproduce the past. First, there was insufficient information to make such a comparison. It is impossible to accurately specify the age distribution of the state's apple trees for earlier years because of a lack of data. Reasonable estimates of the age distribution of trees have been available only in recent years.

Second, the authors believe simulation models should not be evaluated solely on its ability to predict the past. Following the argument by Raulerson [12], the important criterion is how well the model explains and contributes to the understanding of the system under study. For policy evaluation purposes, revealing the nature of the system under study is more important than predicting the past.

Summary

Proposals for monopolist allocation models for perennial crops are quite common. Yet, increasing grower returns by discrimination among markets may be shortsighted. The effect of higher grower revenues upon supply was incorporated into a simulation model of Washington's apple industry. Supply response was restricted with a polynomial distributed lag. The simulation included stochastic elements to specify the effects of weather and fruit quality.

Under the monopolist allocation policies, expected production nearly doubles. This increased production is sold in the more elastic processing market creating expected revenues well in excess and with less expected variation than those under the present policy. The

monopolist policies produced expected prices slightly above or equal to the average cost of production. Under present allocation policy, prices declined and trees were removed. At the end of the time horizon, expected grower prices are about equal to production costs, producing stable tree numbers and stable production under the monopolist type model.

Thus, although a supply response from increased prices under the monopolist policy did occur, discounted returns to growers were much higher than under present policy. The greatest benefit from models such as this one is their ability to give an industry an insight into the future under alternative actions. These models can be used by growers to examine the future implications of other market alternatives.

FOOTNOTES

*Scientific paper 4191, project 0060, College of Agriculture Research Center, Washington State University

John L. Baritelle is an agricultural economist with the Commodity Economics Division, Economic Research Service, USDA, stationed at Washington State University, Pullman, Washington, and David W. Price is an Associate Professor of Agricultural Economics at Washington State University, Pullman, Washington.

¹Yield was generated for a mature tree equivalent. A tree equivalent represented the production from a 12-year-old tree or older. A five-year-old tree was considered one-eighth of a tree equivalent, a six-year-old tree, one-fourth of a tree equivalent and so on.

²While the results of this survey by the Statistical Reporting Service are not published, access to it was provided to the authors.

³This assumes the removal process due to economic factors to be the negative of the planting process.

⁴It was assumed that trees dying due to attrition were replaced within an orchard. This is an accepted practice in Washington, and it results in orchards with trees of varying ages.

⁵The prices received by growers is commonly referred to as the packinghouse door price hereafter called the PHD price.

⁶The t values are expressed in the parentheses and were calculated as follows:

$$\beta_{\tau} = \frac{D}{\sum_{i=1}^D} (\tau^i - T^i) a_i$$

Thus, where D=2,

$$\begin{aligned}
 \text{Var } \beta_{\tau} &= \text{Var} [a_1 (\tau - T) + a_2 (\tau^2 - T^2)] \\
 &= (\tau - T)^2 \text{Var } a_1 + (\tau^2 - T^2)^2 \text{Var } a_2 \\
 &\quad + 2 (\tau - T) (\tau^2 - T^2) \text{Cov } (a_1 a_2)
 \end{aligned}$$

Hence:

$$t = \frac{\beta_{\tau}}{\sqrt{\text{Var } \beta_{\tau}}}$$

⁷Scott estimated his equations by ordinary least squares. He assumed that the quantities sold fresh and processing were not determined simultaneously. His assumptions seem valid since crop quality and not quantity has determined the proportion of the crop sold to the respective markets. Fresh prices to growers have been substantially higher than processing prices.

⁸Significance of the coefficients at the .95 and .90 levels is indicated by * and **, respectively.

⁹Both coefficients are significant at the .99 level.

¹⁰The -0.5 cents per pound represented the cost of hauling fruit to a dump.

¹¹The probability is .32 that quality is poor. U.S. production was previously explained.

¹²The source of future population estimates was [17]. The source of future per capita income estimates was [18].

¹³This was 1 percent per year for trees 20 years and under and 3.7 percent per year for trees over 20 years.

REFERENCES

- [1] Almon, S., "The Distributed Lag Between Capital Appropriations and Expenditures," Econometrica, 33:178-196, Jan. 1965.
- [2] Baritelle, J. L., Supply Response and Marketing Strategies for the Washington Apple Industry, unpublished Ph.D. thesis, Washington State University, 1973.
- [3] Dhrymes, P. J., Distributed Lags: Problems of Estimation and Formulation, San Francisco, Holden Day Co., 1971.
- [4] Doran, S., and J. Lange, Apple Production Costs for the Okanogan County Area of Washington, Washington Agricultural Experiment Station Extension Manual 3484, July 1971.
- [5] French, B. C., The Long Term Price and Production Outlook for Apples in the United States and Michigan, Michigan Technical Bulletin 225, 1956.
- [6] French B. C., and R. G. Bressler, "The Lemon Cycle," Journal of Farm Economics, 44:1021-1036, Nov. 1962.
- [7] Hall, R. E., and R. C. Sutch, A Flexible Indefinite Distributed Lag, Berkeley, University of California Center for Research and Management Science, Working Paper No. 124, 1968.
- [8] Hamilton, J. R., Acreage Response: An Econometric Analysis of the Acreage of Selected California Fruit and Nut Crops, Ph.D. thesis, University of California Berkeley, May 1972.
- [9] Johnston, J., Econometric Methods, 2nd ed., New York, McGraw-Hill Book Company, 1972.

- [10] Malinvaud, E., Statistical Methods of Econometrics, Amsterdam, North Holland Publishing Co., 1966.
- [11] Price, D. W., Intraseasonal Demand, Supply and Allocation of Washington Apples, Washington State University Technical Bulletin 73, 1973.
- [12] Raulerson, R. D., Grower-Oriented Supply and Marketing Policies for Frozen Concentrated Orange Juice, Florida Agricultural Experiment Station, Ag. Econ. Report 1, 1969.
- [13] Scott, M. J., The Value of a Processing Diversion to the Washington Apple Industry, Master's thesis, Washington State University, 1971.
- [14] U.S. Department of Agriculture, Annual Crop Report, Statistical Reporting Service in cooperation with Washington State Department of Agriculture, 1947-1971.
- [15] _____, Fruit Reports, Statistical Reporting Service in Cooperation with Washington State Department of Agriculture, 1947-1972.
- [16] _____, Weekly Weather Crop Bulletin, Statistical Reporting Service in Cooperation with Washington State Department of Agriculture, 1946-1972.
- [17] U.S. Department of Commerce, Population Estimates and Projections, Bureau of Census Current Population Reports, Series P-25, No. 477, March 1972.
- [18] _____, Survey of Current Business, 52:4, April 1972.
- [19] Zuroske, C. H., Apple Production Costs and Returns, Washington State Agricultural Experiment Station Bulletin 696, April 1968.